

ANNUAL REPORT
OF THE
BOARD OF REGENTS
OF THE
SMITHSONIAN INSTITUTION,
SHOWING
THE OPERATIONS, EXPENDITURES, AND CONDITION
OF THE INSTITUTION
FOR THE
YEAR ENDING JUNE 30, 1899.

REPORT
OF THE
U. S. NATIONAL MUSEUM.

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“Of the Report of the Smithsonian Institution, ten thousand copies; one thousand copies for the Senate, two thousand for the House, five thousand for distribution by the Smithsonian Institution, and two thousand for distribution by the National Museum.”

REPORT
OF THE
U. S. NATIONAL MUSEUM,
UNDER THE DIRECTION OF
THE SMITHSONIAN INSTITUTION,
FOR THE
YEAR ENDING JUNE 30, 1899.

REPORT OF THE U. S. NATIONAL MUSEUM FOR THE YEAR
ENDING JUNE 30, 1899.

SUBJECTS.

I. Report of the Assistant Secretary of the Smithsonian Institution,
with Appendices.

II. Papers describing and illustrating Collections in the U. S.
National Museum.



UNITED STATES NATIONAL MUSEUM,
UNDER DIRECTION OF THE SMITHSONIAN INSTITUTION,
Washington, October 1, 1899.

SIR: I have the honor to submit herewith a report upon the present condition of the United States National Museum, and upon the work accomplished in its various departments during the fiscal year ending June 30, 1899.

Very respectfully,

RICHARD RATHBUN,
Assistant Secretary.

Mr. S. P. LANGLEY,
Secretary, Smithsonian Institution.

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PART I.

R E P O R T

UPON THE

CONDITION AND PROGRESS OF THE U. S. NATIONAL MUSEUM
DURING THE YEAR ENDING JUNE 30, 1899.

BY

RICHARD RATHBUN,

ASSISTANT SECRETARY OF THE SMITHSONIAN INSTITUTION.

REPORT

UPON

THE CONDITION AND PROGRESS OF THE U. S. NATIONAL MUSEUM DURING THE YEAR ENDING JUNE 30, 1899.

BY

RICHARD RATHBUN,

Assistant Secretary of the Smithsonian Institution.

GENERAL CONSIDERATIONS.

Mr. Charles D. Walcott, who, following upon the death of Doctor Goode, had agreed to add to his duties as Director of the Geological Survey those of Acting Assistant Secretary of the Smithsonian Institution in charge of the National Museum, felt obliged to relinquish the latter position with the year ending June 30, 1898. During his incumbency there was a modification in the administration of the Museum, which consisted in gathering the different departments under three heads and placing three scientific men in charge of them as head curators. One, the Head Curator of Biology, Dr. F. W. True, by virtue of his appointment as Executive Curator, took charge of the executive office immediately following the retirement of Mr. Walcott, and administered it with zeal and fidelity. The Secretary, who is by law Keeper of the Museum, has always retained the direction of its policy and attended personally to many of the important acts connected with its administration. His numerous and exacting duties made him feel the necessity of further aid in this direction, and in accordance with a resolution of the Board of Regents removing the restrictions placed upon the appointment of the writer as Assistant Secretary, in 1897, the latter has given a certain oversight to the affairs of the Museum, without, however, being able to spare sufficient time to supervise all of its details.

The Secretary in his own report has expressed his appreciation of the value and efficiency of the services rendered by Mr. Walcott to the Museum during the year and a half in which he was connected with it in an administrative capacity. It should be added that the Museum still has the benefit of Mr. Walcott's services as Honorary Curator of the Division of Stratigraphic Paleontology, and, beyond this, that his advice and his valuable aid have been given to the Museum on many occasions since his official administrative connection with it ceased.

The present National Museum is an integral part and the direct outgrowth of the Smithsonian Institution. In the fundamental law creating the Institution, Congress provided for the erection of a building suitable for natural history collections, including a geological and mineralogical cabinet, and further ordered that—

Whenever suitable arrangements can be made from time to time for their reception, all objects of art and of foreign and curious research, and all objects of natural history, plants, and geological and mineralogical specimens belonging to the United States, which may be in the city of Washington, in whosoever custody they may be, shall be delivered to such persons as may be authorized by the Board of Regents to receive them, and shall be so arranged and classified in the building erected for the Institution as best to facilitate the examination and study of them; and whenever new specimens in natural history, geology, or mineralogy are obtained for the Museum of the Institution, by exchanges of duplicate specimens, which the Regents may in their discretion make, or by donation, which they may receive, or otherwise, the Regents shall cause such new specimens to be appropriately classed and arranged.

From the results of this legislation sprang the Museum, yet several propositions and institutions antecedent to the establishment of the Smithsonian Institution contributed to the origin and development of the present collections.

To Doctor Goode's careful researches into the history of American scientific institutions the reader desiring to know the history of the National Museum in detail is referred.¹ As far back as 1806 Joel Barlow, the well-known author of *The Columbiad*, put forward a plan for the establishment of a national institution in which a general museum had a prominent part. The early students and public men of the United States fully recognized the importance, at least for natural history studies, of the gathering and preservation of collections, and many such turned toward Philadelphia, which, even after it ceased to be the national capital, continued for a time the scientific and literary center of the country.

The first real scientific collection, both as regards material and arrangement, which came into the possession of the United States Government was the mineralogical cabinet of James Smithson (since unfortunately destroyed by fire), and this, with the results of the policy initiated in furtherance of the act incorporating the Smithsonian Institution, formed the basis of the present national collections.

It is anticipating somewhat, however, to make this statement, since collections began to be brought together in Washington before the Smithsonian Institution was actually founded, although they were directly traceable to the Smithson bequest. Not long after its announcement there was formed in Washington, chiefly through the exertions of the Hon. Joel R. Poinsett, an organization under the title

¹ The Genesis of the National Museum. By G. Brown Goode. Report of the U. S. National Museum for 1891, pp. 273-380.

of "National Institution," later changed to "National Institute," which had for its avowed purpose the direction of the Smithsonian bequest and the pursuit of objects in consonance with the terms of that foundation. This organization, ten years before the Smithsonian Institution was prepared to receive collections, gathered together quite a quantity of historical and natural history material, which was kept in the Patent Office, and which in 1862, upon the expiration of the charter of the Institute, was delivered to the National Museum, although a portion of the historical collection was retained at the Patent Office until as late as 1883.

The first exploring expedition affording important collections was that under Lieutenant Wilkes, which started out in 1838. The material from this source was turned over to what was known as the National Cabinet of Curiosities, being a part of the National Institute and located in the Patent Office. Serious conflicts of authority arose, however, between the curator of the collection, the Commissioner of Patents, and the authorities of the National Institute, and in 1857 these collections were transferred to the Smithsonian Institution. As Doctor Goode has aptly put it: "From the marriage of the National Cabinet of Curiosities with the Smithsonian Institution the National Museum of the United States was born."

In 1850 Prof. Spencer F. Baird was appointed Assistant Secretary of the Institution, and, with the approval of Secretary Henry, he at once entered into relations with the numerous surveying parties then exploring throughout the western country to secure through them natural history and ethnological collections. Added to these were the exertions of officers of the Army engaged in similar work, some of whom were themselves experts in natural history or ethnology.

In 1871 a new important avenue for increasing the collections of the National Museum was opened by the establishment of the Fish Commission, under the direction of Professor Baird. Many explorations have been carried on by the Commission with a view to increasing scientific knowledge, in order that results useful to the people might flow therefrom. One of the chief factors in this work has been the steamer *Albatross*, especially built for dredging and for making collections of the fauna of the deep sea.

These and numerous other agencies, whether through surveys or departments of the Government, through industrial and commercial enterprises pushing their way into the little-known regions of the west and north or through the zeal of private individuals, brought together a great mass of valuable, if heterogeneous, material, to which was added at the close of the exposition in 1876, partly by gift of foreign countries and partly from private exhibitors, so great a quantity of specimens as to render imperative the erection of a separate building for the national collections.

This structure, though built at a time when the conditions required for the proper care and display of large collections of natural history were by no means well understood, is yet admirably adapted to museum exhibition purposes, lending itself readily both to arrangement and adjustment, and giving ample light. But though the plan was good, the realization was unworthy. The building is cheap and unenduring, and is, besides, without storage or laboratory facilities. For the area covered, its cost was less than that of any other building ever erected by the Government, and the result is commensurate with that fact. Of its general plan many museum experts have only words of praise; of its unworthiness as the home of the national collections of this great nation there can be no question.

The Museum building was ready for occupancy in 1881, and it was then deemed adequate for years to come. Yet such has not been the case. The additions to the collections have so far exceeded expectations that more than ten years ago it was already overcrowded, although more than three-fourths of the Smithsonian building is still devoted to the same purposes, and houses some of the most important collections.

The number of specimens in the Museum is now nearly four and one-half millions, covering every department of knowledge, although strongest in the fields of natural science and ethnology. It is not possible here to name even the most important collections nor the sources from which they have been derived; nor would such a statement in any way give an adequate picture of the Museum. It is not the possession of collections, but their availability to the public at large and to students which really does credit to an establishment of this kind. Of this fact no one had a keener perception than Doctor Goode, who was associated with Professor Baird directly in the management of the Museum from 1878 to 1887, and from that year, upon his appointment as Assistant Secretary, had complete oversight of all the details of its management. He had the most profound desire to make the collections available to the people, to have them arranged so that they might be seen, and to have them labeled so that they might be instructive. Himself a scientific man and in sympathy with scientific work, he yet regarded the public use of the Museum as its primary object, and well was this policy rewarded by accessions and gifts from this very public, which have gone to enrich not only the exhibition, but the duplicate collections, thus benefiting both classes for which the Museum was intended. So skillful was his handling of this delicate problem that neither interest ever clashed, and the one but served the other.

The writer has presented these few brief statements, not with the idea of giving a history of the Museum, nor any sort of adequate recognition to the men who have had it in charge, but simply to show in outline what the purposes of the Museum have been; how the devo-

tion of its officers has made it grow; how the other Departments of the Government have strengthened it; how private persons all over the country have aided in building up and increasing the importance of the national collections commensurate with the growth of intelligence and the development of research in a country so preëminently devoted to the arts of peace as the United States.

BUILDINGS.

Through the construction of four new galleries and the leasing of three small buildings south of B street, some additional space has been gained during the year, but not more than was required to meet the urgent current demands caused by recent increases in the collections and the needs of the mechanical work. All of the galleries in question were designed for storage purposes, two to receive mainly the Geological Survey collections elsewhere referred to, one in part for the Division of Plants, and one for the overflow from the Library. In this connection it is interesting to note that the ten galleries erected during the past three years have added to the Museum building, which contained originally 140,625 square feet on the ground floor, an area of only about 22,600 feet, equivalent to about 16 per cent, while the collections have increased over twenty-fold since the first occupancy of the building in 1881.

The renting of additional outside quarters has made it possible to remove from the Museum building or from its immediate vicinity all of the shops in which the heavier or more noisy kinds of work are carried on or whose contents constitute an element of danger from fire, such as the carpenter and paint shops, as well as the laboratories for several branches of specimen preparation.

It becomes necessary, unfortunately, to call attention to certain structural weaknesses in the roof of the Museum building, disclosed by the great storm of February, 1899, which caused a number of the main iron girders to buckle badly and gave warning of more serious trouble in the near future unless ample precautions be promptly taken. The small size of the appropriation available for the purpose rendered it impossible to do more at the time than repair the immediate damage, but a thorough inspection will be made to determine what further action may be required. This roof was built some twenty years ago, before the extensive use of iron or steel in such constructions and when the conditions of their use in buildings of so great a width were but imperfectly understood.

THE COLLECTIONS.

Additions.—The scientific collections have been increased during the year to the extent of over 210,000 specimens, comprised in 1,497 accessions. The total number of specimens now in the Museum is

recorded at above 4,355,000, without fully taking into account many hundreds of bottles of small organisms, which, were it possible to enumerate their contents, would swell the total almost incredibly.

As the custodian of all specimens obtained by Government scientific expeditions, both at home and abroad, as the recipient of innumerable gifts and exchanges from private sources, many of which have been of very large size, and by purchase, the National Museum has acquired a greater fund of material than any other similar establishment in this country, while but few in Europe can equal or surpass it in this regard. With adequate and appropriate quarters it would soon take rank with the oldest and best museums of the world.

Among the more important accessions of the year in anthropology have been a collection of about 1,000 pieces representing the costumes, implements, and ceremonial objects of the Plains and Rocky Mountain Indians, brought together a number of years ago by M. E. Granier, now of Paris, France; a second installment of the Steiner collection of prehistoric stone implements and other objects from the Indian mounds near Grovetown, Georgia; and a part of the celebrated basketry collection of Dr. W. J. Hudson, illustrating in much detail the exquisite workmanship of the Pomo Indians of California. The above were acquired by purchase.

In biology the Museum is deeply indebted to Mr. W. H. Ashmead, one of its assistant curators, for the generous gift of his valuable private collection of insects, consisting of over 60,000 specimens and containing a very large number of types. The Division of Insects has now nearly 1,000,000 specimens, of which 125,000 were received the past year. This is the largest numerical showing made by any branch of the Museum, the Division of Mollusks coming next, followed by the Division of Marine Invertebrates.

In geology mention may be made of the large collection of vertebrate fossils acquired by the U. S. Geological Survey, which had been in the custody of Prof. O. C. Marsh, at Yale College. Since the death of this distinguished paleontologist the transfer of this collection to the National Museum has been arranged for by the Director of the Survey, and the work of bringing it to Washington was in progress at the close of the fiscal year. A very large amount of space will be required for its installation.

The Government bureaus to which the Museum has been chiefly indebted for material are the Geological Survey, the Fish Commission, and several divisions of the Department of Agriculture. In addition to the Marsh collection, already referred to, the Geological Survey has turned over during the year several important series of invertebrate and plant fossils described in its recent reports, besides a number of rock specimens and rare minerals. The Fish Commission has contributed a very extensive and valuable collection from the island of

Porto Rico and its vicinity, comprising fishes, marine invertebrates, and land animals, and also much material from other regions. From the Department of Agriculture mammals, insects, and plants have been received.

Exchanges have been extensively carried on with scientific institutions in all parts of the world, and, as the returns have consisted mainly of specimens identified by competent authorities, making them immediately useful for comparison in the study of new material, the Museum has been greatly benefited by these transactions.

Installation.—The display collections in anthropology now occupy 9 halls and 4 galleries, though all of these have not yet been made ready for the public. Much has been accomplished during the year in the way of adding to these exhibits and improving them in every branch of the department and with most effective results. The changes are most conspicuous in the North Hall, or Hall of American History, from which all the cases of small size and odd pattern have been removed, to give place to 30 large cases of uniform and pleasing design, arranged in 4 rows, with roomy aisles between. The most important additions to the historical collections have related to the war with Spain, and these, owing to their number and the large size of some objects, have made it necessary to extend this exhibit into the central rotunda. The Boat Hall, occupying the North East Range, has also been entirely rehabilitated, a terrazzo pavement replacing the old wooden floor, and a very capacious case having been built around the four sides of the room. The boat collection, which has been assembled at the cost of much time and effort, is a very large and comprehensive one, representing by models and actual examples the primitive and modern crafts of all parts of the world, and its rearrangement has been carried out in a systematic and instructive manner.

Although chiefly occupied with the duties of Executive Curator, Doctor True has still been able to make some progress in the reinstallation of the exhibition collections which come under his immediate charge as Head Curator of Biology. The plans for this work, as described in the report for 1898, contemplate a faunal basis for the new arrangement, in which the fauna of North America shall have special prominence. The mounted specimens of mammals have been replaced in the South Hall, though only temporarily, pending the construction of new cases. The American species remain on the ground floor, while those of the Old World have been transferred to the recently constructed gallery above.

The number of birds on display has been greatly reduced, though the space occupied remains the same, thus remedying the overcrowded condition of the cases, improving their appearance, and bringing the exhibit more within the comprehension of the public. Experiments

are also being made to secure an effective lighting of the large central part of the Bird Hall, which the absence of windows has rendered practically valueless for exhibition purposes. A series of the game birds and game fishes of North America has been placed in the entrance hall of the Smithsonian Building, and the exhibition collection of marine invertebrates has been rearranged and relabeled.

In the Department of Geology the reinstallation in new quarters of the systematic series of nonmetallic products, the geographic series, and the building and ornamental stones has been nearly completed. The collection of meteorites has now become very extensive, and that of gems is not surpassed either in numbers or varieties by any public collection in this country.

EXPLORATIONS AND RESEARCHES.

Though having insufficient funds for making field explorations on an extensive scale, some work of this character, to fill in gaps in the collections, has been carried on nearly every year, the direction given it being along lines or into regions not covered by other Government bureaus. Realizing the practical utility of early researches into the natural history of the recently acquired possessions, an appropriation for that purpose was asked of Congress, and its failure of passage at the last session will, it is hoped, only defer the project for a short time. Soon after the close of hostilities an agent was dispatched to Cuba and Porto Rico to obtain material illustrative of the historical phases of the war with Spain. Much success was met both in securing collections and in interesting persons on the ground to add to them.

Important researches in California and Mexico, with reference to prehistoric man as well as the modern Indians, were conducted by Dr. W. H. Holmes, who brought back a large and interesting collection. Mr. J. B. Hatcher is carrying on extensive inquiries in Patagonia for both Princeton University and the National Museum, and one important lot of specimens has already been received from him. Dr. J. N. Rose and Dr. Walter Hough spent some time in Mexico in botanical and ethnological investigations, and a number of other small expeditions were in the field at one time or another during the year, their activities relating to several different subjects.

As before explained, the explorations by which the Museum is mainly benefited are those conducted by the Geological Survey, the Fish Commission, and certain scientific divisions of the Department of Agriculture. Mention should also be made of the numerous contributions received from officers of the Army and Navy, whose opportunities for collecting have been greatly increased by the present activities in the military service. There have been many accessions from these various sources during the year, and references to the field work in connection

with which the specimens were obtained will be found elsewhere in this report.

While the scientific staff is constantly occupied with the routine duties involved in the care and installation of the collections, a number of its members have found time for research work and the preparation of important scientific papers. Persons not belonging to the staff and in part attached to other bureaus of the Government have been given facilities for study, and specimens in many groups have been sent away to specialists, both in this country and abroad, for examination and report. In this way the collections are being worked up and made known through the medium of the Museum publications, though not nearly so fast as they are added to.

PUBLIC BENEFITS OF THE MUSEUM.

The primary object of the Museum is to store and safeguard the Government and other collections confided to its care and to arrange and classify these collections so as to facilitate their study. This has been interpreted to include the display of such parts of the collections as may instruct the general public, the granting to properly qualified students of facilities for working up materials, and the preparation of sets of duplicate specimens for distribution to the educational institutions of higher grade throughout the country.

A public museum is, of course, chiefly known through its accessibility to the visiting public, and a very large part of the work of the National Museum consists in the proper arrangement of carefully selected specimens in attractive cases with suitable labels attached. The force necessary to guard the collections and to keep the building open and in presentable condition uses up a large share of its energy and funds, and the American public is not slow to take advantage of the opportunity offered. During the past year 192,471 persons visited the Museum building and 116,912 the Smithsonian building. It is not possible to fairly institute a comparison between the number of visitors to the National Museum at Washington and to great public museums elsewhere, whether national or municipal, since the latter are usually situated in the very largest cities in each State or country, with vast populations whence visitors may be drawn, while in Washington there is a comparatively small population, and it can be safely estimated that a very large percentage of the visitors to the Museum are from places other than the Capital, so that the influence of the Museum extends to every part of the country.

Of almost equal importance as to results, though restricted to a small number, is the policy of rendering the collections accessible to properly accredited investigators and students. The Smithsonian Institution from the outset never engaged directly in teaching in any form, assuming that the many educational institutions throughout the

country afforded ample facilities for this purpose, but its collections and to a certain extent even the time of the members of its scientific staff have been at the service of students and scholars whose training warranted the expectation that their researches here would be fruitful in the advancement of knowledge. An ever-increasing number of such persons have resorted to the Museum from time to time or have been sent material for examination, no less than 110 having been engaged in studies upon the collections during the past year. Their names and the special studies in which they were engaged will be found recorded elsewhere in this report.

Yet another class of persons have made demands upon the Museum—those who, being unable to come to Washington, ask for information by letter. These are sometimes scientific men engaged in special work; more often the general public desiring answers to some question, wishing to have some specimen which they have picked up identified, or other matters of this sort. All subjects with which the Museum has to deal and, indeed, many which in no way come within its scope have been included in this correspondence. Whenever the requests for information have been at all reasonable or have come within the province of the Museum or the knowledge of any member of its staff, such letters have been answered, although they entail an ever-increasing amount of research and time.

In the collections which reach the Museum there are naturally many duplicates, and these are used for two purposes—first, for exchanges with other museums, thereby furnishing a means for filling gaps in the collections, and secondly, in furtherance of the general plan for the diffusion of knowledge, being prepared in small sets, labeled, and sent to educational institutions of the higher grades throughout the United States.

Since the first international exposition in the United States, held at Philadelphia in 1876, there have been many such, either international in scope or of sufficient importance to receive recognition from Congress. All Congressional acts authorizing and aiding expositions in this country have directed participation by the Smithsonian Institution and its bureaus, and the collections which have been sent to them have invariably been drawn, in the main, from the National Museum. This participation of the Museum has recognized advantages to the country, in rendering public-spirited persons in different localities familiar with museum benefits and methods, and to it are directly traceable the founding of several museums. It has also at times resulted in considerable accessions to the National Museum, although of later years these have been less valuable than formerly.

There are, however, on the other hand, certain disadvantages of which mention should be made. Expositions have followed each other so closely that there is hardly a time when a portion of the Museum staff

is not engaged in planning for or taking part in one or unpacking and replacing the specimens which have been returned. The collections which are sent out necessarily suffer to some extent, and while it has been the policy of the Museum not to exhibit in the perishable structures usually built for such purposes any unique object or one which could not be replaced, many excellent specimens have been displayed at every exposition in which the Museum has been represented, and these have unquestionably deteriorated. Should the holding of expositions in the country continue at such brief intervals as during the past ten years, and the Museum be expected to participate in all of them, it would seem almost necessary that a special duplicate collection for these purposes be kept on hand, since it is not only the injury to the specimens which is to be deplored, but the constant interference with the arrangement of the collections and the great amount of labor expended in removing specimens from their cases and in properly replacing them.

At the Trans-Mississippi and International Exposition held at Omaha during the summer and early autumn of 1898 the several scientific departments of the Museum were extensively represented in connection with the Government display.

The participation of the Government Departments and bureaus in two other expositions has been authorized by Congress during the past year. The first of these, the Pan-American, will be held at Buffalo in 1901, and the second, the Ohio Centennial, at Toledo in 1902 or 1903. In each case \$500,000 has been appropriated, \$200,000 being for the buildings and \$300,000 for the exhibits. The preliminary arrangements for the Pan-American Exposition had so far progressed before the close of the year as to call for the appointment of representatives composing the Government board of management. Dr. Frederick W. True has been designated to act for the Museum in this capacity.

LIBRARY.

Through the purchase, by special act of Congress, of the scientific library of the late Doctor Goode, the Museum has secured a very noteworthy addition. This collection comprises 2,900 bound volumes, 18,000 pamphlets, and 1,800 portraits, autographs, etc., and contains many rare and valuable publications, being especially rich in the literature of museums and of fishes. Its acquisition increases the size of the working library belonging to the Museum to some 15,000 books and 26,500 pamphlets, but besides this, in order to meet the requirements of the scientific work, the Smithsonian collection has at all times to be largely drawn upon, and the accommodations assigned the library have long since been outgrown. A gallery has recently been built across one end of the West North Range to afford relief, but it can only be regarded as a temporary expedient.

PUBLICATIONS.

The publications issued during the year comprise five volumes, namely: The Annual Report for 1896; volume 20 of the Proceedings in bound form, and the separate papers of volume 21; and parts 2 and 3 of the important bulletin entitled "The Fishes of North and Middle America," by Doctors David S. Jordan and Barton W. Evermann. The number of scientific papers based upon Museum collections which have been printed, chiefly in the above volumes though to some extent in outside journals, is 318, representing 75 authors.

REPORTS OF HEAD CURATORS.

REPORT ON THE DEPARTMENT OF ANTHROPOLOGY..... By WILLIAM H. HOLMES.
REPORT ON THE DEPARTMENT OF BIOLOGY..... By FREDERICK W. TRUE.
REPORT ON THE DEPARTMENT OF GEOLOGY..... By GEORGE P. MERRILL.

REPORT ON THE DEPARTMENT OF ANTHROPOLOGY FOR THE YEAR 1898-99.

By WILLIAM H. HOLMES,
Head Curator.

During the year a number of important changes have been made in the manner of transacting the business of the Department of Anthropology. Some of the changes relate to the abbreviation of the routine, but the most important ones result from the introduction of the card-catalogue system into the work of the Department staff, and the keeping of all the catalogue books by a recording clerk in the office of the head curator. Formerly, separate books were assigned to the several divisions and independent sections. This work is now conducted by a single expert assistant, and the curators and other keepers of the collections make card catalogues for their own use.

FIELD WORK.

No systematic field work is provided for by the Museum, but limited funds are available for use when especially important results are promised. The work for the year has been as follows:

The head curator spent September and part of October in California visiting various Indian tribes and giving particular attention to the question of man's antiquity in the Sierra region. Interesting ethnological collections were made representing the Digger, the Pomo, and the Tulare tribes, and much archæological material was secured in the auriferous-gravel region, in the San Joaquin Valley, in the vicinity of Los Angeles, and on the island of Santa Catalina. A visit to the Indian tribes of New Mexico and Arizona was planned, but was abandoned because of the epidemic of smallpox which was discovered to be raging among many of the pueblos.

On the breaking out of the war with Spain it was recognized that an important epoch in our national history had been initiated, and measures were taken to secure for the Museum such relics and mementos of the campaign as would be of interest to the people. The War Department and the Navy Department were appealed to, and Mr. Paul Beckwith, assistant in the Section of American History, was sent to Cuba and Porto Rico to act as agent for the Institution. Mr. Beckwith's visit to Cuba was cut short by the breaking out of yellow fever, but in Porto Rico between four and five months were spent, chiefly at Ponce, and many valuable additions were made to the historical series, and, besides, a number of archæological objects were secured. Unfortunately, a considerable portion of the collections, delivered to transportation agents at San Juan, never reached the Museum.

After returning from Porto Rico, Mr. Beckwith paid visits to Norfolk, Brooklyn, Philadelphia, and other points, for the purpose of examining and securing such objects of interest as had reached the navy-yards from various points, and more especially from the war vessels destroyed by our fleet at Santiago de Cuba.

In April the head curator was invited to be the guest of Mr. George Brackenridge, of San Antonio, Texas, on a trip to various points in Mexico. The journey afforded him an opportunity of revisiting several points of interest, including the valley of Mexico, San Juan Teotihuacan, and Orizaba, and of examining for the first time two of the most interesting archaeological sites in Mexico, namely, the ruins of Xochicalco, near Cuernavaca, state of Morelos, and the obsidian mines of Hidalgo. At the latter place valuable observations were made and many minor relics illustrative of the quarrying and shaping of the obsidian by the ancient Nahuatl tribes were obtained.

Toward the latter part of May, Dr. Walter Hough, assistant curator of the Division of Ethnology, joined Dr. J. N. Rose, of the Division of Botany, in an extended excursion into Mexico. Three months were spent in the field and Doctor Hough was enabled to make the acquaintance of the native peoples at many points and to secure collections of interest in ethnology, ethnobotany, and archæology.

COLLECTIONS RECEIVED.

The more important collections received through gift, purchase, and exchange during the year may be briefly mentioned:

1. A collection of 121 specimens of Polynesian ethnological objects, brought together mainly by Mr. Henry Adams and acquired through the bequest of Mr. W. H. Phillips, of which the archæological portions were recorded during the preceding year.

2. Two hundred and thirty-four objects illustrating the potter's art as practiced in early days in Morgantown, West Virginia, presented by Miss Jennie Thompson through Dr. Walter Hough. The period covered extends from 1790-1888.

3. A collection of considerable importance embodying archæological and ethnological materials from Mexico and Central America, purchased from Mr. E. W. Nelson, who spent a number of years traveling and collecting in these countries.

4. A large number of well-preserved specimens of ancient mound pottery, acquired by purchase from Mr. G. F. Morris, of Memphis, Tennessee.

5. A collection of 18 ancient Peruvian trephined skulls, brought together by Dr. M. A. Munñiz and acquired through the Bureau of American Ethnology.

6. The most important collection received by the Division of Ethnology during the year was purchased from M. Emil Granier, of

Paris. It consists mainly of ethnological materials collected from the Indian tribes of the middle-western section of the United States.

INSTALLATION WORK.

Division of Ethnology.—The installation work of the Division of Ethnology is under the direct supervision of Prof. O. T. Mason, curator, who has been ably supported by Dr. Walter Hough, assistant curator, and T. W. Sweeny, preparator. Dr. J. Walter Fewkes and Mrs. M. C. Stevenson have most generously lent their aid in the Pueblo section, and the head curator has taken an active part in planning and promoting the work. The following halls and galleries are occupied by the division: West North Range, North West Range, North West Court Gallery, West Hall, and West Hall Gallery, north side.

Collections illustrating many of the Indian tribes of the United States and Canada have been assembled in the West North Range whose walls are occupied by the great series of Catlin paintings, an appropriate association, considering that the peoples represented in the collections are in large part those among whom Catlin worked. The principal series of cases have been arranged to form two sets of alcoves, eight on the south side and eight on the north, each alcove devoted to a single ethnographic province.

Although the exhibits are not yet as complete as could be desired, they form undoubtedly the most complete exposition of the great group of tribes represented ever brought together.

Within the alcoves the collections are grouped as to subject-matter, first by tribes and second by industrial or other cultural concepts, such as costume, weapons, and basketry. The installation unit is the case, the half case, and the unit box. The labels are carefully drawn up to serve as a key to the classification and grouping. The alcove labels, standing for ethnic provinces are of generous dimensions and are placed at the back of the alcoves, above the wall cases. The case or section labels, standing for ethnic and industrial subdivisions, are smaller and are placed against the upper edge of the cases or at other points in close connection with the exhibits to which they pertain.

Brief individual labels are employed in connection with the specimens. The system of labeling is carried out, so far as it happens to be applicable, in the other halls of the Department.

The wide aisle extending lengthwise of the hall accommodates a series of large cases occupied mainly by lay-figure groups. It is intended that the floor space in each alcove shall, in time, contain a family group illustrating some typical tribe of the province represented by the alcove; but as this is not practicable at present, house groups on a small scale, showing how the people of the province live, are used, or otherwise miscellaneous exhibits are introduced to fill the spaces.

This hall was until recently occupied for lecture purposes. Its permanent assignment to the Division of Ethnology has enabled the curators to place on exhibition a large body of material not heretofore shown.

The North West Range contains exhibits from the northwest coast Indian tribes and the Eskimo. The only change made during the year had to do with the reinstallation of collections, especially the larger objects, the aim being to enhance the general effect of the hall. The removal of the long-coiled radiators which formerly occupied the floor along the entire west side, and the substitution of a continuous line of cases, was accomplished during the previous year and added greatly to the capacity and effect of the hall.

The geographical order of the exhibits and the peoples represented are kept in mind. In passing from Alcove VIII of the West North Range, where the Yukon-Mackenzie province is shown, are encountered at the north end of the hall a large group of exhibits illustrating the Northwest Coast peoples. These occupy the north and west walls, parts of the east and south walls, and a number of floor cases. Eskimo collections fill most of the floor cases toward the south, and the wall cases and wall spaces in the east and south. In the window spaces are a line of transparencies, the views relating mainly to the peoples represented in the collections of the hall.

The North West Court, which contains the series of exhibits from the Pueblo tribes of the arid region of the Southwest, has received much attention during the year. Doctor Fewkes has arranged an extensive series of Tusayan vases on the west side and Mrs. Stevenson has installed a case illustrating the use of prayer sticks by the Pueblo tribes. The collection of modern pottery has been overhauled and a series of unit boxes containing baskets, textile products, ceremonial objects, etc., has been placed on top of the wall case surrounding the hall.

The Gallery of the North West Court has not yet been opened to the public. The new wall case was finished about the close of the year and the installation of collections from Mexico and Central and South America has been commenced. The case on the west and north sides of the gallery is temporarily occupied by the very extensive collection of basketry which Professor Mason is engaged in studying.

West Hall is occupied mainly by collections illustrating the various peoples of Europe, Asia, and Africa. These have been partially reinstalled during the year. The gallery on the north side has been furnished with alcoved wall cases, and collections from the Indo-Pacific have been placed in them. The work of installation is not yet complete. Professor Mason has prepared a great number of labels during the year and many of these have been typewritten and placed with the

exhibits. Many labels for alcoves, cases, and groups prepared during the year have been submitted to the printer.

Division of History.—In no other section of the Department has such decided advance been made as in that of American history. This branch is under the custodianship of Mr. A. Howard Clark, but as he is necessarily much preoccupied with editorial duties, a great deal of the work has fallen to the share of his assistant, Mr. Paul Beckwith; and the head curator has from the start given all possible aid and encouragement to the work, which he regards as of first importance in the national collection.

At the beginning of the preceding fiscal year the exhibits of the section were confined to a few cases in the North Hall. The floor space then accommodated the collections of ceramics, lacquers, coins, and metal work, besides many things of minor importance. Now, the historic collections occupy the floor space almost exclusively and the Rotunda also is utilized by this section. Mr. Clark's report for the year contains the following paragraphs:

During the last decade general interest in American history has rapidly increased, and to keep pace with this popular demand the Section of American History in the National Museum has been gradually developed until it has become one of the most instructive branches of the Museum.

The year ending June 30, 1899, was an eventful one in American history, and the war with Spain caused public attention to be centered on the military as well as the political history of the country. To illustrate and perpetuate the history of events of the year, the head curator of the Department of Anthropology permitted an extension of the space heretofore allotted to historical relics and encouraged the collection of as many objects as possible that pertained to the war, and in making this special increase in the collection it was found possible to add considerably to the series of objects illustrating earlier events in the nation's history.

The actual number of accessions during the year was 165, which included about 1,027 individual specimens. Among the most important may be mentioned a large number of objects gathered by Mr. Beckwith during a trip to Porto Rico and Cuba, including a very exhaustive series of swords of Toledo steel, representing the various arms of the service, flags, uniforms, and the paraphernalia of military life.

Other very interesting accessions were received from the Navy Department, including numerous relics recovered from the battle ship *Maine*, destroyed in Havana Harbor, bronze cannon captured from the Spanish in Manila by Admiral Dewey, relics from Cervera's fleet destroyed off Santiago, and numerous relics of various battles and events of the war with Spain. The War Department also contributed some Spanish rifles and other objects. Many individuals, particularly Gen. G. H. Harries, Capt. H. C. Wilson, Lieut. J. C. Ord, Capt. Richard P. Leary, Admiral Charles O'Neil, Capt. Robley D. Evans, contributed objects of special interest.

There has been installed in the section a special case devoted to historical objects, loaned by the National Society of the Colonial Dames of America, including personal relics of George Washington, Thomas Jefferson, Patrick Henry, James Madison, Lord Fairfax, and others eminent in American history.

The collection of the Daughters of the American Revolution has been made of added interest by the exhibition of personal relics of Charles Carroll, of Carrollton, and some interesting objects pertaining to the colonial history of Maryland.

Perhaps the most interesting single objects received during the year were the John Paul Jones flag, with a musket and boarding sword, used in the battle between the *Bon Homme Richard* and the *Scrapis*, presented to the Smithsonian Institution by Mrs. Harriet Perry Stafford.

The most striking improvement in the installation of these exhibits has resulted from the removal of all cases of small size and odd patterns from the hall and the assembling of some thirty large cases of the best design. These are arranged in four rows, extending lengthwise of the hall, having roomy aisles between, the whole effect being simplified so that the groupings of furniture and objects conform properly with the architectural lines and proportions of the hall. The exhibits are arranged chronologically. Beginning at the left of the north entrance with the period of discovery the visitor passes down through illustrations of colonial and Revolutionary times to the opening of the civil war in 1861. Returning to the north end of the hall on the east side we have, first, collections relating to the civil war, including seven cases devoted to the relics of General Grant, one case to the meager series pertaining to Lincoln, and six cases to miscellaneous relics. These are followed by cases containing exhibits relating to great American inventors, and at the south end and overflowing into the Rotunda are collections illustrating the late war with Spain.

Division of Mechanical Technology.—This division is in charge of Mr. J. E. Watkins, curator, with Mr. George C. Maynard as aid. The notable feature of the year was the rehabilitation of the North East Range, called also Boat Hall. The east side is devoted to a series of models illustrating the water craft of the world, beginning at the north with the simple raft, and passing step by step through the successive grades of elaboration in hull, propelling devices, and steering apparatus to the modern steamship. This series is continued in the floor cases at the south end of the hall in a very important group of exhibits illustrating the introduction of steam power and the specialization of modern steam navigation. A number of floor cases toward the north end contain models of boats of various semicivilized countries.

The wall case of the west side displays an extensive series of models of fishing craft, mainly those in use in American waters, and the ceiling is hung with primitive boats from many parts of America.

This division occupies also the east half of East Hall, the principal exhibits relating to land transportation and electricity. Much progress has been made, but the work of installation has not yet reached such a degree of completion as to warrant the publication of details.

Section of Graphic Arts.—The Section of Graphic Arts occupies the Northeast Court, and is in charge of the head curator, with Mr. Paul Brockett as assistant. The very complete series of exhibits was brought together by Dr. S. R. Koehler, curator, who retired from active supervision of the work on account of ill health. The cases

have been rebuilt and are arranged in alcoves, six on the east and six on the west side. On the east side exhibits are presented in continuous order, illustrating the technology of the engraver's art; on the west are illustrations of the pictorial product, beginning at the south with early prints and closing at the north with the color printing of to-day. In the aisle which extends from north to south are exhibits illustrating the history of painting.

Division of Religions.—The Division of Religions, Dr. Cyrus Adler, custodian, and I. M. Casanowicz, aid, has been assigned to the South Gallery of the West Hall, where a handsome alcoved wall case has been built. The series of exhibits begin at the east with illustrations of the Jewish religion, and these are followed by Greek, Roman, Mohammedan, and Buddhistic groups. Collections of the Division of Historic Archæology, also in charge of Doctor Adler, are placed in the east end of West Hall and remain about as installed the previous year.

Division of Prehistoric Archæology.—The exhibits of this division, which are in charge of Dr. Thomas Wilson, assisted by Mr. E. P. Upham, have not undergone any radical change during the year, although the work of installing new material and perfecting the arrangement of the old has gone steadily forward.

RESEARCH AND PUBLICATIONS.

The usual activity has been shown by the anthropological staff in conducting researches germane to the work of the department. Professor Mason, curator of the Division of Ethnology, has prepared and completed a paper on the curved steel knife among the Eskimo and Canadian tribes, in which an attempt is made to show that carving and etching and fine netting for snowshoes are contemporaneous with this knife. Before the steel knife the Eskimo did little creditable carving. Also a paper on a peculiar heddle frame for belt weaving was traced from the Pueblo country to its source in Europe.

The Indians of the Kootenai use a bark canoe, pointed at the water line like a modern ram. It is unique in the Western Hemisphere, but photographs and descriptions have been gathered by Professor Mason to show its nearest congeners on the Amur.

For some time Professor Mason has been gathering material for the study of zootechny among the American aborigines. This has enabled him to divide the continent into certain marked zootechnic areas, in which even the language, social institutions, and beliefs of the peoples are modified. Following up this idea of areas of characterization, he has pursued the subject of geographic distribution of hunting devices associated with the capture of certain species.

It happened during the year that the Spanish-American war suddenly brought into conspicuous attention the ancient history of Porto

Rico, and the Smithsonian Institution has found it advisable to republish Professor Mason's papers on the Latimer and Guesde collections of West Indian antiquities.

Dr. Walter Hough, assistant curator, completed his monograph on Eskimo lamps, and continued his investigation of the utilization of fire and the manufacture of bark textiles.

Mr. J. D. McGuire has been engaged in making an exhaustive study of primitive technology.

Dr. Thomas Wilson has carried on various researches relating in the main to prehistoric archæology.

In connection with a paper treating of Museum buildings he has conducted studies regarding the amount of light admitted through glass of various kinds, and an extended article on the use of poisoned arrows by primitive peoples has been prepared. Doctor Wilson has also elaborated a paper on the subject of prehistoric trephining, and has continued his investigation relating to arrow points, spear heads, and knives of prehistoric times.

The head curator has been so fully occupied with administrative duties in the Museum that little time has been at his disposal for research work. The trip to California in the interest of the Museum collections gave him the opportunity of visiting the auriferous gravel region, from which a considerable body of testimony has been obtained relating to the antiquity of man. This evidence he has carefully examined, and a paper reviewing the general subject will appear in the *American Anthropologist* for the year 1899.

REPORT ON THE DEPARTMENT OF BIOLOGY FOR THE YEAR 1898-99.

By FREDERICK W. TRUE,
Head Curator.

The year covered by the last report was one of great changes, due to reorganization of the scientific staff of the Museum and the erection of galleries in the Museum building. A new plan for the exhibition series in biology was decided upon and a beginning made in carrying it into effect. This plan contemplates the arrangement of the exhibition series on a faunal basis, the fauna of North America being given special prominence. Good progress in this line was made in several divisions during the year covered by the present report.

IMPROVEMENTS IN THE EXHIBITION HALLS.

In the Division of Mammals the old wall cases, which were no longer suitable on the floor, were transferred to the gallery and added to, so as to occupy the whole length of the hall on both sides. In these were installed the series representing the mammal faunas of the Old World, Africa being on the east side, and Eurasia and Australia on the west side. The cases were refitted throughout, the backs being covered with plain burlap and the floor with linoleum. Such shelves as were needed were made of pine and covered with burlap to correspond with the back. This style of fitting is comparatively inexpensive, is pleasing in effect, and has the excellent quality of extreme durability. All the Old World mammals were placed in these cases, but for the small forms—squirrels, mice, bats, etc.—temporary floor cases were brought into use, pending the construction of cases especially adapted for this purpose. The whole series received temporary labels. On the screen at the south end of the gallery, which separates the exhibition space from the paleontological laboratories, the beautiful illustrations of the cat family from Elliot's *Monograph* were displayed. There is not sufficient space at this end of the gallery for mounted specimens.

The floor of the South Hall, as stated in last year's report, is given up exclusively to American mammals. The cases on hand were arranged to give as good an effect as possible, but on account of the galleries some new cases will doubtless have to be erected for the large forms. The seals, sea lions, and walruses, especially, are not satisfactorily installed.

The great progress made in the study of North American mammals during the last decade has rendered it necessary to thoroughly revise the exhibition series representing this fauna, and the taxidermic work was almost entirely restricted to North American species during the past year. The object aimed at is to have on exhibition a perfect specimen of every known species and subspecies inhabiting North America.

The exhibition series of North American fishes, reptiles, and batrachians was considerably improved and completely labeled. It can not, however, be extended, nor can the faunas of other parts of the world be represented without additional space. The present quarters are far from ideal, either as regards lighting or arrangement of space.

The most radical change of the year was in the Division of Birds. On account of the large number of specimens mounted for various expositions, and for other reasons, the exhibition series had become entirely overcrowded, so that nothing could be seen satisfactorily. After long consideration of the matter it seemed impossible to apply any other remedy than to withdraw a large proportion of the birds. This was done under the supervision of the curator and assistant curator, and the result has proved most satisfactory. Although the lighting of the hall is not of the best, the whole exhibition series of single-mounted specimens can now be seen to good advantage, except in the quadrangular space in the center of the hall. No improvement of the lighting is possible at that point without artificial means. Experiments were made in that direction at the close of the year which promise to solve the difficulty.

The groups of birds, which are among the most attractive features of the series, are still poorly provided for. They are chiefly installed in cases made for use in temporary expositions, and are neither dust-tight nor sufficiently uniform in pattern.

The exhibition series of invertebrates (other than mollusks and insects) was very thoroughly revised. The main series, as in other branches, is now North American. A new system of installation was devised for the dry specimens, which are exhibited in flat table cases. The specimens representing each species are placed in a separate shallow tray. All the trays are of equal depth and uniform in size (or a multiple of the unit). When a case has its full complement of trays it has the appearance of being divided into compartments, with a single species in each compartment. The effect is very satisfactory. Temporary typewritten labels were made for the larger part of the series during the year. Certain parts of the series, such as worms, entomostraca, etc., are still incomplete, as the Museum collections do not at present contain specimens in these classes suitable for exhibition purposes.

The synoptic series of invertebrates, formerly in the Division of

Comparative Anatomy, has been placed in the same hall with the other invertebrates, at the west end of the Smithsonian building, in cases specially constructed to receive it. It needs revision and the addition of numerous types.

Nothing of special moment was accomplished toward improving the exhibition series of insects and of mollusks.

Owing to the erection of a gallery in the East-South Range, the whale skeletons suspended from the ceiling near the side walls had to be removed to a position nearer the center of the hall. To protect the roof from collapse and to sustain the skeletons, specially constructed wrought-iron slings were devised by the Chief of Buildings. The hall was necessarily in confusion while these large specimens were being readjusted, but at the close of the year it had been brought again to an orderly condition. The exhibition series of osteological specimens is very full and can not be much expanded in the present quarters.

A special series, comprising the principal North American game birds and game fishes, was placed on exhibition in the hallway of the Smithsonian building, together with a number of mounted heads of large game—the moose, caribou, antelope, etc.

ACCESSIONS.

The accessions of the year, though not equaling those of 1898 in number of specimens, were of at least equal scientific interest and importance.

The U. S. Fish Commission transmitted an extensive zoological collection made during its recent exploration of the island of Porto Rico. It comprised not less than 5,000 mollusks, representing some 400 species (including a number of new forms and other rare and interesting material) and a large series of invertebrates of other classes.

While associated with the representatives of the U. S. Fish Commission in the zoological exploration of Porto Rico, Mr. A. B. Baker collected an extensive series of bats, about 200 reptiles and batrachians (including several undescribed species), and over 100 bird skins.

In the Division of Mammals, on account of the fact that the material was largely collected to supply deficiencies, the additions were of much interest. Some 900 small mammals were collected for the Museum by Mr. Loring in Norway, Germany, and Italy. These were chiefly from localities from which the types of the earlier European mammalogists were derived, and hence of importance in determining the identity of described species. A collection of European bats and an additional lot of small mammals from Norway were also purchased. These are the first collections of European mammals of any moment which have found their way into the Museum. Baron de Selys-

Longchamps, well known as an authority upon the rodentia, presented 25 specimens of small mammals, identified by himself.

A collection of 13 Alaska moose and wild sheep was obtained for the Museum by Mr. Dall DeWeese. One of these specimens has been made the type of a new species of moose—*Alces gigas* Miller.

Among the mammals received from the National Zoological Park were an elephant and a lion.

The additions to the collections of birds, though less in extent than in some previous years, included much important material, among which should be mentioned a collection of 58 specimens of Colombian birds, presented by Mr. Outram Bangs, of Boston, Massachusetts, and 5 skins of the Californian Condor, purchased from Mr. F. H. Holmes, of Berryessa, California.

Doctor Ralph, custodian of the Section of Birds' Eggs, as in past years, made a valuable contribution to the collection under his charge, consisting in this instance of some 200 eggs from various sections of North America. Mr. C. F. Baker, of Alabama, presented 127 eggs from the Western United States.

The U. S. Fish Commission transferred to the Museum a large collection of reptiles and batrachians which had been assembled from time to time by its field agents. This contained many specimens of importance, including unique specimens of a discoglossoid toad, the only representative of this suborder of batrachians which has been found in the Western Hemisphere. It has been described by Doctor Stejneger under the name of *Ascaphus truei*.

A small but interesting collection of reptiles from Java, made by Prof. D. G. Fairchild, was transmitted to the Museum by the Department of Agriculture.

A series of fishes of North and Central Asia, collected by M. Chaffanjon, was received from the Musée d'Histoire Naturelle, Paris. The U. S. Fish Commission transmitted fishes from Florida, Lake Superior, Alaska, and Kamchatka, together with the types of *Paraliparis roseus*, and *Bathylagus milleri* and *Ulocentra meadiæ*. Two rare fishes were received from the Pacific coast, a specimen of a *Rhamphocottus*, presented by Mr. O. E. Shaffer, Port Townsend, Washington, and a specimen of *Icosteus enigmaticus*, presented by Mr. John Chapman, of San Diego, California.

Mr. William B. Moss, of Ashton-under-Lyne, England, a valued correspondent and contributor to the Museum, donated two lots of small shells, comprising some 3,000 specimens, collected by Rev. and Mrs. James Hadfield at Lifou Island, Loyalty Group. They belong for the most part to species recently described and hitherto unrepresented in the Museum.

Mr. B. H. Wright, of Penn Yan, New York, continued his donations of river mussels (Unionidæ), including types of species described by

him. Rev. E. H. Ashmun, Mr. T. S. Oldroyd, and Dr. E. A. Mearns, U. S. A., should also be mentioned as contributors of valuable specimens. Miss Mary J. Rathbun collected some 800 mollusks in the waters about Grand Manan, New Brunswick.

Regarding accessions to the Division of Insects, Dr. L. O. Howard, honorary curator, reports as follows:

The last fiscal year was an extraordinary one in the history of the Division of Insects, and it was not expected that such another one would occur again for some time to come. Notwithstanding this, however, the present fiscal year surpasses it not only in the number of accessions, but, it is believed, also in scientific value.

In 1897 the accessions numbered only 139, a large increase over previous years. In 1898 they numbered 246, while this year they reached 285, an increase of 39 over last year.

On account of the vast number of duplicates in the Hubbard and Schwarz collection, it was estimated that over 226,000 specimens were received, while this year they amount to only 125,000. The number of specimens received this year is therefore less than last year, although the number of species is several thousand greater.

This is due principally to the extensive collection of Hemiptera, Hymenoptera, Siphonaptera, and Mallophaga, presented by Prof. Carl F. Baker, and to the addition of the Ashmead collection, both being exceedingly rich in species and containing types and co-types of species described by these entomologists, as well as those of many other authorities. With these two collections the Museum is now well represented in the orders mentioned above and without doubt surpasses all other collections in America.

The gift by Mr. W. H. Ashmead, assistant curator, of his private collection, is a most notable one and deserves especial mention. It was largely made by this indefatigable worker in the State of Florida, and has been greatly added to by a systematic series of exchanges carried on for many years with entomologists in different foreign countries; but perhaps its chief value lies in the large number of types which it contains. Mr. Ashmead's broad entomological knowledge and interest have led him to undertake systematic work in a number of different groups, and the great value of the gift thus becomes apparent.

Numerous invertebrates of other classes were received during the year, among which should be mentioned 40 lots, chiefly crustacea (including a number of type specimens), donated by Mr. W. P. Hay, of Washington, D. C.; a collection of amphipod crustaceans from the New England coast, donated by Dr. S. D. Judd, of Washington, D. C.; 27 species of crustaceans, corals, and echinoderms, donated by Rev. W. A. Stanton, of Balize, British Honduras, and 20 species of crabs, shrimps, and worms, donated by Mr. H. W. Henshaw, of Hilo, Hawaii.

The accessions to the herbarium during the past ten years have been as follows:

1889-90	370	1894-95	670
1890-91	621	1895-96	236
1891-92	511	1896-97	370
1892-93	567	1897-98	307
1893-94	693	1898-99	264

Among the important additions of the past year was a portion of Rugel's Florida collection, comprising 1,049 specimens, donated by the British Museum.

Mr. J. G. Baker, of London, England, presented a large part of his private herbarium. Mr. Louis A. Kengla, of San Francisco, California, presented a hundred specimens of algæ suitable for exhibition. From Maj. H. E. Hasse was received the gift of 233 specimens of California lichens.

A large number of important specimens from Samoa, Mexico, Costa Rica, and from various parts of the United States were purchased during the year.

WORK ON THE STUDY SERIES.

The principal work accomplished in the Division of Mammals, in addition to the usual routine operations and the rearrangement of the exhibition series (already referred to), was the improvement of the collection of small skins and a rearrangement of the study series. A large proportion of the skins of rodents and other small mammals which have been accumulating from year to year have long needed making over on a uniform model, in order to be thoroughly available for purposes of comparison. During the past year it was found possible to assign a taxidermist to this work for about six months, during which time some 800 skins were remodeled. A rearrangement of the whole study series of small skins, based on Troussart's recently published catalogue of mammals, was begun, and the greater part of the rodents were put in order during the year. The collection of skulls of small mammals was also rearranged.

In the Division of Birds the large amount of work done on the exhibition series left little opportunity for other than current routine work. The determination of type specimens was continued, and some 20 were located and separated out from the general collection.

The study collection of birds' eggs is in good condition, but the exhibition series is much in need of revision and renovation. The honorary curator of this section has not only been the largest contributor to the growth of the collection, but has devoted much of his time personally to the current work.

The study series of reptiles and batrachians is much in need of revision, but up to the present time it has not been found possible to supply the large amount of new shelves needed before a rearrangement can be commenced. The curator has devoted his time chiefly to the improvement of the exhibition series and to investigations.

Work was continued on the exhibition series of casts of American fishes under the supervision of the assistant curator.

Much time was occupied in the Division of Mollusks in cleaning, assorting, and naming the very extensive collection of shells presented last year by Prof. R. E. Call. The shells of the family Helicidæ and the Pyramidellidæ of the west coast of America were thoroughly studied and rearranged and many species identified. The important

collection made by the Fish Commission in Porto Rico was also assorted and identified. The whole study series is in excellent condition.

The same remark applies to the collections of insects, which are now almost entirely free from pests. More standard insect drawers are, however, needed. Many thousand insects were pinned and labeled by the preparators during the year, but much of this material is still unidentified. The collections of all orders of insects are now arranged tentatively and are available for study and comparison. Special mention should be made of the Lepidoptera, which has been brought into excellent condition through the unremunerated labor of Dr. H. G. Dyar, custodian. The division has not only had the benefit of the gratuitous services of the honorary curator, Dr. L. O. Howard, but of several other members of the entomological staff of the Department of Agriculture and also of Mr. E. A. Schwarz.

Mr. W. H. Ashmead, assistant curator, arranged and identified most of the African and Asiatic Hymenoptera during the year, together with some material from Central and South America. The dragon flies and Neuropterous insects were rearranged by Mr. Currie, aid.

In the Division of Marine Invertebrates the card catalogue of Brachyuran crustaceans, comprising about 5,000 titles, was revised and transferred to standard library-bureau cards. The collection of Hexactinellid sponges, which has been for some time in the hands of Professor Shulz for study, was catalogued. Dr. J. E. Benedict and Miss Rathbun, assistant curators, identified the crabs collected in Porto Rico by the U. S. Fish Commission.

The rearrangement of the exhibition series, necessitated by the erection of galleries, occupied a large share of the time of the staff of the Department of Comparative Anatomy. In connection with that work, the skeleton of the extinct Arctic sea cow, *Rhytina*, and of the finback whale, were cleaned and remounted. The time of the curator and assistants was divided between this division and that of Vertebrate Paleontology.

The following passage from the report of the honorary curator of the Division of Plants, Mr. F. V. Coville, gives a condensed statement of the work accomplished in that division during the year:

The collection of plants formerly stored on the south balcony of the Museum, which was referred to in the report of last year as having been transferred to the National Herbarium, has greatly taxed the present capacity of our cases, and it is doubtful whether the accumulation of mounted material, Mexican and otherwise, now on hand can be distributed until the new adjoining balcony is fitted up. This collection, when finally arranged, listed, and stamped, numbered over 30,000 specimens, being particularly rich in European material. The work of stamping the general series, with a view to ascertaining the total number of specimens in the herbarium, has been carried forward at intervals. Thus far 21,618 sheets have been stamped.

Three preparators have been engaged in mounting, labeling, and repairing specimens during the year. The total number of specimens is 22,559, of which 13,314 have been stamped and distributed. The large collection presented by Prof. W. H.

Brewer, representing the types described in the Botany of the California Survey, has been most carefully prepared with all the original data mounted with the specimens, which will be determined and distributed as rapidly as possible.

The selection, verification, and marking of type specimens has been delayed, owing to the resignation last December of the preparator employed on this work. The total number of types thus far indicated is 1,619. It is important that this work be continued, both for the advantage it affords to consulting botanists and for the desirability of ascertaining definitely the exact number of types in the collection.

In the rearrangement of and research work on the collection considerable progress has been made. We have introduced genus covers printed in colors to correspond with the larger continental areas, the North American being black, the West Indian, Mexican, and South American red, and the Old World blue. An extension of this scheme is now under consideration.

The herbarium is now in orderly arrangement as far as the Ericaceæ, and the work on it will be pushed during the coming year.

The south tower room has been fitted up for the accommodation of the cryptogamic collections by the addition of an iron balcony supporting cases on three sides, with a stairway leading to an attic room provided with cases suitable for storage purposes. For several months Mr. O. F. Cook, now honorary assistant curator in charge of Cryptogamic Botany, very kindly gave his services and those of his two assistants in caring for these collections. Mr. Cook was commissioned to prepare an exhibit of algae for the Trans-Mississippi Exposition at Omaha, and this work was brought to completion in the early part of last summer. A supplementary series has been placed on the exhibition front of the east balcony. It soon became evident that an officer would shortly be required to devote his entire attention to the valuable cryptogamic collections, many of which still remain inaccessible for study. Early in January Mr. William R. Maxon was employed on a six months' contract to put these collections in order, and he is now, after most faithful and painstaking labor, able to report the practical completion of his task. In the three main groups of the lower cryptogams, the mosses, fungi, and lichens, all undetermined material has been sorted out and will be sent to specialists in those groups for identification and return; while the large accumulations of unmounted material have been properly placed in pockets and labeled, ready for distribution on the shelves. Mr. Maxon has also distributed several thousand mounted sheets of ferns and fern allies, readjusting the covers and identifying dubious specimens. During the past few weeks he has been engaged in caring for the large collection of alcoholic material sent in by Messrs. Swingle and Fairchild.

FIELD WORK.

Several members of the scientific staff of the department engaged in field work during the year. The fishes of the State of New York were studied by Dr. T. H. Bean and Mr. B. A. Bean, on Long Island.

Mr. W. H. Dall, Mr. Robert Ridgway, and Mr. F. V. Coville joined the Harriman Alaska expedition and made investigations of the mollusks, birds, and plants of that Territory. Miss M. J. Rathbun spent a month at Grand Manan Island, New Brunswick, studying the shore invertebrates and dredging in shallow water.

INVESTIGATIONS.

A large number of scientific investigations were in progress, the results of some of which were published during the year. Mr. G. S. Miller, jr., published several short papers on mammals and partially

completed a revision of the free-tailed bats. He began also a revision of European mammals and a correlation of the life zones of Europe and North America.

Mr. Robert Ridgway continued work on his extensive manual of North and Middle American birds, completing the family Fringillidae, and entering upon the families Corvidae and Tanagridae. It is anticipated that the first part of this work will be ready for publication next year. Considerable progress was made by Dr. C. W. Richmond in the preparation of a card catalogue of described genera and species of birds.

Mr. Barton A. Bean and Dr. Hugh M. Smith, of the U. S. Fish Commission, prepared a preliminary catalogue of the fishes of the District of Columbia.

Mr. William H. Dall presents the following statement regarding his work on mollusks:

During the year the greater portion of my time given to investigation has been specially occupied by a revision of the species and the classification of bivalve mollusks belonging to the Tertiary beds of the United States, and incidentally of the marine fauna of its shores. Many of our living species are found also in several Tertiary strata, and therefore in studying species which are found in the Tertiary beds it is necessary to compare them with the living species as well as with other fossils in order to make sure that they are undescribed or identify them with already described species. For this reason the investigation of the Tertiary fauna which I have been carrying on for a number of years, and which is now nearly finished, has practically included in nearly all the groups a revision of the classification of the living animals of the same groups common to our coast. During the past year especial attention was given to some of these groups, among which may be mentioned the Leptonacea, the Solens, and some groups of the Lucinidae. Nearly all the time available for special researches has been devoted to this subject, and such other researches as I may have made are comparatively unimportant.

Mr. C. T. Simpson continued his study of the river mussels, or *Naiades*, and reports that he has completed a classification of the group and will soon be prepared to publish the results of his work.

Mr. J. E. Benedict has continued his work on the crustaceans of the family Galatheidæ. Miss M. J. Rathbun prepared an article on the Decapod Crustaceans of West Africa for the New York State Colonization Society.

Mr. F. A. Lucas has completed his study of the fossil bisons of North America and continued his investigations on the anatomy of the swifts and the development of the skull of the cormorant.

In addition to his scientific labors as Botanist of the Department of Agriculture, Mr. F. V. Coville entered upon a comprehensive study of the genus *Ribes*. Mr. Rose has continued his monograph of the Agaves, and visited Mexico for the purpose of studying and collecting specimens of the more obscure forms. Mr. Pollard has progressed with his work on the violets, and in that connection has prepared sets of authentic specimens of the various species of *Viola* for distribution.

USE OF THE COLLECTIONS.

The zoological and botanical collections have been made use of to a very large extent during the year by naturalists from all sections of the United States. Some investigators have visited Washington for this purpose, and in other cases collections have been sent out of the Museum temporarily to investigators both at home and abroad.

Among those who made use of the ornithological collections should be mentioned Mr. E. W. Nelson, Mr. H. C. Oberholser, and Mr. W. H. Osgood, of the Department of Agriculture; Mr. Outram Bangs, of Boston, Massachusetts, and Miss Florence Merriam, of Washington, District of Columbia.

Mr. Oberholser, at the request of the Museum, determined the collections of birds recently received from Liberia, the Kameruns, Madagascar, and Kashmir. The committee on nomenclature of the American Ornithologists' Union spent a week in studying new subspecies for the purpose of determining their claims to recognition.

Frequent use was made of the collections of fishes by the officers of the U. S. Fish Commission, especially by Doctors Evermann, Smith, and Kendall.

Sir Charles Elliot, British commissioner to Samoa, prosecuted investigations on the Nudibranch mollusks. Mr. G. A. Drew, of Johns Hopkins University, studied and published on the mollusks of the family Lediæ.

The collections of insects have been very largely consulted by entomologists throughout the country.

Miss Harriet Richardson continued her study of the isopod crustaceans during the greater part of the year, and prepared a special report on the isopods of the Pacific coast of North America, which has recently been published in the Proceedings of the Museum. Mr. T. Wayland Vaughan, of the U. S. Geological Survey, began an investigation of the West Indian corals, and Dr. H. F. Moore, of the U. S. Fish Commission, studied the isopod crustaceans collected by the Commission in Porto Rico. Mr. W. P. Hay assisted in determining the crayfishes recently received, and described a new form of isopod from a well in Irvington, Ind.

The herbarium has received a good share of attention from botanists. Special mention should be made of the services of Prof. E. L. Greene in determining various specimens for the Museum.

The practice of lending material for study to recognized experts not residing in Washington was continued as heretofore. A large amount of material was sent out, but only the principal loans can be noticed here.

Dr. Howard Ayers, of the University of Missouri, obtained the myxinoid fishes in the collection for use in connection with a monograph of that group which he has in preparation.

Specimens of *Dinolestes*, *Atherinopsis*, *Apogon*, and *Exocetus* were

sent to Mr. E. C. Starks for dissection. Mr. Starks afterwards returned excellently prepared skeletons of these fishes.

A series of specimens of mice was sent to Mr. Barrett-Hamilton, London, England, who is engaged in a revision of the European species of the genus *Mus*.

A series of 76 small shrikes was sent to Mr. R. M. Strong, Cambridge, Massachusetts, to assist him in the determination of the percentage of variation in that group. Dr. Jonathan Dwight, jr., obtained the loan of some 60 specimens for use in his study of the molting of birds. A collection of house wrens was sent to Mr. W. E. Loucks, Peoria, Illinois, for examination. Messrs. Outram Bangs and Arthur Stone obtained the use of Colombian birds. A series of specimens of wrens and sparrows was lent to Mr. William Brewster, Cambridge, Massachusetts.

Mr. F. W. Gamble, of Owens College, Manchester, England, who is monographing certain families of annelids, was furnished the specimens of several genera.

Dr. J. Percy Moore received additional installments of leeches. The Museum collection of geophyreans was sent to Prof. Henry B. Ward, University of Nebraska, who is monographing the group.

The Caprellidæ in the Museum were placed in the hands of Doctor Mayer, of the Naples Biological Station, to assist him in preparing a supplement to his monograph.

Dr. F. Meinert, Zoological Museum, Copenhagen, Denmark, was accorded the use of the collection of Pycnogonida for a monograph of that group.

Loans of insects were made to 12 experts during the year, among whom were the following: Dr. Philip P. Calvert, of the Philadelphia Academy of Sciences, received all the unworked dragon-flies (Odonata), partly for naming and partly in connection with his work on the *Biologia Centrali-America*. In the interest also of this great faunal publication, the Mexican and Central American Acrididæ were sent to Professor Lawrence, University of Nebraska, for study. The specimens of the family Pyralidæ were placed in the hands of Prof. C. H. Fernald, of the Agricultural College, Amherst, Massachusetts, for monographic purposes.

Loans of about 1,800 herbarium specimens were made during the year, chiefly in small lots for purposes of identification.

PERSONNEL.

Mr. Gerrit S. Miller, jr., received a temporary appointment as assistant curator, Division of Mammals, July 13, 1898, and on October 15, 1898, was regularly added to the staff. Mr. J. H. Riley was appointed aid August 8, 1898, and Mr. M. W. Lyon, jr., August 15, 1898. Mr. Riley was assigned to the Section of Birds' Eggs, and Mr. Lyon to the Division of Mammals.

REPORT ON THE DEPARTMENT OF GEOLOGY FOR THE YEAR 1898-99.

By GEORGE P. MERRILL,
Head Curator.

Although the year just closed compares favorably with its predecessors, so far as relates to the acquisition of materials, it has not been possible to advance the work of installation to the extent hoped for in the beginning.

ORGANIZATION.

The department as now organized consists of the following divisions: (1) Physical and Chemical Geology (Systematic and Applied), (2) Mineralogy, and (3) Stratigraphic Paleontology, including the sections of Vertebrate Fossils, Invertebrate Fossils, and Paleobotany.

ACCESSIONS.

In the order given, the number of accessions is as follows:

Divisions.	Regular.	Temporary.	Total.	
			1898-99.	1897-98.
Geology	147	132	279	141
Mineralogy	41	75	116	166
Vertebrate Paleontology	27	5	.....	.....
Invertebrate Paleontology	82	17	99	116
Paleobotany	37	2	39	.....
Total	334	231	533	423

In the Division of Geology a very considerable amount of the material received is in itself of slight commercial value. It consists in large part of specimens designed to show the mineral resources of the United States or to fill existing gaps in the systematic series of economic products. Especial mention should, perhaps, be made of a small collection of monazite sands from Brazil; asbestos from Italy; silver-lead-antimony ore from Zencudo mines in Colombia, South America; a large and miscellaneous assortment of ores and economic products from the Central and Western States, received from the Omaha International Exposition; three fine slabs of onyx marble from Colorado, and a series of 19 specimens of polished spheres of Japanese breccia, the gift of the late Prof. O. C. Marsh.

In the Section of Systematic Geology mention should be made of a

series of rocks illustrating the Upper Cambrian formations of the Lake Superior region, collected by Mr. C. R. Van Hise, of the U. S. Geological Survey; a series of clastic rocks illustrating the geology of the slate regions of eastern New York and western Vermont, collected by Prof. T. N. Dale, of the Geological Survey; a fine series of jointed sandstones from the Black Hills of South Dakota, collected by Mr. N. H. Darton, of the Geological Survey; and a series of volcanic products from Vesuvius and other parts of Italy, collected by Mr. F. W. Crosby.

The Division of Mineralogy has been enriched by the acquisition of samples of 4 new minerals—erionite, wellsite, bixbyite, and clinochlore—as well as of 11 other species new to the collection; and of 3 new meteorites from Polk County, Minnesota; Adams County, Pennsylvania, and Mount Oscuro, New Mexico, respectively.

Mention should be made of 6 specimens of roscoelite on auriferous quartz from Eldorado County, California, and 5 specimens of crystallized arsenic from Japan.

The gem collection has received, through the liberality of Dr. L. T. Chamberlain, a fine cut citrine quartz, weighing $139\frac{1}{2}$ carats; 21 cut Montana sapphires, selected to show colors, and 2 cut sapphires, weighing $3\frac{1}{2}$ carats, all from Yogo Gulch, Montana; 1 opal from Mexico, and 2 garnets of the variety rhodolite, from North Carolina. Four opals from Mexico were also obtained by purchase.

In the Section of Vertebrate Fossils the accessions especially worthy of note are a series of mammal skulls from a new locality in the White River Miocene, from the Geological Survey; a fine skull of *Hydracodon nebrascensis*, the gift of Mr. A. W. Barber, and the fossil skull of a new species of bear and a small series of fish remains from the chalk formations of Kansas, collected by Mr. A. B. Baker.

An account of the large series of fossil vertebrates forming the Marsh collection at Yale University, which is in progress of removal from New Haven, will be deferred for the report for next year.

The collection of vertebrate fossils from the Cope estate, mentioned in the last report, was received early in the year. This collection, it will be remembered, was made under the auspices of the Hayden Survey, and comprises over 175 specimens, including many of the types of fishes and reptiles described by Professor Cope in his volume on the Vertebrates of the Tertiary formation of the West and in the Bulletins of the Survey.

The accessions in the section of Invertebrate Fossils are reported by Mr. Schuchert as being neither so large nor so valuable as last year. A large portion of the material received was deposited by the U. S. Geological Survey, and consists of 6,534 Paleozoic fossils, 214 Mesozoic, and 16 Tertiary. Among these the most valuable is a series of 3,990 specimens of Cambrian brachiopods, determined by Prof. Charles

D. Walcott, and the figured specimens, 158 in number, of Lower Cretaceous gryphaeas, described by Messrs. Hill and Vaughan in Bulletin No. 151 of the Geological Survey. A collection comprising some 4,000 specimens of Cincinnati fossils was purchased from Mr. H. E. Dickhaut, of the Survey. This collection is particularly rich in pelecypods.

Three valuable collections of post-Paleozoic fossils were received in exchange from the Geological Museum at Leyden, the University Museum of Natural History at Turin, Italy, and the British Museum of Natural History, London.

As a matter of historical interest, it may be noted that the Troost collection of crinoidea, which, together with the manuscript describing them and drawings for 107 species, was sent by the Smithsonian Institution to Prof. James Hall in 1853, was returned last November by the administrator of the Hall estate.

The Section of Paleobotany, until the opening of the present fiscal year, has been in charge of honorary curators. In order to relieve them of the detailed routine work Dr. A. C. Peale was appointed aid and placed in charge of the collections. Much of the work which he has had to do has been upon material which has been in the Museum collections for many years. The comparatively small number of accessions, therefore, furnishes by no means a measure of the work performed. Among the principal collections which have been received by this section during the fiscal year were: Lower Carboniferous plants from Henry County, Missouri, described in Monograph 37 of the Geological Survey; a series of 900 Carboniferous plants from Indian Territory, described by Mr. David White in the Nineteenth Annual Report of the Survey, and 26 boxes of Carboniferous plants, comprising the Armstrong collection, purchased for the Museum by Mr. R. D. Lacoe.

PRESENT CONDITION OF COLLECTIONS

The progress made in caring for the collections has been all that the circumstances permitted. In the Section of Applied Geology the work of installing the systematic series of nonmetallic products in the new rail cases has been nearly completed. The rearrangement of the geographic series on the ground floor of the Southwest Court is also completed, although several thousand labels yet remain to be prepared. The entire collection of building and ornamental stones, comprising between 3,000 and 4,000 specimens, has been moved and installed in the wall cases of the same court.

The collections in systematic geology, occupying the West South Range, are not yet fully arranged, though the series illustrating the materials of the earth's crust is in order, as is also that illustrating folding and faulting and volcanic products. A magnificent group of

basaltic columns, collected for the Museum by Mr. F. W. Crosby, has lately been added to this series. Manuscript for upward of 2,500 labels has been prepared and is ready for the printer. The actual work of arranging these collections, it should be stated, has fallen upon Mr. W. H. Newhall, with such assistance as could be given by Museum laborers.

I might add that in all the work of this department steps are being taken toward a reduction of the number of specimens exhibited and an improvement in the quality. The reduction in number in certain of the collections is necessitated by lack of space, but it is believed that on the whole a careful selection of the specimens exhibited will cause the collections to have more educational value than will an increase in number.

The collections in the Division of Mineralogy, as stated in my last report, have been as well arranged as possible with the present exhibition cases. New cases are needed along the west wall. As the collections in this division are now well systematized, I submit Mr. Tassin's report upon them in full.

The exhibition series is arranged under the following heads: Systematic series; comparative series; gem collection; meteorite collection.

The systematic series is divided into two general classes—native elements and compounds of the elements. The compounds of the elements are further divided and grouped under certain heads according to their more negative constituents, as follows:

Compounds of the halogens, fluorides, chlorides, bromides, and iodides. Compounds of sulphur, selenium, tellurium, arsenic, and antimony, including sulphides, selenides and tellurides, arsenides, antimonides, sulpharsenides, and sulphantimonides; also sulphosalts. Oxygen compounds, including oxides and the oxygen salts, borates, aluminates, chromites, ferrites, manganites, plumbates, arsenites and antimonites, selenites and tellurites, carbonates, silicates, titanates, columbates and tantalates, nitrates, vanadates, phosphates, arsenates and antimonates, sulphates, selenates and tellurates, chromates, molybdates and tungstates, iodates, and uranates. Compounds of organic origin, including salts of organic acids and carbon compounds.

Each of these classes is further separated into groups according to their chemical relationships. Each group is preceded by a general group label stating the class to which it belongs, the group name, a list of the minerals composing that group, together with their chemical formulæ, system of crystallization, and a short description of the occurrence, association, and characteristic form of each member of the group. Following the group label, arranged in order from left to right, are the several members of the group selected to illustrate, as completely as the conditions will permit, their occurrences, associations, color, habit, etc.

Each specimen is mounted on a standard block, in front of which is a small label giving the name, locality, etc., of the individual.

The comparative series.—Here the properties of minerals are defined, illustrated, and compared. In each case the label containing a definition of the property under consideration precedes a series of specimens and, wherever they can be used advantageously, a series of models illustrating that property.

The meteorite collection, including the Shepard and Museum collections, now contains several hundred specimens representing 336 falls. As in the other series, the collections are preceded by introductory labels, on which are noted the more prominent physical and chemical characters of meteorites, together with the classification here adopted. The arrangement of the two collections is somewhat different, that of the Museum being geographic, while the Shepard collection is chronologic.

The gem collection now compares favorably with any other public collection of this kind in the country, both in number and kinds of stones exhibited. It is especially rich in those gems and ornamental stones which occur in the United States, as is shown by the following tabulated statement:

Name.	Locality.	No. of stones.	Color.	Remarks.
Aragonite	Colusa County, California.	1	Brown.....	Cut cabochon.
Beryl.....	Avondale, Pennsylvania.	2	Yellow	2 and 3 carat stones.
Beryl aquamarine.	Paris, Maine.....	1	Colorless.....	Small brilliant.
Do.....	Stoneham, Maine.....	2	Bluish green.....	Good brilliants, 1 and 2 carats.
Do.....	Royalston, Massachusetts.	1	.....do	Fine 8-carat brilliant.
Do.....	Fitchburg, Massachusetts.	3	Yellowish green..	Small stones.
Do.....	Litchfield, Connecticut.	5	.....do	Good 1-carat brilliants.
Do.....	Portland, Connecticut..	1	Bluish green	Fine 14-carat brilliant.
Do.....	Asheville, North Carolina.	1	.....do	2½-carat step-brilliant; good.
Do.....	Mitchells Peak, North Carolina.	1	.....do	Fine 9½-carat brilliant.
Do.....	Mitchell County, North Carolina.	1	Blue.....	7-carat opaque cabochon.
Do.....	Near Ray Mine, North Carolina.	11	Bluish green	Fine brilliants.
Do.....	Ray Mine, North Carolina.	19	.....do	Do.
Beryl emerald.....	Stony Point, North Carolina.	26	Emerald green ...	Small brilliants; color fair.
Do.....	.....do	1	.....do	Largest example found in America.
Beryllonite.....	Stoneham, Maine.....	3	Colorless.....	Weight, 3½ to 5 carats.

Name.	Locality.	No. of stones.	Color.	Remarks.
Cassiterite	Chesterfield, South Carolina.	1	Yellow	Mounted as a scarf pin.
Chrysolite	Arizona	1	Bottle green	2½-carat brilliant.
Do.....	Fort Wingate, New Mexico.	6	.....do	1½-carat brilliants.
Catlinite.....	Pipestone County, Minnesota.	2	Reddish	1 earring and 1 pipe.
Coral (fossil)	Iowa	2	.....	Paper weights.
Do.....	Petowsky, Michigan....	1	.....	Do.
Cyanite.....	Mitchell County, North Carolina.	1	Blue.....	3¼ carat, step-cut.
Corundum ruby ...	Corundum Hill, North Carolina.	1	Blood red	Do.
Corundum sapphire.	.....do	8	Blue and green....	Small stones.
Do.....	Montana	27	Various colors	Good stones, showing complete range of color.
Do.....	Yogo Gulch, Montana ..	2	Royal blue	3½-carat stones.
Corundum asteria.	Elijay, North Carolina..	3	Bronze	Cut cabochon, good stars.
Diamond	Cabin Fork Creek, Kentucky.	1	Yellowish	¾-carat polished pebble.
Fluorite	Amelia Court-House, Virginia.	1	Brown.....	5-carat stone.
Gadolinite.....	Llano County, Texas ...	1	Black.....	8-carat brilliant.
Garnet var. almandite.	Delaware County, Pennsylvania.	2	Dark red	4-carat cabochons.
Do.....	Macon County, North Carolina.	3	Cherry red	1 to 5 carat brilliants, good.
Do.....	Fort Defiance, Arizona .	5	Violet red	1 to 2 carat brilliants, good.
Do.....	New Mexico.....	7	.....do	1-carat brilliants.
Garnet pyrope.....	Macon County, North Carolina.	17	Red	Do.
Garnet rhodolite ..	North Carolina	2	Violet red	Good brilliants.
Garnet spessartite.	Amelia Court-House, Virginia.	9	Orange red	Good stones, one 39 carats.
Jade.....	Alaska.....	2	Olive green.....	Labrets or belt buckles.
Malachite	Arizona	6	.....	Slabs and polished pieces.
Microcline .....	.....	.....	.....	.....
Microcline amazonstone.	Delaware County, Pennsylvania.	2	Green	Cabochon cut.
Do.....	Amelia Court-House, Virginia.	1	.....do	Do.
Do.....	.....do	2	.....do	1 dish and a paper weight.
Do.....	.....do	6	.....do	Balls.
Do.....	Pikes Peak, Colorado....	2	.....do	Cabochon cut.
Obsidian	Yellowstone Park	11	Brown to black....	Do.
Oligoclase	Mitchell County, North Carolina.	2	Colorless.....	2½ to 6 carat brilliants.
Oligoclase moonstone.	Delaware County, Pennsylvania.	3	.....do	Cabochon cut.
Do.....	Hanover County, Virginia.	1	.....do	Do.
Do.....	Amelia Court-House, Virginia.	10	White and colorless.	Polished pieces and cabochon cut.
Oligoclase sunstone	Delaware County, Pennsylvania.	3	.....	Do.

Name.	Locality.	No. of stones.	Color.	Remarks.
Opal.....	Garfield County, Washington.	1	.....	Massive.
Do.....	Douglas City, Washington.	1	.....	Do.
Prehnite.....	Paterson, New Jersey...	3	Light green.....	Cabochon cut.
Prehnite chlorostrolite.	Isle Royale, Lake Superior.	10	.....	Do.
Pyroxene.....	Davidson County, North Carolina.	1	.....	Polished slab.
Pyroxene dropside	Dekalb, New York.....	4	Green.....	Cut brilliant and cabochon.
Quartz.....	Paris, Maine.....	1	Opalescent.....	Cabochon.
Do.....	Fairfax Court-House, Virginia.	3	Green banded....	
Quartz, agate.....	Lake Superior.....	1	.....	Polished piece.
Quartz, agatized wood.	Arizona.....	11	.....	Slabs and ornaments.
Quartz, amethyst..	Stow, Maine.....	2	Amethystine.....	13 and 23 carat stones.
Do.....	Upper Providence, Pennsylvania.	1	Deep amethystine	35-carat gem.
Do.....	Warlick, North Carolina	1	Light amethystine	14½-carat gem.
Do.....	Macon County, North Carolina.	2	Amethystine.....	One cut and one massive.
Do.....	Alexander County, North Carolina.	11	.....do.....	All cut from same mass, weights from 2½ to 197 carats.
Quartz, cat's-eye ..	Cumberland, Rhode Island.	1	Dark green.....	Cabochon.
Quartz, chalcedony	Yellowstone Park.....	4	Grayish.....	
Quartz, chrysoprase.	Tulare County, California.	1	Green.....	Do.
Quartz, citrine.....	Alexander County, North Carolina.	1	Citrine yellow....	
Do.....	Florissant, Colorado....	1	.....do.....	139½-carat top brilliant.
Quartz, moss agate.	Yellowstone Park.....	11	.....	Cabochon and polished pieces.
Quartz rock crystal.	Chestnut Hill, North Carolina.	3	Colorless.....	Fine stones.
Do.....	.....do.....	1	.....do.....	Ball 11 cm. in diameter.
Do.....	Red Hill, North Carolina.	18	.....do.....	Arrowheads.
Quartz, rose.....	Paris, Maine.....	1	Rose pink.....	Opalescent cabochon.
Do.....	Stoneham, Maine.....	1	.....do.....	Do.
Do.....	McDowell County, North Carolina.	4	Light rose.....	Stick-pin heads.
Quartz, smoky.....	Mount Mica, Paris, Maine.	1	Smoke brown....	Step brilliant, large.
Do.....	Stoneham, Maine.....	1	.....do.....	Do.
Do.....	Fairfax County, Virginia.	3	.....do.....	Small brilliants.
Do.....	Mount Pisgah, North Carolina.	1	.....do.....	Large rose, cut.
Do.....	Iredell County, North Carolina.	1	.....do.....	Do.
Do.....	Magnet Cave, Arkansas.	1	.....do.....	Do.
Do.....	Pikes Peak, Colorado....	1	.....do.....	Large top brilliant.
Do.....	Florissant, Colorado....	1	.....do.....	Do.

Name.	Locality.	No. of stones.	Color.	Remarks.
Quartz, with inclusions	Rhode Island.....	1	.....	With actinolite inclusions.
Do.....	Fairfax County, Virginia.	1	.....	With (?) inclusions.
Do.....	Alexander County, North Carolina.	2	.....	With rutile inclusions.
Do.....	Iredell County, North Carolina.	5	.....	Do.
Do.....	Burke County, North Carolina.	1	.....	Crystal, with tourmaline inclusions.
Do.....	Hot Springs, Arkansas.	3	.....	With chlorite inclusions.
Do.....	Colorado.....	2	.....	With Göthite inclusions.
Do.....	Arizona.....	2	.....	With Dumortierite inclusions.
Do.....	California.....	1	.....	With gold inclusions.
Rhodonite.....	Cummington, Massachusetts.	1	Flesh red.....	Polished ellipsoid.
Do.....	Franklin, New Jersey..	1	do.....	Cabochon cut.
Rutile.....	Hiddenite, North Carolina.	5	Red black.....	Small $\frac{1}{2}$ -carat brilliants.
Samaraskite.....	Mitchell County, North Carolina.	1	Black.....	6 $\frac{1}{2}$ -carat brilliant.
Serpentine.....	Massachusetts.....	2	.....	Necklace and ornaments.
Do.....	United States.....	12	.....	Slabs and ornaments.
Do.....	California.....	1	.....	Flower-shaped ornament.
Serpentine var. bowensite.	Smithfield, Rhode Island.	3	.....	Polished pieces.
Serpentine var. williamsite.	Lancaster, Pennsylvania.	3	.....	Do.
Smithsonite.....	Marion County, Arkansas.	2	Lemon yellow....	Cabochon cut.
Sodalite.....	Litchfield, Maine.....	1	Blue.....	4 $\frac{3}{8}$ -carat cabochon.
Spodumene, hiddenite.	Stony Point, North Carolina.	7	Emerald green....	Small brilliants, $\frac{1}{2}$ carat and less.
Thompsonite.....	Grand Marais, Minnesota.	17	.....	.....
Titanite.....	Brewster, New York....	2	Honey yellow....	Step brilliants.
Do.....	Bridgewater, Pennsylvania.	1	Greenish brown..	4-carat stone.
Topaz.....	Stoneham, Maine.....	1	Colorless.....	3-carat brilliant.
Do.....	Chatham, New Hampshire.	1	do.....	12-carat brilliant.
Do.....	Pikes Peak, Colorado...	1	do.....	17 $\frac{1}{2}$ -carat step brilliant.
Do.....	do.....	1	Wine red.....	14 $\frac{1}{2}$ -carat step brilliant.
Do.....	Utah.....	3	Colorless.....	1-carat brilliant.
Tourmaline.....	Paris, Maine.....	1	Dark green.....	57-carat gem.
Do.....	do.....	1	Wine red.....	18-carat gem.
Do.....	do.....	1	Sherry.....	16 $\frac{1}{2}$ -carat gem.
Do.....	do.....	7	Colorless.....	Small brilliants.
Do.....	do.....	2	Smoky and green.	Both cut from same crystal.
Do.....	do.....	5	Green shades....	4 to 7 carat stones.
Do.....	do.....	4	do.....	1 to 3 carat stones.
Do.....	do.....	11	do.....	Less than 1-carat stones.
Do.....	do.....	15	Blue.....	1 to 4 carat stones.
Do.....	do.....	6	Red.....	Do.
Do.....	do.....	1	Black.....	$\frac{1}{2}$ -carat stone.

Name.	Locality.	No. of stones.	Color.	Remarks.
Tourmaline	Paris, Maine	3	Particolored.....	
Do.....	Auburn, Maine	10	Colored.....	
Do.....	Middlesex County, Connecticut.	3	Green	Brilliant.
Do.....	Dekalb, New York.....	1	Pale yellow	5½-carat stone.
Do.....	Macomb, New York	2	Brown.....	1-carat stones.
Turquoise	Los Cerillos, New Mexico.	11	.....	Cabochon and ornamental pieces.
Variscite	Candelaria, Nevada	1	Green	
Do.....	Lewiston, Utah	2	.....do	Polished pieces.
Willemite	Franklin, New Jersey ..	3	Greenish yellow..	Small brilliants.

The study series contains the material which appeals exclusively to the specialist. It comprises those specimens which serve to illustrate the occurrence and associations of a mineral in any one locality and which are not needed for the exhibition series, or which are not unnecessary duplicates of material already on hand. Each specimen in this series is numbered, labeled, and contained in a paper tray. The several specimens are then arranged geographically by species; the species are arranged in groups, as in the systematic series, and placed in drawers. This series also includes all the original and type material belonging to the division which is not needed for exhibition. Those types used in the exhibition series are here represented by cards giving the position of the type specimens in the cases.

Little has as yet been done in the way of permanently installing the exhibition series of vertebrate fossils, owing to the construction of new cases and the absence of Mr. F. A. Lucas, the Curator, for several weeks in New Haven. The death of Professor Marsh involved the immediate withdrawal and turning over to the Museum of the vertebrate fossils collected under the direction of the Geological Survey, which work has naturally taken a large share of the time and attention of the Curator since March. This collection will be referred to again in the next report.

The final arrangement of the collection of invertebrate fossils has been delayed by the need of cases. The entire Paleozoic portion has been removed from the floor of the southwest court and placed on the gallery in the same court. This installation is not, however, final. With the completion of the rail cases, it is hoped to remove from the floor of this court the Mesozoic and more recent invertebrate fossils, thereby making room for the collections in vertebrate paleontology. At present, the mounted exhibition series in this section consists only of Cambrian, Upper Carboniferous, and Tertiary forms. Mr. Charles Schuchert has labored most industriously, and reports that, with the assistance of Mr. Williard, he has during the year placed in final Museum form upward of 20,000 specimens and prepared 2,900 cata-

logue cards, as well as manuscript for 1,319 labels. With the present force, however, it will not be possible to complete the installation of the exhibition series for at least two years.

In the Section of Paleobotany I have to report the installation of an exhibition series comprising some 1,000 specimens in the wall cases occupying the south and west galleries of the Southeast Court. Some 1,300 specimens were received and catalogued during the year, and four volumes, comprising 2,000 entries in the old catalogues, have been copied. At least 12,000 entries yet remain to be made of materials now in the Museum. There is need of another assistant in this section.

RESEARCH.

But little opportunity has been offered for special investigation by officers of the Museum. Dr. E. C. E. Lord has occupied a desk in the laboratory of the Division of Geology and has been engaged upon the study of the rocks collected by Dr. E. A. Mearns, U. S. A., of the Mexican Boundary Survey and other rocks collected by himself on the coast of Maine and by Messrs. Schuchert and White in Greenland.

The head curator has partially revised for publication the manuscript for a handbook of the collection of nonmetallic minerals which was begun some three years ago. He has also written sundry other papers, the titles of which, so far as they have yet been published, are given in the Bibliography (Appendix IV). Mr. Wirt Tassin, assistant curator in charge of the mineral collections, has now in press a handbook of the exhibition series, illustrating the characters of minerals, and also a paper showing the classification adopted in the arrangement of the mineral collections under his charge. He announces having in preparation a catalogue of the mineral collections and a handbook of the collection of meteorites. Mr. Schuchert has been engaged, when opportunity offered, in reworking the Lower Helderberg and Oriskany collections, and has prepared two papers for publication. He has practically completed a paper on the Lower Devonian Aspect of the Lower Helderberg and Oriskany, and one on the Lower Silurian Fauna of Baffin Land. He is also continuing his work, begun more than three years ago, on the fossil starfishes of America. Mr. Lucas has completed a study of the fossil bison; identified a series of vertebrates from the White River Miocene, submitted by the Geological Survey, and described a hitherto unknown fossil snake from the Eocene of Alabama.

SOURCES OF NEW MATERIAL.

With the exception of the collections of Kinderhook fossils made by Mr. Paul Bartsch, of the Division of Mollusks, while at his home in Burlington, Iowa, no geological explorations of consequence have been undertaken by members of the Museum staff. Mr. F. W. Crosby,

of this city, while traveling in Europe, collected many objects of value, including a fine series of Italian asbestos and an exceptionally large cluster of basaltic columns from near Bonn, in Prussia. In like manner, Prof. C. H. Hitchcock, of Hanover, New Hampshire, while in the Hawaiian Islands, made important geological collections. Inasmuch as the materials have not yet arrived at the Museum, further notice concerning them is left for the next report.

Through the kindness of the Geological Survey the Museum was enabled to detail Mr. H. E. Dickhaut, of that bureau, to collect an extensive series of Upper Silurian fossils in the vicinity of Lockport, New York.

Mr. R. D. Lacoe has, by two important donations, continued to exhibit his interest in science and in the National Museum. Through the kindly interest of Mr. Harry Lee, the State Commissioner of Mines, a fine series of telluride ores and other desirable materials from Colorado has been procured.

As in the past, the chief source of accumulation is the Geological Survey, particularly for paleontological, stratigraphical, and lithological material. Dr. L. T. Chamberlain has on three occasions manifested his interest in the gem collection, as noted elsewhere.

ASSISTANCE AFFORDED STUDENTS AND INVESTIGATORS.

The custom of lending collections to workers outside of the Museum has been adhered to. A small collection of Japanese marbles was lent to Prof. O. C. Marsh, and 116 thin sections of granites to Prof. B. K. Emerson. From the Division of Mineralogy a series of silicates and several specimens of chalcedony were turned over to Messrs. Clark and Diller, of the Geological Survey, to be used in special investigations being conducted by them. In like manner teeth of Paleozoic sharks have been lent to Prof. C. R. Eastman, of Cambridge. Invertebrate Paleozoic material has been lent to Mr. J. W. Beede, of the University of Kansas; to Dr. G. F. Girty, of the Geological Survey; to M. M. Cossman, of Paris; and Dr. Anton Fritsch, of Prague.

The study of the collections has not been limited wholly to members of the Museum staff. As already noted, Dr. E. C. E. Lord has continued his studies in the Division of Geology, while Doctor Fritsch, of Bohemia, and Doctor Matthews, of the American Museum of Natural History, have briefly studied methods of installation, and, in the case of Doctor Fritsch, the fossil Myriapoda and Arachnida in the Lacoe collection.

Prof. F. W. Cragin, graduate student of Johns Hopkins University, Baltimore, has passed several weeks in the Museum, working on the collection of Texas Jurassic fossils. In the Section of Vertebrate Paleontology, Dr. O. P. Hay has described two new species of fossil turtles and Mr. Gerrit S. Miller, jr., one new species of Pleistocene bear.

Prof. Atreus Wanner, superintendent of the public schools of York, Pennsylvania, has twice visited the Museum to utilize the Triassic materials in the collections in connection with his work on the Triassic plants from near York, Pennsylvania.

Twenty-six papers bearing upon subjects in the department collections have been prepared during the year, either by the staff of the Museum or by those having access to the collections. These titles are given in the Bibliography and need not be repeated here.

STORAGE AND WORKROOMS.

Much material (several hundred boxes) belonging to the Paleontological collections is still in storage. It is hoped that some time in the near future this, too, may be made available to students.

With the renting of the Emery Building, on Tenth street southwest, the workrooms and all machinery used in preparatory work were removed to that building, thus affording a much-needed space for packing and unpacking material, and such incidental work as could not properly be carried on in the offices and exhibition halls.

In the Section of Systematic Geology there are several special series of exhibits that could be prepared to advantage, such as collections illustrating the geology of special areas, to include maps, sections, and other drawings and photographs, besides the actual specimens. A very attractive exhibit illustrating the geology and physical geography of the Yellowstone Park has also been projected, but not yet carried out.

In the Section of Applied Geology there is need of special exhibits illustrative of various phases of the science. Models of one or more important mines, or relief maps and sections of mining regions, together with samples of the ore and wall rocks, form desirable exhibits, as do also collections showing the origin and derivation of ore, the geological distribution of useful minerals of various kinds, the qualifying conditions for artesian wells, etc.

Several such exhibits have been projected, but are still far from complete.

In my report as curator for 1892 I announced the preparation of 200 sets of rocks and ores, ranging in number from 66 to 104 specimens each. The last of these was sent out during the spring of 1899. Since 1892 other materials have been gradually accumulated, in the line of both geology and invertebrate paleontology, for other sets, but no opportunity has been found to put them in order. The interest at present manifested in the study of soils and the problems connected therewith led the curator to begin, a year or more ago, the preparation of 100 sets of rocks and their decomposition products, as described in his work on rockweathering. This work, too, is still unfinished.

The death of Prof. O. C. Marsh, which occurred on March 18, 1899,

has precipitated the work of transferring to the Museum the collections of vertebrate fossils made by him under the authority of the Geological Survey during the years 1882 to 1893, referred to in the last report. Representatives of the department have been at New Haven since April 10, engaged in the work of packing. The labor of bringing the material here and installing it, together with the incidental work of cataloguing and looking after the records, will tax to the utmost the resources of the section for many months to come. As much of the material is still in the matrix, the services of another preparator are essential. With this additional help, it might be possible to prepare one or more restorations of some of the more striking forms, like *Triceratops*, which would add greatly to the interest and educational value of the display collections.

SUMMARY OF THE OPERATIONS OF THE YEAR.

THE MUSEUM STAFF.

Dr. O. C. Marsh, professor of paleontology in Yale University and for many years connected with the staff of the National Museum as honorary curator of Vertebrate Fossils, died on March 18, 1899.

Dr. Frederick W. True has been appointed the Representative of the Smithsonian Institution and National Museum on the Government Board for the Pan-American Exposition to be held in Buffalo in 1901, and Mr. W. V. Cox has been designated as chief special agent in the same connection.

Mr. J. L. Willige continued to act as chief clerk until December 12, when he was relieved by Mr. W. V. Cox, who had then completed his duties away from Washington in connection with the Trans-Mississippi and International Exposition.

Mr. George C. Maynard, custodian of the Electrical Collections, was on August 1, 1898, also designated as aid in the Division of Mechanical Technology.

Mr. J. H. Riley and Mr. Marcus W. Lyon, jr., were appointed aids in the Department of Biology on August 8 and August 15, respectively, and on January 1, 1899, Miss Carrie Harrison, aid in the Division of Plants, was transferred to the Department of Agriculture.

Mr. E. A. Schwarz has been placed in charge of the entire collection of Coleoptera, as custodian, and Mr. Nathan Banks has been made custodian of the Collection of Arachnida.

Prof. O. F. Cook, for some time an assistant curator in the Division of Plants, having accepted a position in the Department of Agriculture, was in March, 1899, made honorary assistant curator in charge of the Cryptogamic collections.

Dr. A. C. Peale was appointed aid in the Section of Paleobotany on July 25, 1898.

Dr. George H. Girty, of the U. S. Geological Survey, was made custodian of the Carboniferous collections in the Section of Invertebrate Fossils on July 29, 1898.

A complete list of the members of the scientific and administrative staffs will be found in Appendix I.

APPROPRIATIONS AND EXPENDITURES.

The appropriations by Congress for the past fiscal year aggregated \$257,000, an increase of \$24,000 over the total for the preceding year. There was an increase of \$5,000 in the item for preservation of collec-

tions, which also contained an added provision for the making of illustrations to an extent not exceeding \$5,500 in cost. For furniture and fixtures, including the furnishing of new galleries, \$35,000 were given, being \$5,000 more than the year before. The purchase of books was provided for in a separate appropriation of \$2,000. The amount allowed for the rent of workshops was increased from \$2,000 to \$4,500, and for continuing the construction of galleries, etc., from \$8,000 to \$10,000. For the purchase of the library of the late Dr. G. Brown Goode, \$5,000 were granted, and the appropriation for printing and binding was increased from \$12,000 to \$17,000.

The total expenditures from these appropriations during the year aggregated \$244,368, leaving a balance, subject to outstanding liabilities, of \$12,632. From the appropriation for 1897-98 disbursements amounting to \$5,385.41 were made, leaving a balance of \$118.18, exclusive of small balances from the printing allotment and the appropriation for the rent of workshops. Expenditures to the amount of \$378.69 were made from the appropriation for 1896-97, under the titles of preservation of collections, and heating and lighting.

The following tables show the expenditures during 1898-99 from the appropriations for the past two fiscal years and the balances on hand June 30, 1899:

Appropriations and expenditures for the fiscal year ending June 30, 1899.

Object.	Appropriations.	Expenditures.	Balance on hand June 30, 1899.
Preservation of collections.	\$165,000	\$160,338.06	\$4,661.94
Furniture and fixtures	35,000	34,004.72	995.28
Heating, lighting, and electrical service.....	14,000	12,219.98	1,780.02
Books.....	2,000	1,300.43	699.57
Postage.....	500	500.00	.....
Building repairs.....	4,000	3,918.92	81.08
Rent of workshops	4,500	4,389.92	110.08
Galleries.....	10,000	5,698.34	4,301.66
Library of the late G. Brown Goode.....	5,000	5,000.00	.....
Printing.....	17,000	16,997.63	2.37
Total	257,000	244,368.00	12,632.00

Disbursements from unexpended balances of appropriations for the fiscal year ending June 30, 1898.

Object.	Balance June 30, 1898.	Expenditures.	Balance June 30, 1899.
Preservation of collections.	\$2,363.51	\$2,266.23	\$97.28
Furniture and fixtures	1,710.46	1,709.23	1.23
Heating and lighting	816.87	811.38	5.49
Building repairs	31.98	27.45	4.53
Galleries	551.87	543.00	8.87
Rebuilding sheds.....	28.90	28.12	.78
Total	5,503.59	5,385.41	118.18

The appropriations for the fiscal year ending June 30, 1900, are as follows:

Preservation of collections	\$170,000
Furniture and fixtures (including \$10,000 for furnishing new galleries)	25,000
Heating, lighting, and electrical service.....	14,000
Postage.....	500
Books, pamphlets, and periodicals.....	2,000
Repairs to buildings, shops, and sheds.....	6,000
Rent of workshops and temporary storage quarters	4,040
Printing and binding	17,000
Total.....	238,540

BUILDINGS.

Iron galleries have been erected in the West North Range, the West South Range, the East South Range, and the South East Range under the item of \$10,000 appropriated for that purpose. The great snow storm of February, 1899, disclosed certain weak places in the roof of the Museum building and caused the buckling of several of the large iron girders. The damaged parts have been repaired and strengthened so far as the appropriation permitted. Two of the old wooden floors have been replaced by terrazzo pavement, and many minor repairs and improvements have been made.

Three additional small buildings have been leased for workshop and storage purposes, thus supplying much-needed space and allowing for the removal of the long frame shed which adjoined the Museum building on the east side.

ACCESSIONS AND REGISTRATION.

The total number of accessions during the year was 1,497, a slight increase over that for the preceding year. The number of specimens embraced in these accessions was 210,323, raising the grand total in the possession of the Museum to 4,355,463. The details are shown in the following table:

Number of specimens received in 1898-99, and total number in the several divisions on June 30, 1899.

Division.	Received in 1898-99.	Total.
Anthropology:		
Ethnology.....	2,253	453,908
Historic archæology.....	104	1,976
Prehistoric archæology.....	3,429	278,018
Technology.....	207	30,628
Graphic arts.....	121	7,355
Medicine	19	6,800
Religions.....	508	2,366
History and biography	1,027	37,183

Number of specimens received in 1898-99, and total number in the several divisions on June 30, 1899—Continued.

Division.	Received in 1898-99.	Total.
Biology:		
Mammals.....	5,031	<i>a</i> 27,016
Birds.....	2,785	<i>b</i> 115,059
Birds' eggs.....	389	61,661
Reptiles and batrachians.....	855	38,977
Fishes.....	701	151,301
Mollusks.....	14,981	740,017
Insects.....	125,000	994,236
Marine invertebrates.....	7,227	509,331
Helminthological collection.....	<i>c</i> 199	<i>c</i> 4,945
Comparative anatomy.....	94	15,585
Plants.....	23,000	391,241
Forestry.....		749
Geology:		
Physical and chemical geology.....	638	77,863
Mineralogy.....	219	29,527
Stratigraphic paleontology.....	21,536	376,721
Total.....	210,323	4,355,463

a Including the specimens added to the Department of Agriculture series during this and the preceding year.

b Including material recently added to the Department of Agriculture series.

c Number of catalogue entries.

The number of entries made in the catalogues of the different divisions was 26,442. In Appendix II will be found a complete list of the accessions for the year.

The following table shows the number of accessions annually since 1881:

Year.	Accession numbers (inclusive).	Number of accessions during the year.
1881.....	9890-11000	1,111
1882.....	11001-12500	1,500
1883.....	12501-13900	1,400
1884.....	13901-15550	1,650
1885 (January to June).....	15551-16208	658
1886.....	16209-17704	1,496
1887.....	17705-19350	1,646
1888.....	19351-20831	1,481
1889.....	20832-22178	1,347
1890.....	22179-23340	1,162
1891.....	23341-24527	1,187
1892.....	24528-25884	1,357
1893.....	25885-27150	1,266
1894.....	27151-28311	1,161
1895.....	28312-29534	1,223
1896.....	29535-30833	1,299
1897.....	30834-32300	1,467
1898.....	32301-33741	1,441
1899.....	33742-35238	1,497

Thirteen thousand seven hundred and twenty-nine packages of various kinds have been received by the registrar, besides 29,628 volumes of publications. Five hundred and fifty-seven of these packages contained specimens for the Museum collections. Three thousand one hundred and seventy-seven packages have been sent out.

DISTRIBUTION AND EXCHANGE.

Twenty-four thousand seven hundred and forty-five specimens were sent out as gifts or in exchange, and 9,850 specimens were lent for study during the year. The gifts have consisted largely of collections of marine invertebrates, rocks, and casts of prehistoric implements, which have been presented to educational institutions in all parts of the country. The distributions are given in detail in Appendix III. The following statement shows the number of "lots" of specimens sent to each State and foreign country:

Alabama.....	6	Tennessee.....	1
Arkansas.....	1	Texas.....	2
California.....	8	Utah.....	1
Colorado.....	2	Virginia.....	1
Connecticut.....	5	Washington.....	2
Delaware.....	3	West Virginia.....	1
District of Columbia.....	16	Wisconsin.....	6
Florida.....	1	Foreign countries:	
Illinois.....	14	Africa.....	2
Indiana.....	3	Argentina.....	2
Iowa.....	9	Australia.....	1
Kansas.....	5	Austria.....	3
Kentucky.....	1	Belgium.....	2
Maine.....	2	Canada.....	6
Maryland.....	1	China.....	2
Massachusetts.....	38	Denmark.....	2
Michigan.....	2	England.....	24
Minnesota.....	11	France.....	2
Mississippi.....	1	Germany.....	3
Missouri.....	8	India.....	4
Montana.....	3	Italy.....	3
Nebraska.....	6	Mexico.....	1
New Hampshire.....	1	Netherlands.....	2
New Jersey.....	3	Peru.....	1
New York.....	35	Scotland.....	1
North Carolina.....	4	Sweden.....	1
North Dakota.....	1	Switzerland.....	2
Ohio.....	7	West Indies.....	2
Pennsylvania.....	16		
Rhode Island.....	1	Total.....	294

Among the more important exchange receipts from foreign establishments and individuals the following may be mentioned: From the British Museum of Natural History, London, England, Set No. 4 of Rugel's Florida plants, and 190 specimens representing 63 species of

fossil corals, in exchange for plants, Tertiary corals, bryozoans, skins and skulls of mammals from Patagonia, and mollusks from the United States and other localities. From the Museum of Natural History, Paris, France, alcoholic fishes from northern and central Asia. From the Geological Survey of Canada, 24 specimens of Trenton fossils in exchange for fossils from Baffin Land. From the Rijks Ethnographic Museum, Leyden, Holland, a collection of ethnological objects in exchange for material of the same character. From the Public Gardens and Plantations, Kingston, Jamaica, 112 plants in exchange for botanical specimens. From the Museum Michoacano, Morelia, Mexico, birds' skins and insects in exchange for publications. From the Albany Museum, Grahamstown, South Africa, 44 birds' skins. From the Riksmuseum, Stockholm, Sweden, 29 species of Actinians in exchange for a similar collection. From Mr. G. Van Roon, Rotterdam, Holland, a collection of beetles from Java and South Africa in exchange for Coleoptera. From Mr. Jean Miguel, Barrubio, Hérault, France, a large collection of fossils from the Paleozoic, Mesozoic, and Cenozoic horizons of Europe in exchange for 272 specimens, representing 147 species, of Paleozoic fossils. From Rev. Paul D. Bergen, Chefoo, China, 48 birds' skins and 2 mammals' skins. From Baron R. de Vrière, Zedelghem, Belgium, a collection of Belgian insects in exchange for 112 specimens of Coleoptera. From Mr. G. Ruscheweyh, Buenos Aires, Argentina, a collection of Argentine Lepidoptera in exchange for material of the same character. From Mr. E. Y. Connell, St. Kitts and Nevis, British West Indies, Carib implements and pieces of pottery in exchange for stone implements. From Mr. C. F. Pavona, Museum of Natural History, University of Turin, 167 specimens of fossil corals, representing 95 species, from the Italian Tertiary deposits, in exchange for fossils. From Prof. M. F. Colunga, Lima, Peru, 24 birds' skins. From Mr. L. Y. Ayson, Masterton, Wellington, New Zealand, 17 birds' skins in exchange for material of the same kind.

Seventy-six specimens of Cambrian fossils have been forwarded to the Geographical-Paleontological Institute, Munich, Germany.

VISITORS.

The number of persons visiting the Museum building was 192,471, and the Smithsonian building, 116,912. The following tables show, respectively, the number of visitors during each month of the past year, and the totals for each year since 1881:

Number of visitors during the fiscal year 1898-99.

Year and month.	Museum building.	Smithsonian building.
1898.		
July.....	24,489	14,879
August.....	14,314	8,066
September.....	14,357	7,964
October.....	19,510	11,411
November.....	12,932	7,365
December.....	10,822	10,281
1899.		
January.....	11,723	7,191
February.....	10,394	6,071
March.....	20,005	10,495
April.....	16,273	12,761
May.....	26,417	14,396
June.....	11,235	6,041
Total.....	192,471	116,912
Approximate daily average on a basis of 313 days in the year.....	615	373

Number of visitors to the Museum and Smithsonian buildings since the opening of the former in 1881.

Year.	Museum building.	Smithsonian building.	Total to both buildings.
1881.....	150,000	100,000	250,000
1882.....	167,455	152,744	320,199
1883.....	202,188	104,823	307,011
1884 (half year).....	97,661	45,565	143,226
1884-85 <i>a</i>	205,026	105,993	311,019
1885-86.....	174,225	88,960	263,185
1886-87.....	216,562	98,552	315,114
1887-88.....	249,665	102,863	352,528
1888-89 <i>a</i>	374,843	149,618	524,461
1889-90.....	274,324	120,894	395,218
1890-91.....	286,426	111,669	398,095
1891-92.....	269,825	114,817	384,642
1892-93 <i>a</i>	319,930	174,188	494,118
1893-94.....	195,748	103,910	299,658
1894-95.....	201,744	105,658	307,402
1895-96.....	180,505	103,650	284,155
1896-97 <i>a</i>	229,606	115,709	345,315
1897-98.....	177,254	99,273	276,527
1898-99.....	192,471	116,912	309,383
Total.....	4,165,458	2,115,798	6,281,256

a Year of Presidential inaugurations.

STUDENTS AND INVESTIGATORS.

Investigations upon collections in the Museum by persons not employed upon its staff have been carried on extensively. The Chinese kites were examined by Mr. A. Lawrence Rotch, of Hyde Park, Massachusetts, with reference to the principles of aerial flotation involved in their construction. The extensive collection of aboriginal tobacco pipes has been studied by Mr. J. D. McGuire, of Ellicott City, Maryland, in connection with the preparation of his monograph on that subject published in the Report of the Museum for 1897. Mr. Stewart Culin, of the University of Pennsylvania, has continued his studies on aboriginal and modern games, as illustrated by specimens in the Division of Ethnology.

The collections in the Division of Mammals have been constantly consulted by the members of the staff of the Biological Survey of the Department of Agriculture. The specimens of *Dermochelys*, a genus of turtles, have been studied by Dr. O. P. Hay, with regard to the systematic position of the genus. In the Division of Marine Invertebrates, Miss Harriet Richardson has been engaged in studying certain Isopoda, and in the preparation of a report upon the Isopods of the Pacific coast of North America, which has recently been published in the Proceedings of the Museum. Dr. H. F. Moore, of the U. S. Fish Commission, spent several weeks at the Museum in working up the Isopoda collected by the steamer *Fish Hawk* on the coast of Porto Rico. A study of the very extensive collection of West Indian corals belonging to the Museum has been begun by Mr. T. Wayland Vaughan, of the U. S. Geological Survey, whose previous researches in this field especially qualify him for the work. Prof. W. P. Hay, of the Central High School, has at intervals given attention to the crayfishes in the collection, naming those recently obtained. He has also described a new form of Isopod in a paper printed in the Proceedings of the Museum.

In the Division of Insects the following persons, among others, have consulted the collections: Miss Ella Weeks, of Manhattan, Kansas; Messrs. Snyder and McDade, of the Chicago Entomological Society; Prof. O. S. Westcott, of Chicago, Illinois; Miss Harriet B. Merrill, of Milwaukee, Wisconsin; Mr. O. Reinecke, of Buffalo, New York; Dr. J. Branchont, of the Bergen Museum, Bergen, Norway; Mr. Henry Bird, of Rye, New York; Prof. John B. Smith, of Rutgers College, New Brunswick, New Jersey; Dr. S. C. Shumucker, of Westchester, Pennsylvania; Prof. T. D. A. Cockerell, of Mesilla Park, New Mexico; Prof. James Hine, of Columbus, Ohio; Dr. Herman Strecker, of Reading, Pennsylvania; Mr. Charles E. Burden, of Washington, District of Columbia; Prof. E. Dwight Sanderson, of College Park, Maryland; Dr. W. J. Holland, of Pittsburg, Pennsylvania, and Mr. W. H. Wenzel, of Philadelphia, Pennsylvania.

In the Division of Fishes Dr. B. W. Evermann, Dr. H. M. Smith, and Mr. W. C. Kendall, of the U. S. Fish Commission, have made use of the collections. Mr. E. C. Starks, of the University of Washington, examined certain fishes in working up the osteology of several aberrant forms.

The committee on nomenclature of the American Ornithologists' Union spent several days in the Division of Birds inquiring into the validity of various subspecies described during the previous year. Mr. E. W. Nelson, of the Department of Agriculture, was engaged for some time in a study of Mexican birds in connection with the determination of material collected by him. Mr. H. C. Oberholser named several collections of birds at the request of the curator. Mr. William Palmer studied the small shrikes of North America and the eastern species of *Geothlypis*. Mr. W. H. Osgood, of the Department of Agriculture, examined the wren-tits. Miss Florence Merriam, of Washington, studied various Western birds. Mr. Outram Bangs, of Boston, Massachusetts, gave attention to the rails, meadow larks, etc., for the purpose of ascertaining the status of certain new forms which he was about to describe.

Sir Charles Elliot, second secretary of the British embassy and British Commissioner to Samoa, prosecuted investigations on the Nudibranchs represented in the Division of Mollusks. Mr. G. A. Drew, of Johns Hopkins University, made a study of the family Lediidae, and has published the results of his work.

In the Division of Plants, Mr. A. M. Ferguson, of St. Louis, Missouri, gave some time to researches on the genus *Croton*; Miss Lewanna Wilkins, of Washington, was engaged during the winter in determining a set of California plants; Mr. J. J. Smith, of Washington, studied the genus *Lophocarpus* and its allies, and Mr. Elmer I. Applegate, of Klamath Falls, Oregon, spent about two months in working up a set of Oregon plants. Mr. J. B. Leiberger, of Hope, Idaho, was occupied during a part of January and February with plants collected in the Western timber reserves. Prof. W. L. Bray has recently carried on extensive studies in the herbarium. Prof. E. L. Greene, of the Catholic University, Washington, has consulted material in various genera and has made determinations for the Museum. Prof. L. M. Underwood, of Columbia University, New York City, visited the herbarium early in the spring for the purpose of examining certain fern groups.

Prof. A. Wanner, who has discovered Triassic plants near York, Pennsylvania, where he resides, has visited the Museum on two occasions for the purpose of comparing his collections with those from the Richmond coal fields of Virginia. Researches on vertebrate fossils have been carried on by Dr. O. P. Hay, of Washington, who has described a new species of fossil turtle. Dr. Anton Fritsch, director

of the National Museum at Prague, Bohemia, studied the fossil Myriapoda and Arachnida in the Lacoe collection, and material has been transmitted to him for further examination. Prof. F. W. Cragin, of Johns Hopkins University, spent considerable time at the Museum in working up a collection of Jurassic fossils from Texas.

Dr. E. C. E. Lord, of Washington, studied the rocks collected on the Mexican border by Dr. E. A. Mearns, U. S. A. The results of Doctor Lord's studies were embodied in a paper which has been published in the Proceedings.

Material has been sent out for examination as follows:

To Mr. F. H. Cushing, of the Bureau of Ethnology, a collection of pipes, gorgets, ceremonial objects, etc. To Mr. Stewart Culin, of the University of Pennsylvania, specimens of Indian gambling implements. To Mr. V. K. Chesnut, of the Department of Agriculture, 27 specimens of Mexican drugs.

From the Division of Mammals the type of *Mictomys innuitus* was lent to Mr. E. A. Preble, of the Department of Agriculture, for use in connection with the determination of species from New Hampshire, and he was also supplied with several specimens belonging to the genus *Zapus*. Ten squirrels and more than 100 mice were furnished to Mr. G. E. H. Barrett-Hamilton, London, England; representatives of the genus *Microtus* to Mr. Vernon Bailey, of the Department of Agriculture, for use in a revision of the genus; about 50 small mammals to Mr. E. W. Nelson, of the Department of Agriculture; 5 pocket mice and 1 gray fox to Mr. W. H. Osgood, of the same Department. The skull of a deer was sent to Mr. Outram Bangs, Boston, Massachusetts.

A specimen of *Desmognathus* was forwarded by the Division of Reptiles and Batrachians to Dr. J. Percy Moore, of the University of Pennsylvania, for comparison; and a specimen of *Amphystoma* to Dr. J. D. Lindahl, of Cincinnati, Ohio. Three double-headed snakes were sent to the Museum of Comparative Zoology, Cambridge, Massachusetts.

From the Division of Fishes a specimen of *Nemichthys scolopaceus* and one of *Chirostoma estor* were sent to Dr. David S. Jordan, of Leland Stanford Junior University; several Myxinoid fishes to Prof. Howard Ayres, of the University of Missouri, and a number of specimens to Mr. E. C. Starks, for use in determining the range of certain genera.

The following sendings were made by the Division of Birds: Thirty-five specimens to Mr. Outram Bangs, Boston, Massachusetts, for use in connection with the determination of material from Colombia; 67 specimens of wrens, sparrows, etc., to Mr. William Brewster, Cambridge, Massachusetts, who was studying the status of these groups in the western part of the United States; 76 specimens of small shrikes to Mr. R. M. Strong, Cambridge, Massachusetts, for study in determining the percentage of variation in that group; 13 specimens of thrushes to Mr. Reginald Heber Howe, jr., Longwood, Massachusetts; 60 bird skins to Dr. Jonathan Dwight, jr., New York City; 62 specimens of House

Wrens to Mr. W. E. Loucks, Peoria, Illinois; 41 specimens of wrens to Mr. Witmer Stone, of the Academy of Natural Sciences, Philadelphia.

The transmissions from the Division of Insects were as follows: A collection of Mexican and Central American Acrididæ to Prof. Lawrence Bruner, of the University of Nebraska; the unworked material in the Odonata to Dr. Philip P. Calvert, of the Academy of Natural Sciences, Philadelphia; miscellaneous material to Prof. F. H. Chittenden, of the U. S. Department of Agriculture, for illustrating work in progress in the Department; specimens of the family Pyralidæ to Prof. C. H. Fernald, of the Agricultural College, Amherst, Massachusetts, for monographic purposes; some wasps and bees to Mr. W. J. Fox, of the Academy of Natural Sciences, Philadelphia, for monographic work; a collection of moths to Sir George F. Hampson, of the British Museum of Natural History, for monographic work; material in the family Chrysomelidæ to Prof. E. Dwight, College Park, Maryland; 15 species of Acrididæ to Prof. Jerome McNeill, of Fayetteville, Arkansas, for use in connection with a synopsis of the species inhabiting Arkansas; a specimen of *Stenopelmatus fasciatus* to Dr. S. H. Scudder, of Cambridge, Massachusetts; and 56 specimens of the genus *Argynnis* to Prof. A. J. Snyder, of Belvidere, Illinois.

From the Division of Marine Invertebrates, annelids of the genera *Ammotrypane*, *Trophonia*, *Ophelia*, etc., were transmitted to Mr. F. W. Gamble, of Owens College, Manchester, England; the collection of leeches was sent to Dr. J. Percy Moore, of the University of Pennsylvania; the collection of Gephyreans to Prof. H. B. Ward, of the University of Nebraska; and the collection of Caprellidæ to Dr. F. Meinert, of the Zoological Museum, Copenhagen, Denmark, all of these having been supplied under arrangement for monographing the several groups.

A small number of specimens were sent from the Division of Mollusks to Dr. V. Sterki, New Philadelphia, Ohio, for examination, and a few slugs to Mr. H. A. Pilsbry, of the Academy of Natural Sciences of Philadelphia.

Material has been supplied by the Division of Plants for special systematic or morphological study to the following: Royal Botanic Gardens, Kew, England, 22 specimens; Dr. T. Maxwell Masters, London, England, 18 specimens; C. De Candolle, Geneva, Switzerland, 23 specimens; Prof. B. L. Robinson, Cambridge, Massachusetts, 537 specimens; Mr. C. S. Sargent, Jamaica Plain, Massachusetts, 59 specimens; Dr. George Davenport, Medford, Massachusetts, 3 specimens; Dr. J. K. Small, Botanical Garden, New York City, 15 specimens; Prof. L. M. Underwood, Columbia University, New York City, 10 specimens; Mr. B. D. Gilbert, Clayville, New York, 88 specimens; Mr. W. Miller, Cornell University, Ithaca, New York, 25 specimens; Mr. F. W. Waugh, University of Vermont, Burlington, Vermont, 5 specimens; Prof. William Trelease, St. Louis, Missouri, 252 speci-

mens; Dr. N. M. Glatfelter, St. Louis, Missouri, 8 specimens; Mr. H. C. Irish, St. Louis, Missouri, 2 specimens; Mr. D. T. MacDougal, Minneapolis, Minnesota, 9 specimens; Prof. E. L. Greene, Catholic University, Washington, District of Columbia, 57 specimens; Mr. H. O. Hall, Army Medical Museum, Washington, District of Columbia, 14 specimens; Mr. Theodor Holm, Washington, District of Columbia, 263 specimens; Mrs. M. R. McConnell, Washington, District of Columbia, 6 specimens.

Several specimens of chalcedony have been sent to Mr. J. S. Diller, of the U. S. Geological Survey, for use in connection with his investigations, and thin sections of rocks have been supplied to Prof. B. K. Emerson, of Amherst College.

Specimens of the teeth of Paleozoic sharks have been lent to Dr. C. R. Eastman, of the Museum of Comparative Zoology, Cambridge, Massachusetts, and a number of fossils to Prof. J. W. Beede, of the University of Kansas, for use in connection with the preparation of a monograph on the fossils of the Upper Carboniferous strata of Nebraska and Kansas.

COOPERATION OF THE EXECUTIVE DEPARTMENTS OF THE GOVERNMENT.

As in past years, much valuable material has been received from several departments and bureaus of the Government, notably the Department of Agriculture, the U. S. Geological Survey, and the U. S. Fish Commission, under all of which extensive explorations into the resources of this country are continuously in progress. The collections derived from this source are enumerated in the List of Accessions (Appendix II), and those of special interest are also discussed in the reports of the head curators.

In this connection reference should be made to the services rendered by those curators and custodians who receive no compensation from the Museum. There are now about thirty of these honorary officers, the majority of whom are in the employ of other branches of the Government, and the assumption of the additional duties which they voluntarily perform in this connection is only rendered possible through the courtesy of the heads of the several departments and bureaus. In accepting the care and development of the collections placed in their charge, they are called upon in most cases to undertake a large amount of arduous routine work for which the Museum has not the means for engaging paid assistants.

INFORMATION FURNISHED.

Temporary accessions, consisting almost entirely of material sent to the Museum for identification, have been received to the number of 518 (numbers 5070 to 5587). Such specimens are usually returned to the senders unless used up in analysis or found desirable for addition to the collections. The amount of time consumed by members of the

scientific staff in making these identifications is necessarily very great, and has proved especially so in the Divisions of Insects and Geology. Many requests for technical information are received daily. When these relate to subjects coming within the scope of the activities of the Museum, as is very generally the case, they are promptly complied with, though the public little realizes the amount of work which this involves.

PUBLICATIONS.

The publications of the Museum issued and distributed during the year were the Annual Report for 1896, together with the separates of the several papers composing the appendix to the same; completed volume 20 of the Proceedings (issued in August, 1898); the separate editions of papers numbered from 1140 to 1178, inclusive, constituting volume 21 of the Proceedings; and parts 2 and 3 of Bulletin 47, entitled *The Fishes of North and Middle America*, by Drs. David Starr Jordan and Barton Warren Evermann. Part 4 of this Bulletin, an atlas of plates of fishes, is well under way.

The Annual Report for 1897 will be in two volumes, the second volume being in the nature of a memorial to the late assistant secretary, Dr. George Brown Goode. The proof reading of the first volume has been finished. The second volume and the Annual Report for 1898 are both in the printer's hands.

The Bibliography, forming Appendix IV of this volume, contains a list of all papers based upon Museum material which have been published during the year. The number of authors represented is 75 and the total number of titles given 318. The following table classifies these papers in accordance with the subjects treated:

Subject.	Papers by Museum officers.	Papers by other investi- gators.	Total.
Administration.....	3	.....	3
Archæology.....	6	.....	6
Biography.....	1	.....	1
Birds.....	25	21	46
Botany.....	7	3	10
Comparative anatomy.....	1	1	2
Ethnology.....	5	1	6
Fishes.....	7	3	10
Fossils.....	14	4	18
General natural history.....	2	.....	2
Geology.....	5	3	8
Insects.....	122	31	153
Mammals.....	16	1	17
Marine invertebrates.....	3	7	10
Minerals.....	.....	1	1
Mollusks.....	13	.....	13
Reptiles and batrachians.....	7	3	10
Miscellaneous.....	2	.....	2
Total.....	239	79	318

Twenty-two papers by members of the staff, based upon Museum material, have with the approval of the Secretary of the Smithsonian Institution been printed during the year in publications other than those of the Museum. Their titles will be found in the Bibliography. The names of the authors are as follows: Mr. Robert Ridgway, Dr. C. W. Richmond, Mr. G. S. Miller, jr., Mr. F. A. Lucas, Dr. J. N. Rose, Mr. C. L. Pollard, Mr. Charles Schuchert, and Mr. B. A. Bean.

LIBRARY.

During the past year the Museum library acquired through purchase, under a special act of Congress, the very important scientific library of the late Dr. G. Brown Goode, consisting of about 2,900 bound volumes, 18,000 pamphlets, and 1,800 portraits, autographs, and engravings. This collection, brought together at the expense of much time and labor on the part of Doctor Goode, contains many rare and valuable publications, and is especially rich in the literature of museums and of fishes.

The overcrowded condition of the library has been somewhat, though only temporarily, relieved by building for its use a gallery in the West North Range.

Six hundred and forty books, 965 pamphlets, and 5,196 parts of periodicals, including the regular Museum accessions and a small part of the Goode library, have been catalogued, and progress has been made in the transfer of titles to the new catalogue cards. From the accessions to the Smithsonian library 231 books, 649 pamphlets, and 8,616 parts of periodicals have been temporarily installed in the Museum. About 16,000 books and pamphlets were borrowed during the year, about one-third for the use of the sectional libraries. Among the purchases for the year have been a large number of works relating to the natural history of Cuba, Porto Rico, and the Philippine Islands. The number of books bound at the Government Printing Office was 441.

Three additional sectional libraries have been authorized, the list now standing as follows:

Administration.	Marine invertebrates.
Anthropology.	Medicine.
Biology.	Mesozoic fossils.
Birds.	Mineralogy.
Botany.	Mollusks.
Comparative anatomy.	Oriental antiquities.
Editorial.	Paleobotany
Ethnology.	Parasites.
Fishes.	Photography.
Geology.	Prehistoric archaeology.
History.	Reptiles.
Insects.	Stratigraphic paleontology.
Mammals,	Technology.

EXPLORATIONS.

Explorations yielding materials of much value have been conducted by members of the scientific staff of the Museum and by others. The importance of giving early attention to the investigation of the ethnology and natural history of the territories recently acquired by the United States was fully realized, but the lack of means has prevented any considerable inquiries in that direction.

In the interest of the Department of Anthropology, Mr. W. H. Holmes, head curator, visited California in September, 1898, and secured a valuable series of objects illustrating the ethnology and archaeology of that State. The auriferous gravel region of Calaveras and Tuolumne counties was studied, and many stone implements, supposed to have a bearing upon the occupation of that area by Tertiary man, were obtained. The ancient soapstone quarries and two prehistoric burial places in Santa Catalina Island were examined, and a number of relics were taken from the latter. The ethnological collection brought home by Mr. Holmes consisted in greater part of examples of the basketry, implements, etc., of the Pomo, Digger, and Tulare Indians.

Mr. Holmes also spent the month of April, 1899, in Mexico, where he obtained an important collection from the site of the ancient Aztec obsidian mines in the State of Hidalgo, besides a number of relics from the ancient cities of San Juan Teotihuacan and Xochicalco.

The autumn of 1898 and a part of the following winter were spent in Cuba by Mr. Paul Beckwith, of the Division of History, with the object of gathering material of historical interest relating to the war with Spain. He was successful in obtaining many valuable objects and also in enlisting the cooperation of military men and others in continuing the collecting.

Dr. George F. Becker, of the United States Geological Survey, for which he has been carrying on investigations in the Philippine Islands, has kindly agreed to look after the interests of the Museum in the same region.

Mr. J. B. Hatcher, sent to Patagonia on an extensive scientific mission by Princeton University, has also entered into an arrangement to supply ethnological material to the National Museum, and one important lot has been received from him.

In May, 1899, Dr. Walter Hough was detailed to carry on ethnobotanical researches in Mexico in connection with certain explorations by the Division of Botany in charge of Dr. J. N. Rose. Earlier in the year Doctor Hough had made a collection of potters' tools and several hundred pieces of pottery in West Virginia.

Mr. E. W. Nelson, while on a botanical expedition to Mexico, under the Department of Agriculture, secured a large number of archaeologi-

cal and ethnological objects, which were purchased by the Museum. Dr. Edward Palmer, also exploring in Mexico for the same department, made collections for the Museum. Dr. Roland Steiner, of Grovetown, Georgia, conducted extensive explorations in aboriginal quarries, workshops, and village sites near the mouth of the Little Kiokee River, Georgia, where he obtained many thousands of specimens, which will be included in the collection now being acquired by the Museum.

Among the explorations which yielded important results to the Department of Biology, those carried on in connection with the cruise of the steamer *Fish Hawk* to Porto Rico by the naturalists of the U. S. Fish Commission and by Mr. A. B. Baker, of the National Zoological Park, are especially worthy of mention. Of mollusks the Museum received some 5,000 specimens, representing about 400 species, many of which were rare and some undescribed. There were also large series of other marine and fresh-water invertebrates, about 180 birds, 200 reptiles and batrachians, and 200 bats.

A large and important series of mammals was collected for the Museum in Sweden, Germany, Belgium, and Switzerland by Mr. J. A. Loring, of Owego, New York. Mr. Dall De Weese, who visited Alaska during the summer of 1898, obtained for the Museum several specimens of the Alaska moose and a large number of the wild white sheep of that Territory.

Ornithological collections received at the Museum were made as follows: by Dr. E. A. Mearns, U. S. A., in Texas; by Mr. Paul D. Bergen and Mr. George D. Wilder, in China; by Mr. Outram Bangs, in Colombia; by Mr. J. Hornung, in the Western United States; by Mr. R. C. McGregor, in California; by Mr. Eugene Coubeaux, in the Northwest Territory, Canada.

A large series of reptiles and batrachians collected by field parties of the U. S. Fish Commission has been turned over to the Museum. This collection embraces a great deal of valuable material for the study of geographic distribution and individual variation, and includes a unique specimen of a discoglossoid toad,¹ the first member of this suborder which has been discovered in the Western Hemisphere. Collections of fishes resulting from explorations in the Northern Pacific Ocean, Alaska, Kamchatka, Lake Superior, and Florida have also been transferred by the Fish Commission. Fishes obtained by Mr. Chaffanjon in northern and central Asia were received from the Museum of Natural History at Paris.

The Division of Marine Invertebrates has been enriched by material collected by Dr. T. H. Bean and Mr. B. A. Bean, on Long Island; by Miss Mary J. Rathbun, at Grand Manan, New Brunswick; by Mr.

¹ Described in Proceedings paper No. 1178, by Dr. Leonhard Stejneger.

William Palmer and Mr. Paul Bartsch, in the Dismal Swamp, Virginia; by Mr. Harold Heath, in Monterey Bay, California, and by the Biological Laboratory, at Cold Spring Harbor, New York.

Mr. August Busck, of the Department of Agriculture, who accompanied the Fish Commission expedition to Porto Rico, obtained there a valuable collection of insects, which has been transferred to the Museum. Agents of the Department of Agriculture, collecting in Mexico, have contributed small numbers of mollusks, some of which are valuable in character.

At the close of the year Dr. J. N. Rose was engaged in botanical work in Mexico. Mr. Walter Evans, who visited Alaska for the Department of Agriculture, brought back with him a fine series of plants, which has been transferred to the Museum. The explorations by members of the Biological Survey of the same department, chiefly in the far West, have added much valuable material to the Herbarium. Important collections in botany have been made in Europe by Mr. W. T. Swingle and Mr. D. G. Fairchild. A number of Mexican plants collected by Mr. E. W. Nelson have been obtained by purchase.

The Department of Geology acquired an extensive series of Upper Silurian fossils, collected in the vicinity of Lockport, New York, for the Museum by Mr. H. E. Dickhaut, of the U. S. Geological Survey; and a large lot of Hamilton corals from near Iowa City, and Kinderhook corals from the vicinity of Burlington, in the State of Iowa, collected by Mr. Paul Bartsch.

Explorations by the Geological Survey have been illustrated by two collections of fossil plants, one representing the Lower Coal Measure, of Henry County, Missouri; the other the Carboniferous formation in the vicinity of McAlester, Indian Territory. Both of these lots have been described by Mr. David White, whose papers will be published by the Survey.

Geological material obtained in Europe by Mr. F. W. Crosby has been added to the collection.

Collectors' outfits.—Outfits have been furnished to the following persons, who have undertaken to collect material for the Museum: Mr. J. S. Holmes, Bowmans Bluff, North Carolina; Mr. D. W. Prentiss, jr., Washington, District of Columbia; Dr. E. A. Mearns, U. S. A.; Lieut. J. W. Daniel, Lynchburg, Virginia; Mr. Milton Whitney, Department of Agriculture; Mr. M. C. Long, Kansas City, Missouri; Dr. B. W. Evermann, U. S. Fish Commission; Rev. Paul D. Bergen, Chefoo, China; Mr. A. B. Baker, National Zoological Park; Lieut. H. E. Wetherill, Manila, Philippine Islands; Commander George E. Ide, U. S. N., Brooklyn Navy-Yard, New York; Sir Charles Eliot, British commissioner to Samoa; Commander J. C. Cantwell, U. S. N., Seattle, Washington; Mr. Leon J. Guthrie, Willemstad,

Curaçao, West Indies; Capt. A. C. Hansard, Lonquillo, Porto Rico; Mr. F. J. Tingley, Kingston, Jamaica; Mr. W. B. Stockman, Havana, Cuba; Mr. James H. Kimball, Roseau, Dominica, West Indies; Mr. E. T. Giers, Port of Spain, Trinidad; Mr. P. McDonough, Bridgetown, Barbados; Mr. W. Randall, Santiago, Cuba; Mr. George Kingsbury, Basse-Terre, St. Kitts, West Indies; Mr. Robert Stein, Sydney, Nova Scotia. Outfits were also furnished to the following members of the Museum staff: Dr. F. W. True, Mr. Gerrit S. Miller, jr., Miss M. J. Rathbun, Mr. William Palmer, Mr. Paul Bartsch, Mr. D. G. Fairchild, and Dr. J. N. Rose.

TAXIDERMY AND OSTEOLOGY.

Eighty specimens in the flesh, consisting of 54 mammals, 15 birds, and 11 reptiles, have been received during the year, a large portion having come from the National Zoological Park. The skins of most of these were prepared for the study series, and skeletons were saved of an elephant, a sea lion, a beaver, and several of the birds and reptiles. The accessions also included 94 mammal skins, which came either dry, fresh, or salted. The number of mammal skins mounted for exhibition purposes was 36.

Besides the above the taxidermic work has included the renovation of a large number of specimens in the divisions of mammals, birds, and reptiles, with reference more especially to the exhibition series, which are being rearranged and placed in more acceptable condition for the public use. The collections in these and other divisions of zoology which were displayed at the Trans-Mississippi Exposition, have been unpacked, renovated, and added to the exhibition series.

The total number of osteological specimens prepared was 1,528, consisting of 1,504 mammal skulls and skeletons, the skeletons of 14 birds, 3 reptiles, 3 fishes, and 4 miscellaneous objects.

PHOTOGRAPHY.

Mr. T. W. Smillie, photographer, reports that 473 negatives, 582 platinum prints, 123 silver prints, and 18 cyanotypes have been made during the year. Several collectors have received instruction in the photographic laboratory, and outfits for field work have been furnished them. Mr. Smillie has continued to act as chairman of the United States Civil Service Board on Photography.

EXPOSITIONS.

Trans-Mississippi and International Exposition.—The Exposition opened at Omaha on June 1, 1898, and continued for five months. The Annual Report for 1898 contains a brief reference to the exhibits

displayed by the Museum, while a more extended account will appear in the Smithsonian Report for 1899.

Pan-American Exposition, Buffalo.—By act of Congress approved March 3, 1899, the sum of \$300,000 has been appropriated for a Government exhibit at the Pan-American Exposition to be held at Buffalo in 1901, besides an additional sum of \$200,000 for the erection of a building. Dr. F. W. True, executive curator, has been designated as the representative of the Smithsonian Institution and National Museum on the Government board of management, and Mr. W. V. Cox as chief special agent.

Ohio Centennial Exposition.—An appropriation similar to that for the Pan-American Exposition has also been made by Congress for a Government exhibit and building at the Ohio Centennial Exposition, to be held at Toledo in 1902 or 1903, as may be determined upon hereafter. This appropriation is contingent, however, upon a grant of \$500,000 to the Exposition by the Ohio State legislature and the raising of the same amount by subscription.

Mention may here be made of the National Electric Light Exposition in New York City in 1899, where the Museum was represented by a number of models of electrical apparatus belonging to the Henry collection.

NECROLOGY.

Dr. Othniel Charles Marsh, Honorary Curator of the collection of Vertebrate Fossils in the National Museum, died at his home in New Haven, Connecticut, on March 18, 1899. Dr. Marsh had held the position of professor of paleontology in Yale University since 1866. He was born in Lockport, New York, in 1831. After being graduated from Yale in 1860 he spent five years in further study in the Sheffield Scientific School and in Germany. His explorations of the extensive fossil deposits of the West were begun in 1868. These led him into wholly unknown fields, and the record of his work from the time of his first connection as a professor with Yale University until his death forms a most important part of the history of recent progress in paleontological research.

Many valuable works embodying the results of his investigations have been published, and others were left in an advanced stage.

In 1876 Doctor Marsh was elected president of the American Association for the Advancement of Science, and in 1883 he became president of the National Academy of Sciences, a position which he held during two terms, or until 1895. He was connected with the U. S. Geological Survey, as paleontologist, for many years. In 1877 a medal was granted him by the Geological Society of London for most distinguished researches in geology and paleontology. He was

a member of many scientific societies both in this country and abroad. The University of Heidelberg conferred upon him in 1886 the degree of Doctor of Philosophy, and Harvard University about the same time gave him the degree of Doctor of Laws. He became a correspondent of the Academy of Sciences of the Institute of France in 1898, and as winner of the Cuvier prize he was the recipient of one of the greatest honors ever conferred upon an American scientific man.

Through the influence of Doctor Marsh, his uncle, George Peabody, made gifts to Yale University which resulted in the establishment of the Peabody Museum.

APPENDIX I.

THE MUSEUM STAFF.

[June 30, 1899.]

S. P. Langley, Secretary of the Smithsonian Institution, Keeper Ex-Officio.

Richard Rathbun, Assistant Secretary.

Frederick W. True, Executive Curator.

SCIENTIFIC STAFF.

DEPARTMENT OF ANTHROPOLOGY:

W. H. Holmes, Head Curator.

(a) *Division of Ethnology*: O. T. Mason, Curator; Walter Hough, Assistant Curator; F. H. Cushing, Collaborator; J. W. Fewkes, Collaborator.

(b) *Division of Historic Archaeology*: Paul Haupt, Honorary Curator; Cyrus Adler, Honorary Assistant Curator; I. M. Casanowicz, Aid.

(c) *Division of Prehistoric Archaeology*: Thomas Wilson, Curator.

(d) *Division of Technology* (Mechanical phases): J. E. Watkins, Curator; George C. Maynard, Aid.

Section of Electricity: G. C. Maynard, Custodian.

(e) *Division of Graphic Arts*: S. R. Koehler, Honorary Curator.

Section of Photography: T. W. Smillie, Custodian.

(f) *Division of Medicine*: J. M. Flint, U. S. N., Honorary Curator.

(g) *Division of Religions*:

Section of Historic Religious Ceremonials; Cyrus Adler, Custodian.

(h) *Division of History and Biography*:

Section of American History; A. H. Clark, Custodian; Paul Beckwith, Aid.

DEPARTMENT OF BIOLOGY:

Frederick W. True, Head Curator.

(a) *Division of Mammals*: Frederick W. True, Acting Curator; G. S. Miller, jr., Assistant Curator; Marcus W. Lyon, jr., Aid.

(b) *Division of Birds*: Robert Ridgway, Curator; Charles W. Richmond, Assistant Curator; J. H. Riley, Aid.

Section of Birds' Eggs: William L. Ralph, Custodian.

(c) *Division of Reptiles and Batrachians*: Leonhard Stejneger, Curator.

(d) *Division of Fishes*: Tarleton H. Bean, Honorary Curator; Barton A. Bean, Assistant Curator.

(e) *Division of Mollusks*: William H. Dall, Honorary Curator; C. T. Simpson, Aid; Paul Bartsch, Aid.

(f) *Division of Insects*: L. O. Howard, Honorary Curator; W. H. Ashmead, Assistant Curator; R. P. Currie, Aid.

Section of Hymenoptera: W. H. Ashmead, in charge.

Section of Myriapoda: O. F. Cook, Custodian.

Section of Diptera: D. W. Coquillett, Custodian.

Section of Coleoptera: E. A. Schwarz, Custodian.

Section of Lepidoptera: Harrison G. Dyar, Custodian.

Section of Arachnida: Nathan Banks, Custodian.

DEPARTMENT OF BIOLOGY—Continued.

- (g) *Division of Marine Invertebrates*: Richard Rathbun, Honorary Curator; J. E. Benedict, First Assistant Curator; Miss M. J. Rathbun, Second Assistant Curator.

Section of Helminthological Collections: C. W. Stiles, Custodian.

- (h) *Division of Comparative Anatomy*: Frederic A. Lucas, Curator.

- (i) *Division of Plants (National Herbarium)*: Frederick V. Coville, Honorary Curator; J. N. Rose, Assistant Curator; C. L. Pollard, Assistant Curator.

Section of Forestry: B. E. Fernow, Honorary Curator.

Section of Cryptogamic Collections: O. F. Cook, Honorary Assistant Curator.

Section of Algæ: W. T. Swingle, Custodian.

Section of Lower Fungi: D. G. Fairchild, Custodian.

Associates in Zoology (Honorary): Theodore N. Gill, C. Hart Merriam, R. E. C. Stearns.

DEPARTMENT OF GEOLOGY:

George P. Merrill, Head Curator.

- (a) *Division of Physical and Chemical Geology (Systematic and Applied)*: George P. Merrill, Curator; W. H. Newhall, Aid.

- (b) *Division of Mineralogy*: F. W. Clarke, Honorary Curator; Wirt Tassin, Assistant Curator; L. T. Chamberlain, Honorary Custodian of Gems and Precious Stones.

- (c) *Division of Stratigraphic Paleontology*: Charles D. Walcott, Honorary Curator; Charles Schuchert, Assistant Curator.

Section of Vertebrate Fossils: F. A. Lucas, Acting Assistant Curator.

Section of Invertebrate Fossils: Paleozoic, Charles Schuchert, Custodian; Carboniferous, George H. Girty, Custodian; Mesozoic, T. W. Stanton, Custodian; Cenozoic, W. H. Dall, Associate Curator.

Section of Paleobotany: Lester F. Ward, Associate Curator; A. C. Peale, Aid; F. H. Knowlton, Custodian of Mesozoic Plants; David White, Custodian of Paleozoic Plants.

Associate in Paleontology (Honorary): Charles A. White.

ADMINISTRATIVE STAFF.

Chief Clerk, W. V. Cox.

Chief of Buildings and Superintendence, J. E. Watkins.

Chief of Correspondence and Documents, R. I. Geare.

Photographer, T. W. Smillie.

Registrar, S. C. Brown.

Disbursing Clerk, W. W. Karr.

Property Clerk, W. A. Knowles (Acting).

Librarian, Cyrus Adler.

Assistant Librarian, N. P. Scudder.

Editor, Marcus Benjamin.

APPENDIX II.

LIST OF ACCESSIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1899.

[All accessions marked "O" indicate material obtained primarily for exhibition at the Omaha Exposition.]

ABBOTT, Miss MILLIE, Vineland, N. J.:
Small collection of medicinal plants.
34270.

ABEL, J. C., Lancaster, Pa.: Collection of
rude chipped implements from the
Conestoga Hills near Lancaster (34256);
33 archaeological objects from the same
locality (34949).

ADAMS, HARRY, Mason City, W. Va.:
Eighty-seven archaeological objects
from Mason County. 33752.

ADDER, Dr. CYRUS, Smithsonian Institution:
Engraved portraits of Ben Jon-
son, Ernest Mach, and Ernest Haeckel
(34328); pictures of Ramsgate, Eng-
land, containing views of churches and
synagogues (34627).

AGRICULTURE, DEPARTMENT OF, Hon.
James Wilson, Secretary: Two thou-
sand two hundred and twenty-six
Mexican insects collected by Prof.
Herbert Osborn (33999); 6 speci-
mens of slugs found on tobacco
plants (34277); South American in-
sects collected by Prof. L. Bruner
(34348); 9 specimens of *Gelechia sol-
anella* (34416); large collection of
Odonata, representing many species
new to the Museum collection
(34572); land shells from Mexico
(34950); 1,878 specimens of Diptera
(35025).

Deposited in the National Herbarium:

Three specimens of a rare fungus
from Arizona (34152); 130 plants
collected by F. V. Coville in Wash-
ington (34259); plant from the
grounds of the Department of Agri-
culture (34275); dried plants from
Oregon and Washington collected by
E. P. Sheldon (34298); 3 specimens
of moss from California and Mary-

AGRICULTURE, DEPARTMENT OF—Cont'd.

Deposited in the National Herbarium— Continued.

land (34450); 2 type specimens of
plants collected by A. B. Eaton in
Newburyport, Mass. (34526); 2
plants from Bering Sea and Florida
(34877); plants obtained by Dr. A.
Koenig, Plum Township, Pa.
(34915); 398 plants (34981); speci-
men of *Ribes divaricatum* collected
by W. F. Hebert (35009); received
through A. B. Eaton, 2 plants from
the conservatory of the Department
of Agriculture (35138). (See under
G. M. Bradford, B. H. Brodnax, L.
Bruner, C. B. Bryan, Frank Burton,
F. V. Coville, F. W. Cusack, Dr. W.
G. Deitz, Anthony Dignowitz, A. B.
Eaton, W. H. Evans, W. W. Harring-
ton, W. F. Heathman, W. F. He-
bert, G. Hogan, A. J. Johnson, A.
Koenig, N. B. Lukenty, W. W. Nor-
man, Herbert Osborn, J. C. Parlin,
C. C. Plitt, E. N. Plank, W. Rosalsky,
W. W. Rowles, J. Ford Sempers, C. L.
Shear, E. P. Sheldon, Aug. Steinman,
F. W. Thurow, S. M. Tracy.

AKRON POTTERY COMPANY, Akron, Ohio:
Clay. 34174.

ALBANY MUSEUM. (See under Grahams-
town, South Africa.)

ALEXANDER, E. P., Greytown, Nicaragua:
Four bats in alcohol, from Greytown
(purchase) (33781); snake (gift) (33782);
seeds of *Contre-veneno*, supposed to be
an antidote for snake bites (gift)
(34631).

ALLEN, C. H., Hon. (See under Navy
Department.)

ALLEN, Dr. J. A. (See under American
Museum of Natural History.)

- ALLEN, J. E., Orlando, Fla.: Specimen of *Lycosa carolina* Hentz. 34265.
- ALLEN, O. D., Ashford, Wash.: One hundred and fifteen plants from Washington. Purchase. 34563.
- AMERICAN MUSEUM OF NATURAL HISTORY, New York City, received through J. H. Winser: Six photographs of Eskimos obtained by Lieutenant Peary in 1896 (gift) (34040); received through Dr. J. A. Allen, 15 mammals from Trinidad (exchange) (34444); collection of ethnological objects obtained from the Northern Eskimos, Port Clarence (exchange) (35098).
- ANDERSON, SAMUEL, White Sulphur Springs, Mont.: Ores, coal, and other material. 34656. (O.)
- ANDRUS, F. J., Elkton, Oreg.: Two species of *Anodonta* from Oregon (33927); 4 species of fresh-water bivalves from Oregon (34135).
- ANGELL, J. P., Pine Bluff, Ark.: Tachinid fly (34022); specimens of *Chærocampa lersa* L and *Arctia nais* Say (34163).
- ANGELL, Miss LILLIE, Orange, N. J.: Thirty-five specimens of violets from New Jersey. 35147.
- ANGELL, M., Pine Bluff, Ark.: Cicindelid, *Tetracha carolina* Linné. 33922.
- ANTHONY, A. W., Portland, Oreg.: Eight specimens of *Peromyscus austerus*. 34349.
- ANTHROPOLOGICAL SOCIETY OF WASHINGTON, Washington, D. C., received through F. W. Hodge, Curator: Bronze medal presented to the Society by the Numismatic and Antiquarian Society of Montreal. 33798.
- ARMSTRONG, F. B., Corpus Christi, Tex.: Birdskin, and skin and skull of a skunk, representing the genus *Spilogale*. Purchase. 35111.
- ARMSTRONG, L. K., Spokane, Wash.: Building stones, slate, and talc. 34663. (O.)
- ARMY MEDICAL MUSEUM. (See under War Department.)
- ARNOLD, E., Battle Creek, Mich.: Seven birds' skins from northwestern Canada. 33821.
- ARNOLD, ROBERT, Mathias Point, Va.: Larva or caterpillar of *Citheronia regalis* Fabr. 33961.
- ARNOLD, W., St. Simons Mills, Ga.: Photograph of the skeleton of a whale (*Mesoptodon bidens*). 33971.
- ASHMEAD, W. H., U. S. National Museum: One hundred and two species of Algae from England, Scotland, and Florida (33834); Ashmead collection of insects, consisting of 60,000 specimens. (35236.)
- ASHMUN, Rev. E. H., Albuquerque, N. Mex.: Land shells from New Mexico. 34217, 34646, 35020.
- AVONDALE LIME AND STONE COMPANY, Philadelphia, Pa.: Limestone used for making quicklime. 34144.
- AYRES, Dr., San Juan, Porto Rico: Spanish hand-press. (See under Porto Rico Collection.) 35201.
- AYRES, Mrs. F. D., Peacock, N. C.: Saddle-back caterpillar, *Empretia stimulea* Clemens. 34036.
- AYSON, L. T., Wellington, New Zealand: Seventeen birds' skins. Exchange. 34453.
- AZTEC CLUB, New York City, received through De Lancey Floyd-Jones: Aztec Club medal, in commemoration of the fiftieth anniversary of the Aztec Club. 34598.
- BACHE, RENÉ, Washington, D. C.: Six photographs of Lapp reindeer people, Alaska. 34367.
- BACKUS, CLEO, Port Townsend, Wash., received through O. E. Shaffer: Specimen of *Rhamphocottus richardsoni* from Port Townsend Bay. 34947.
- BAGWELL, G. D., Fort Assiniboine, Mont.: Collection of objects used during the Spanish-American war. 34068.
- BAKER, A. B., National Zoological Park: Vertebrate fossils (34542); collection of natural history specimens, rocks, ores, and a rope slipper from Porto Rico (34779).
- BAKER, Prof. C. F., Auburn, Ala.: Six specimens of Umbelliferae (33817); large collection of insects containing many type specimens (33963); 6 plants from Colorado (34008); large collection of Hymenoptera, consisting of about 24,000 specimens and including many new species (34091); crabs from the Gulf of Mexico (34047); specimen of *Uca minax* (34132); collection of insects

- BAKER, Prof. C. F.—Continued.
representing about 13,000 specimens (34187); a large collection of *Siphonaptera*, consisting of about 234 glass slides mounted in balsam (34228); collection of about 16,000 specimens of Homoptera, birds, and birds' eggs obtained principally from Colorado, and a skin of *Spermophile* (*Spermophilus elegans*) (34272).
- BAKER, Prof. C. F., St. Croix Falls, Wis.: Crustaceans, mollusks, sea-urchins, and a fish from Santa Marta, Colombia and Haiti. Exchange. 34570.
- BAKER, Dr. FRED., San Diego, Cal.: Two species of land and marine shells from South Coronado Island, Lower California (34630); 13 specimens of mollusks belonging to the genus *Vitrinella* from California (34720).
- BAKER, J. G., Royal Gardens, Kew, England, received through Dr. W. T. Thiselton-Dyer, director: A large and valuable collection of plants, containing about 5,000 specimens and constituting a part of Mr. Baker's private collection. 34652.
- BAKER, Dr. J. W., U. S. Navy, Erie, Pa.: Imago and pupa cases of May-fly, *Hexagenia limbata* Pictet (33771); Coccinellid beetle, *Anatis 15-punctata* Oliv. (33873).
- BAKER UNIVERSITY, Baldwin, Kans., received through C. S. Parmenter: Forty specimens of insects. 35028.
- BALDWIN, H. O., New Brighton, Pa.: Unfinished arrowhead and a Carboniferous plant found near the junction of Beaver River with the Ohio River. 35013.
- BALDWIN, WALTER, Mount Vernon, Ind.: Badge of the First Brigade, Second Division, Seventh Army Corps, U. S. Volunteers worn by the donor during the Cuban campaign of the Spanish-American war. 34968.
- BALL BROTHERS, Cocoanut Grove, Fla.: Photograph of a specimen of Lady-fish, *Albula vulpes*, from Biscayne Bay. 34804.
- BALLINGER, R. H., Seattle, Wash.: Sample of diatomaceous earth. 34261.
- BALZER, S. M., New York City: Automobile carriage made in 1894 (gift); extra engine accompanying the carriage (deposit). 35051.
- BANGS, OUTRAM, Boston, Mass.: Four parrot skins from South America (gift) (34014); specimen of *Oryzomys obscurior* (gift) (34078); 54 birds' skins from South America (gift) (34098); 14 small mammals from Colombia (exchange) (34477); 13 mammals (gift) (34784).
- BANGS & GAYNOR, Fayetteville, N. Y.: Cement rock. 34243.
- BANKS, NATHAN, Department of Agriculture: Four named species of Myrmecoleonids, new to the Museum collection. Exchange. 34043.
- BANNING, HANCOCK, Los Angeles, Cal.: Soapstone vessels from Avalon, Santa Catalina Island, coast of California. 34715. (O.)
- BANNING & Co., Los Angeles, Cal.: Soapstone and talc. 34336.
- BARBER, Mrs. A. A., Washington, D. C.: Part of a weatherworn skull of a buffalo. 34079.
- BARBER, A. W., Washington, D. C.: Leg bones of *Hippotherium* (34197); large chipped implement of quartzite from the shore of White River, South Dakota, skull from near the Bad Lands, and 6 fragments of a peculiar concretion from Rosebud Indian Reservation (34910).
- BARBER, E. A., Philadelphia, Pa.: Collection of pottery and porcelains (34791); collection of early American pottery (34926). Purchase.
- BARBER, C. M., Rudioso, N. Mex.: Nineteen specimens of reptiles and batrachians from New Mexico. Purchase. 34617.
- BARBER, HERBERT, Washington, D. C.: Eight species of *Odonata*. 34577.
- BARBOUR, E. H., University of Nebraska, Lincoln, Nebr.: Concretions and minerals. 34785.
- BARLOW, Hon. A. D., City of Mexico, Mexico, received through Department of State: Mexican musical instrument. 34889.

- BARLOW, CHESTER, Santa Clara, Cal.: Nine birds' skins from California. 34004.
- BARNHART, DR. J. H., Tarrytown, N. Y.: Plant, representing a new species of *Utricularia*. 34388.
- BARNUM, REV. FRANCIS, Georgetown University, Washington, D. C.: Specimens of *Dallia pectoralis* and the Arctic form of Ten-spined Stickleback, *Pygosteus pungitius brachypoda*. 34338.
- BARR, J. A. (See under Smithsonian Institution, Bureau of Ethnology.)
- BARRETT, O. W., Museo de Tacubaya, Tacubaya, D. F., Mexico: One hundred and forty insects. (33897, 34334.)
- BARRETT-HAMILTON, G. E. H., and O. H. JONES: Collection of invertebrates, insects, and other specimens from Petropaulovski and Karaga Village, Kamchatka, and from the island of Karaghinsky, Bering Sea. 34286.
- BARRETT-STRAIT, MISS C., Lancaster, S. C.: Unfinished banner-stone or butterfly ornament from South Carolina. 35230.
- BARTSCH, PAUL, U. S. National Museum: Two specimens of bat (*Lasiurus borealis*) from Missouri (34071); amphipods and isopods from Iowa (34106); 72 specimens of mammals from Burlington, Iowa (34154); mink (*Putorius vison*) from Burlington, Iowa (34281); 4 turtles and 2 frogs from Iowa (34413); natural history specimens and fossils from Burlington and Iowa City (34699); natural history specimens (34756); turtle from Eastern Branch, District of Columbia (35029); collection of isopods, sponges, shells, fishes, and plants from Virginia (35186).
- BARTLETT, C. H., South Bend, Ind.: Inscribed wooden tablet. Deposit. 33980.
- BAWM, H. E., Washington, D. C.: Krag-Jørgensen rifle cartridge issued during Spanish-American war, Santiago de Cuba. 33996.
- BEACH, SUMNER, Denton, Mont.: Four arrow points and a shell bead found in the Judith Basin, Fergus County, Mont. Exchange. 34707.
- BEADLE, C. D., Biltmore, N. C.: Two hundred and ninety-five plants (34412); 4 specimens of violets (34451). Exchange.
- BEALL, MISS FANNIE, Washington, D. C.: Saddle once owned by General Grant and deposited in the National Museum in 1867 by Gen. A. H. Markland. 34665.¹
- BEAM, C. C., Bluffton, Ind.: Two lizards, representing the species *Anolis copei* and *Sceloporus siniferus* from Mexico. 34798.
- BEAN, B. A., U. S. National Museum: Collection of fishes, mammals, reptiles, crustaceans, and insects from Long Island, New York (33975); beetle (34117); Purple Grackle (34213).
- BEAN, DR. T. H., Washington, D. C.: Amphipods from Caledonia, N. Y., and Carolina, R. I. (33754); shells and cases of caddis-fly larva (33759); collection of lichens from Alaska and Siberia obtained in 1880 (34470); 3 specimens of leeches, representing the genus *Branchellion* taken from a Ray at Southampton, N. Y. (34495). (See under E. D. Merrill.)
- BEAN, DR. T. H., and B. A. Bean, U. S. National Museum: Collection of natural history specimens from Long Island, obtained during the summer and fall of 1898. 34283.
- BEATTY, H. L., Bainbridge, N. Y.: Cuban fractional currency used during Weyler's régime, 50 centavos, issued in Habana, Cuba, May 15, 1896. 34783.
- BEAUPRÉ, EDWIN, Portsmouth, Ontario, Canada: Two specimens of Yellowthroat, *Geothlypis trichas*, from Canada. 35195.
- BECERRA-MUÑOZ, DIEGO, Aibonito, P. R.: Large idol. (See under Porto Rico Collection, 35201.)
- BECKER, G. F., Manila, P. I.: Skeleton of a male Nigrito; skeleton of a female Nigrito; skull of a Filipino, collected near Nariveles. 34441.
- BECKWITH, C. H., Omaha, Nebr.: Six souvenir medals of the Trans-Mississippi and International Exposition. 34310. (O.)
- BECKWITH, PAUL, U. S. National Museum: Regulation army canteen used during the civil war, 1861-1865 (33853); 10 crabs, representing 2 species from San Juan Bay, Porto Rico, and 20 bats from Porto Rico (34792). (See under Norfolk Collection; Porto Rico Collection.)

¹In view of certain satisfactory evidence submitted by Miss Beall in January, 1899, the ownership of the saddle is now vested in her name.

- BEECHER, Dr. CHARLES E., Yale University, New Haven, Conn.: Model of specimen of *Triarthrus becki*; cast of specimen of *Arthrolycosa antiqua*; 2 specimens of *Elymocarissiliqua* Beecher; 4 specimens of *Tropidocaris bicarinata* Beecher, and 5 specimens of *Echinocaris socialis* Beecher. 34342.
- BEECHER, W. L., Reading, Pa.: Specimen of *Actias luna* Linnaeus. 34092.
- BEEDE, Prof. J. W., University of Kansas, Lawrence, Kans.: Eight specimens of *Myalina swallowi* from Turner, Kans. (exchange), (34164); 10 specimens of *Pseudomonotis* from the upper coal measures of Kansas (gift) (34932).
- BEER, WILLIAM, New Orleans, La.: Engraved portrait of Pierre Margry. 34327.
- BELL, Col. JAMES, U. S. A., War Department, Washington, D. C.: Mounted head of *Alces americanus*. Deposit. 34549.
- BENEDICT, J. E., U. S. National Museum: Bat (*Lasiurus borealis*) from Omaha, Nebr. 34584.
- BENJAMIN, Mrs. MARCUS, Washington, D. C.: Ribbon badge of the Grand Commandery, South Dakota, at the grand encampment of the Knights of Pythias, Pittsburg, Pa., October 11-14, 1898; badge of jurors at the Trans-Mississippi and International Exposition; medal worn at the Peace Jubilee, Philadelphia, October 26, 1898, and badge and gilt medal of the Peace Jubilee, Spanish-American war, Philadelphia, 1898 (34721); 3 specimens, in stone, of animals manufactured by the Union Stoneware Company, of Red Wing, Minn. (34973).
- BENNET, Gen. W. T., Ponce, P. R.: Spanish buttons, insignia worn on Spanish summer helmets, and a ditty-bag distributed by the Red Cross Society to the soldiers of the Porto Rican campaign. (See under Porto Rico collection 35201.)
- BENTON LEAD AND ZINC MINING COMPANY, Benton, Wis.: Lead and zinc ore. 34250.
- BERGEN, Rev. P. D., Chefoo, China: Forty-eight birds' skins and 2 mammal skins from China. Exchange. 34573.
- BERKELEY SAND COMPANY, Berkeley Springs, W. Va.: Sand. 34222.
- BERNADOU, Lieut. J. B. (See under Lieut. H. C. Poundstone.)
- BETHEL, E., Denver, Colo.: Ten plants. 33788.
- BETHEL, S., Lewiston, Idaho: Toad (*Bufo columbiensis*) (33852); specimen of *Japya americana* (34768).
- BEYMER, A. R., Rocky Ford, Colo.: Two rude arrow points and a small stone pendant from near the Apiskapaw River, Colorado. 34946.
- BICKMORE, Prof. A. S., American Museum of Natural History, New York City: Two mounted photographs of a mammoth skeleton in the Museum at St. Petersburg, Russia. 34511.
- BIEDERMAN, C. R., Gold Hill, Oreg.: Grooved implement of sandstone (33751); collection of insects (33772); lizard (33825).
- BIGNELL, G. C., Saltash, Cornwall, England: Pupae of *Pieris rapae* infested with hymenopterous and dipterous parasites. 34888.
- BIGNOLD, L. B., Montesano, Wash.: Specimen of *Epeira trifolium* Hentz. 34303.
- BILTMORE HERBARIUM, Biltmore, N. C.: Sixty-four specimens of violets. Exchange. 35134.
- BINNEY, W. G., Burlington, N. J.: Ten specimens of *Polygyra columbiana* from San Mateo County, Cal. 34517.
- BIOLOGICAL LABORATORY, Cold Spring, N. Y.: Crustaceans. Exchange. 34016.
- BIRD, HENRY, Rye, N. Y.: Thirty-four moths with pupae. 34637.
- BISHOP, Mrs. JOSEPHINE, Albany, N. Y.: Three photographs of the Cohoes mastodon. 34754.
- BISHOP, Dr. L. B., New Haven, Conn.: Song Sparrow from North Dakota. 34033.
- BLACK DIAMOND MINING COMPANY, San Francisco, Cal.: Sample of coal. 34220.
- BLAIR, R. A., Sedalia, Mo., received through Charles Schuchert: Three hundred specimens of Choteau fossils. 33745.
- BLAKE, W. P., Tucson, Ariz.: Rose-colored tuff from Tucson Mountains, Arizona. 35083.
- BLISS, E. W., Childersburg, Ala.: Moth (*Telega polyphemus*). 34991.

- BLISS, MRS. S., Bigbug, Ariz.: Specimen of *Phusiotis gloria* Leconte. 34978.
- BLUE, A., Bureau of Mines, Toronto, Canada: Corundum in granite from eastern Ontario. 34893.
- BOEPPLE, J. F., Muscatine, Iowa: Specimens of Unionidae (gift) (34273); 24 polished valves of shells of Unionidae, and iron concretions (exchange) (34550); buttons manufactured from fresh-water mussels (gift) (34750).
- BOETTGER, DR. O. (See under Frankfurt-am-Main, Museum Senckenbergianum.)
- BONXELL, W. B., Macon, Ga.: Bauxite from Demorest. 35014.
- BOSTON FLINT PAPER COMPANY, Hallowell, Me.: Garnets used for abrasive purposes. 34331.
- BOUGHNER, A. V., Greensboro, Pa.: Salt glaze jar made in 1860 at the Boughner Pottery Works, and obtained by Dr. Walter Hough. 34054.
- BOUGHNER, CLAUDE, Greensboro, Pa.: Glass bottle manufactured at the Albert Gallatin Glass Factory about the year 1803. Purchase. 34208.
- BOUGHNER, WILLIAM, Greensboro, Pa.: Brown glaze jug made at the Boughner Pottery Works in 1849, obtained by Dr. Walter Hough. 34055.
- BOUNDS, J. M., Chepultepec, Ala.: Fossils and fragments of soapstone. 34495.
- BOUVIER, E. L. (See under Paris, France, Musée d'Histoire Naturelle.)
- BOWMAN, N. W., Massanetta Springs, Va.: Specimen of *Dynastes titypus* Linnaeus. 33826.
- BOYLE, W. J., Brooklyn, N. Y.: Sample of diatomaceous earth from Ireland. 34600.
- BRADFORD, Commander R. B., U. S. N. (See under Navy Department.)
- BRADFORD, G. M., Bay City, Mich., received through Department of Agriculture: Plant. 33864.
- BRAENDLE, F. J., Washington, D. C.: Eleven plants (34082); Yellow-bellied Sapsucker, *Sphyrapicus varius* (34850).
- BRAINARD, Lieut. F. R., U. S. N.: Cartridge case of shot fired from the U. S. S. *Uncas* off Maya Point, Matanzas Bay (gift) (34089); received through Mrs. Ellen Brainerd Van Arsdale, flag
- BRAINARD, Lieut. F. R.—Continued.
of truce carried by Lieutenant Brainard into Havana on May 15, 1898 (deposit) (34122).
- BRANDEGEE, T. S., San Diego, Cal.: Type specimen of a plant (exchange) (34087); plant from lower California (gift) (34528); plant from lower California (exchange) (34587); 3 plants (exchange) (34675).
- BRANDT, E. S., Navy Department: Mauser rifle cartridge complete; from El Caney, Santiago de Cuba. 33920.
- BRELSFORD, W. H., U. S. National Museum: Brass number worn on the collar of Spanish uniforms to designate the regiments numerically. 34185.
- BRETON, Miss A. C., Mexico, Mexico: Specimen of pottery, human bones, etc., from a burial place in Mexico (34171); 16 obsidian implements from Cerro de Nabajas, Mexico (34487); small carved stone frog from Mexico (35151).
- BRIGGS, Dr. A. A., East Andover, N. H.: Five plants. 33914.
- BRIGGS, C. F. (See under Smithsonian Institution, Bureau of Ethnology.)
- BRIMLEY, H. H. & C. S., Raleigh, N. C.: Reptiles from New Mexico. 34383.
- BRISTOL, Dr. C. L. (See under New York University.)
- BRITISH MUSEUM. (See under London, England.)
- BRITTS, Dr. J. H., Clinton, Mo.: Unio, representing a new species. 34360.
- BROCKETT, PAUL, U. S. National Museum: "Green's Arctic Lamp," patent. 33978.
- BRODNAX, Dr. B. H., Brodnax, La.: Medicinal plants (33809); specimen of Velvet Ant or False Ant, *Mutilla occidentalis* (34062); received through Department of Agriculture, plant (35159).
- BROWER, J. V., St. Paul, Minn.: One hundred and seventy-five chipped flint objects from Kansas; also 2 bound volumes containing descriptions of the same. Exchange. 34670.
- BROWN, A. T., North Bend, Pa.: Rustic cane carried by the donor through the campaign of Santiago de Cuba, and carved and lettered to illustrate events connected with the campaign. 33912. Returned.

- BROWN, H. E., Mendocino, Cal.: Thirteen plants (gift) (34513); 175 plants (purchase) (34761).
- BROWN, Mrs. J. C., New York City: Photograph of a New Guinea shield, and photograph of an African shield. 35117.
- BROWN, Mrs. N. M., Ashtabula, Ohio: One thousand six hundred and eighty-one plants collected by E. W. Nelson in Mexico. (33787, 33929, 34031, 34237). Purchase.
- BROWN, W. L., Corona, Cal.: Four species of insects. 34580.
- BROWNE, H. H. (no address given): Specimen of *Hydrometra lineata* Say. 33747.
- BROWNE, Mrs. William Henry. (See under National Society of the Colonial Dames of America.)
- BRUNER, Prof. L., Lincoln, Nebr., received through Dr. L. O. Howard: Collection of South American Orthoptera and Hymenoptera from Argentina. Purchase. 34229. (See under Agriculture, Department of.)
- BRUNETTI, E., London, England: Two hundred and ninety-six specimens of Diptera. Exchange. 34578.
- BRUSON, C. B., Fort McPherson, Ga.: Moth. 33969.
- BRYAN, Rev. C. B., Hampton, Va., received through Department of Agriculture: Specimen of *Myosurus* sp. 35031.
- BRYANT, F. W., Ramona, Cal.: Specimens of mollusks belonging to the genus *Truncatella*. 34463.
- BRYANT, F. W., Ramona, Cal.: Shell from New Mexico. 35017.
- BUCK, W. T., Freehold, N. J.: Grooved axes, arrow points, and other objects. 34497.
- BULKLEY, E. W., Brooklyn, N. Y.: Medicinal plants. 33810.
- BURDEN, C. E., Mount Pleasant, D. C.: Nineteen specimens of Hymenoptera, etc., including 5 species new to the Museum collection (33774); 19 specimens of Hymenoptera and *Odonata* (33855); 7 dragon flies (33888); 2 specimens of *Libellula plumbea* Ulk and *Fronscolombia vinosa* Say (34552).
- BURTCH, VERDI, Penn Yan, N. Y.: Song Sparrow (partial albino) from New York (34215); 3 species of Unionidae (34475).
- BURTON, FRANK, Berwyn, Md., received through the Department of Agriculture: Two specimens of *Silene dichotoma*. 33790.
- BUSH, Mrs. A. E., San Jose, Cal.: Shells, representing the genera *Anodonta* and *Sigaretus*. 35071.
- BUSH, B. F., Courtney, Mo.: One hundred and twenty-four plants. Purchase. 35179.
- BUTTERWORTH, JOHN, Shaw, near Oldham, England: Sections of coal plants from the Lancashire and Yorkshire coal fields. 34248.
- BUTTS, EDWARD, Kansas City, Mo.: Twenty-seven specimens of Upper Carboniferous fossils, representing 9 species. 34411.
- CALKINS, Lieut. C. G., U. S. N., San Francisco, Cal.: Lacquered case containing several hundred playing-cards from Japan and 2 joints containing gambling sticks from China. Purchase. 35141.
- CALLIS, J. M., Pendleton, Ky., received through Mrs. N. J. Whitesides: Crossed guns: hat ornament of the regulation pattern of the United States Army, worn by the donor during the Santiago campaign and at the assault on the San Juan redoubts, July 1, 1898. 33896.
- CALMORE, C. A., Santa Monica, Cal.: Fifty-one specimens of *Eucalyptus* from California. 34704.
- CAMBRIDGE TILE MANUFACTURING COMPANY, Covington, Ky.: Thirty-five specimens of art tiles. 35090.
- CAMMANN, Dr. D. M., New York City: Specimen of Agrinoid, representing the species *Anomalagrion hastatum*. 34864.
- CAMP, J. H., Lima, Ohio: Specimen of *Corydalis cornutus* Linné (33800); specimens of *Scalops aquaticus machrinus* (34961).
- CAMPBELL, M. R. (See under Interior Department, United States Geological Survey.)
- CANBY, W. M., Wilmington, N. C.: Ninety-nine plants (34410); type specimen of a plant from Georgia (34941). Exchange.
- CARDENAS, AMADOR, received through Prof. F. W. Clarke: *Onyx* from Jimulco, Coahuila, Mexico. 34657. (O.)

- CARINTHIA, AUSTRIA: Freie Vereinigung Tiroler Botaniker, Dillach im Oberdrauthale, received through Hans Simmer: 1,132 plants collected in Europe. Exchange. 34515.
- CARL GREN, DR. OSCAR. (See under Stockholm, Sweden, Riksmuseum.)
- CARMICHAEL, R. D., Meadow, Ala.: Two hundred rude chipped implements, arrow points and other objects (34433); 77 chipped objects, principally rude arrowheads (34669).
- CARNEGIE MUSEUM, Pittsburg, Pa., received through E. B. Williamson: Two specimens of *Anodonta*. 34404.
- CARSON, MAJ. J. M., San Juan, P. R.: Pair of shoulder straps. (See under Porto Rico Collection. 35201.)
- CARTER, W. A. (See under Dr. W. A. Phillips.)
- CATRELL, W. H., Buffalo, N. Y.: Centavo, Spanish copper coin, recovered from the wreck of the Spanish steamer *Alphonso XII*, sunk in Mariel Harbor, Cuba. 34901.
- CHAFFANJON, M. (See under Paris, France, Musée d'Histoire Naturelle.)
- CHANDLER, W. E., Washington, D. C.: One hundred and twelve South American photographs and pictures. 35099.
- CHAPMAN, JOHN, San Diego, Cal.: Specimens of Rag-fish, *Icosteus wignificus*. 35119.
- CHAPMAN, N. A., Portsmouth, Ohio: Teeth of mammal found in an old Indian village. 34786.
- CHAPPELL, S. B., Northport, N. Y.: Three arrowheads. 34440.
- CHENEY, A. N. (See under Sportsman's Exposition, New York; Quebec exhibit.)
- CHILTON, DR. CHARLES, Edinburg, Scotland: Five species of Amphipods from New Zealand. Exchange. 34757.
- CHISSELL, E. T., Bluefields, Nicaragua: Seven insects. 34504.
- CHITTENDEN, F. H., Department of Agriculture: Specimen of *Xylophilus ater* Lec. 33990.
- CHRISTY FIRE CLAY COMPANY, St. Louis, Mo.: Fire clay. 34240.
- CLAIBORNE, R. S., Washington, D. C.: Badge of the First Division, Second Army Corps, U. S. Volunteers, worn during the Cuban campaign (34848); regulation army belt with three Spanish cartridge boxes; letter head and illustrated card of the San Quentin Regiment of Spanish Infantry, commemorating the action in which the Cuban general Maceo was killed (34861).
- CLAPP, G. H., Pittsburg, Pa.: Thirty-six species of land and fresh-water shells from Java (34326); specimen of *Polygyra christyi* from Tennessee (34585); specimen of *Gastrodonta clappi* from Tennessee (34616); 2 species of North American land shells (34645); 3 land shells from Indian Territory (34767).
- CLARK, G. W., Wyandale, N. Y.: Specimen of "Vital ore." 34836.
- CLARKE, PROF. F. W. (See under Amador Cardenas and Interior Department, U. S. Geological Survey.)
- CLARKE, R. E., Spokane, Wash.: Specimen of mispickel from Idaho. 35003.
- CLAYPOLE, PROF. E. W., Akron, Ohio: Specimens of Carboniferous nodules from Lancashire, England. 33921.
- CLENDANIEL, G., Dover, Del.: Official badge, Grand Army of the Republic, Thirty-fifth Encampment. 33998.
- COBB, J. L., Lincolnton, N. C.: Specimen of *Misumene americana* Keys, 35150.
- COBB LIME COMPANY, Rockland, Me.: Limestone used for making quicklime. 34246.
- COCKERELL, M. D., Mesilla Park, N. Mex.: Three specimens of *Porcellio laevis*. 34957.
- COCKERELL, PROF. T. D. A. (See under New Mexico Agricultural Experiment Station.)
- COCKERELL, ERNEST, Madison, Kans.: Cecropia moth, *Attacus cecropia* Linnaeus. 35072.
- COHUTTA TALC COMPANY, Spring Place, Ga.: Specimens of talc. 34339.
- COLDITZ, M., Allardt, Tenn.: Thirty-four arrow-points and spear-heads. 35075.
- COLE, W. D., Bryn Mawr, Cal.: Fossil vertebra of a whale found on the foothills south of Pomona, southern California. 34892.
- COLEMAN, MRS. CHARLES WASHINGTON. (See under National Society Colonial Dames of America.)

- COLLINS, F. S., Malden, Mass.: Fascicle No. 9 (50 specimens) of *Phycotheca Boreali-Americana* (33789); 50 plants comprising a collection of miscellaneous algae (34403); 50 specimens of North American seaweeds (34624); 50 plants (34988). Purchase.
- COLLINS, G. N., Department of Agriculture: Collection of insects from central New York (34201); black snake from Washington, D. C. (34960).
- COLLINS, J. FRANKLIN, Providence, R. I.: Twenty-two plants. Exchange. 34323.
- COLLINS, Capt. J. W. (See under Hon. Chris Michelsen.)
- COLUMBIA COLLEGE, New York City. (See under Senff Zoological Expedition.)
- COLUMBIAN TALC COMPANY, Gouverneur, N. Y.: Six specimens of crude and ground talc. 35047.
- COLUNGA, Prof. M. F., Lima, Peru: Twenty-four birds' skins from Peru. 34909. Exchange.
- COMMONWEALTH IRON COMPANY, Commonwealth, Wis.: Iron ore. 34300.
- COMSTOCK, F. M., Cleveland, Ohio: Three plants. Exchange. 34828.
- CONNELL, E. Y., St. Kitts and Nevis, British West Indies: Collection of Carib implements from Barbados and West Indies; also a few pieces of pottery. Exchange. 33870.
- COOK, Capt. C. C., U. S. Volunteers, Washington, D. C.: Collection of swords used during the Cuban campaign, Spanish-American war. Deposit. 34741.
- COOK, Dr. E. P., Jr., Chicago, Ill.: Dip-terous larva. 33991.
- COOK, Prof. O. F., U. S. National Museum: Specimen of *Polyspilota validissima* Gerst, from Clay Ashland, Siberia, obtained by Mrs. J. E. D. Sharp (33775); collection of insects from central New York (34201).
- COQUILLET, D. W., U. S. National Museum: One hundred and nineteen specimens of Diptera, including types of 6 species. 34745.
- CORAM, G. M., Utica, N. Y.: Egg cluster of *Cliseocampa americana*. 33814.
- CORDEIRA, JOHN, New Bedford, Mass., received through A. C. Hawes: Specimen of *Squilla* from Acushnet River, Massachusetts. 34862.
- CORNELL UNIVERSITY, Ithaca, N. Y. (See under E. C. Townsend.)
- COUBEAUX, EUGENE, St. Louis, Saskatchewan, Northwest Territory, Canada: Thirteen birds' skins; 1 nest and eggs representing the genus *Sturnella* from Northwest Territory. Exchange. 34749.
- COVILLE, F. V. (See under Agriculture, Department of.)
- COWART, S., Cowart, Va.: Set of false teeth with a growing oyster attached. 34347.
- COX, W. V., U. S. National Museum: Peace Jubilee badge and medal of the Trans-Mississippi and International Exposition, Omaha, 1898 (34718); New York Herald, dated February 10, 1887, containing a facsimile of the Herald's account of the funeral of Alexander Hamilton; Daily Graphic, dated September 22, 1886, containing a facsimile of the Constitution of the Confederate States of America, and a picture of the officers of the Cabinet taken at Montgomery, Ala. (35015).
- CRANDALL, Prof. C. S., Fort Collins, Colo.: Three plants. 34564.
- CRAWFORD, Dr. JOSEPH, Philadelphia, Pa.: One hundred and twenty-five plants. Exchange. 34399.
Four specimens of *Viola*. Exchange. 35054.
- CRAWFORD, LAMAR, New York City: Human skull and fragments of pottery found in a mound near New River, Virginia. 34074.
- CRIDLER, Hon. T. W. (See under State, Department of.)
- CROCKETT, JAMES, Irish Lane, Pa., received through Bureau of Ethnology: Two stone hoes, 2 celt-shaped pebbles, 3 fragments of hammer stones, 4 arrow-heads, and 12 pebbles and spalls. 33900.
- CROSBY, F. W., Washington, D. C.: Three photographs of Mount Etna (exchange) (34619); two cases of geological material from Somma and Vesuvius (purchase) (34840). (See under J. B. McCarthy.)
- CROSS, C. W. (See under Interior Department, U. S. Geological Survey.)

- CROSSAS, ANDRES, San Juan, P. R.: Spanish flag from San Cristobal Castle, San Juan. (See under Porto Rico Collection 35201.)
- CUTCHER, PHILIP, Vicksburg, Miss.: One hundred and sixty-two fossils from the Vicksburg Eocene. 34112.
- CUMMINGS, MISS C. E., Wellesley, Mass.: Thirty lichens from North America. Exchange. 34703.
- CURTICE, COOPER. (See under Interior Department, U. S. Geological Survey.)
- CURTIS, C. J., Davidsonville, Md.: Birds' skins, mammal skins, turtles, skull of a bird, and a crustacean. 35057.
- CUSACK, F. W., Westcliff, Colo.: Specimens of *Gentiana barbellata* Engelm. (34086); through Department of Agriculture, specimen of *Gentiana humilis* (35183).
- CUSICK, W. C., Union, Oreg.: Twenty plants. 34512.
- DALE, T. NELSON. (See under Interior Department, U. S. Geological Survey.)
- DALL, MRS. C. H., Washington, D. C.: Piece of calico printed in 1872 with certain designs relating to the life of Horace Greeley. 33777.
- DALL, W. H., U. S. Geological Survey: Forty-two lots of marine shells from California. 35045.
- DALRYMPLE, C. H., Gold Hill, Oreg.: Photograph of interlocked deer antlers. 33938.
- DANIEL, Lieut. J. W., U. S. V., Lynchburg, Va.: Collection of mammals. 34356.
- DANIELS, L. E., Brookston, Ind.: Specimens of *Polygyra profunda* (34114); 3 species of unios (34337); 4 species of shells from Florida (34900); crab (*Uca pugilator*) (35002).
- DANN, RAYMOND, Rochester, N. Y.: Relics from an old Indian cemetery at Honeoye Falls, N. Y. 34397.
- DARTON, N. H. (See under Interior Department, U. S. Geological Survey.)
- DAVIS, MISS C. L., Leesburg, Va.: Caterpillar of a black butterfly (*Papilio troilus* Linnaeus). 34015.
- DAVIS, HOMER SPENCER, Rosa, Idaho: Black sand and gold. 35131.
- DAVIS, JOHN (U. S. S. *Texas*): A clip containing five Mauser rifle cartridges recovered from the wreck of the Spanish ship *Cristobal Colon*. 34103.
- DAVIS, N., IDA, Mich.: Limestone used for making quicklime. 34251.
- DAVIS, W. T., New Brighton, Staten Island, N. Y.: Twenty-two insects. 34826.
- DAY, A. E., Beirut, Syria: One hundred and forty-five specimens of Lepidoptera from Syria. Exchange. 34118.
- DAY, DR. DAVID T. (See under Interior Department, U. S. Geological Survey; Raleigh Scott; W. F. Young.)
- DEAM, C. C., Bluffton, Ind.: Two lizards from Mexico. 34798.
- DEANE, WALTER, Cambridge, Mass.: Twenty-five plants. Exchange. 35180.
- DEITZ, DR. W. G., Hazleton, Pa., received through the Department of Agriculture: Nine specimens of *Tineina*. 34727.
- DE NYSE, W. L., Gravesend Beach, Brooklyn Borough, N. Y.: Two leeches, representing the genus *Branchellion*. 35130.
- DERBY, Prof. O. A., Rio de Janeiro, Brazil: Monazite sand and minerals from Brazil. 33757.
- DERR, H. B., Chicago, Ill.: Specimen of *Fusus marmoratus*. 34123.
- DESHA, MISS M., Washington, D. C.: Two-headed snake. 34484.
- DETROIT GRAPHITE MANUFACTURING COMPANY, Detroit, Mich.: Graphite. 34176.
- DE WEESE, DALL, Canyon, Colo.: Five skins and 4 skulls of moose; 8 skins and 8 skulls of sheep. Purchase. 34402.
- DEWEY, Admiral GEORGE. (See under Navy Department.)
- DEWEY, L. H., Department of Agriculture: Plant (34677); three violets from Michigan (35152).
- DIAL, MRS. M. B., San Luis Obispo, Cal.: Eight species of marine and freshwater shells. 34782.
- DIAZ-HELLIN, MANUEL, Bayamon, P. R.: Carrying bag used in place of a knapsack. (See under Porto Rico Collection 35201.)
- DICKHAUT, H. E., U. S. National Museum: Private collection of Cincinnati group fossils (purchase) (33859); fossils from

DICKHAUT, H. E.—Continued.

Middleport and Lockport, N. Y. (collected) (33949); collection of Cincinnati group fossils, consisting of crinoids, brachiopods, and mollusks (purchase) (34574).

DIGNOWITZ, ANTHONY (no address given): Received through the Department of Agriculture: Plant from San Juan, P. R. 34944.

DILLER, Dr. J. S. (See under Interior Department, U. S. Geological Survey.)

DINGUS, H. H., Nasbie, Va.: Fossil plant. 34390.

DISTRICT OF COLUMBIA VOLUNTEERS, received through Brigadier-General Harries: Spanish bronze cannon, dated 1794, taken from a Spanish trench on San Juan Hill, Santiago de Cuba. 34896.

DODGE, B. E., Richfield, Mich.: Polished stone needle, 2 flint drills, and an arrowhead found in Genesee County. Deposit. 34694.

DOGGETT, J. O., Piedmont, S. C.: Specimens of damourite. 34046.

DOLPH, J. M., Port Jervis, N. Y.: Stone gouge from the building grounds of the Lenni-Lenape Indians, Orange County, New York. 34394.

DOUGLASS, A. E., Flagstaff, Ariz.: Four astronomical and surveying instruments and a bromide copy of a letter written by Gen. George Washington to Andrew Ellicott, dated October 20, 1792. Deposit. 34395.

DRAKE, C. M., Gorda, Cal.: Four species of land shells. 34959.

DRAKE, E. L., Winchester, Tenn.; Sphinx Moth, *Charocampa tersa* Linnaeus. 33936.

DRIGGS-SEABURY GUN AND AMMUNITION COMPANY, Washington, D. C., received through Ordnance Department, War Department: Driggs-Seabury 1-pounder steel shell. 34254.

Du Bois, E., Bluffton, S. C.: Specimen of *Lycosa carolina* Hentz. 34285.

Du BOSE, J. H., Huguenot, Ga.: Collection of hammer stones and chipped implements. 35058.

DUGÈS, Dr. A., Guanajuato, Mexico: Two photographs of birds and a photograph of a mammal (gift) (33838); fishes, rep-

DUGÈS, Dr. A.—Continued.

tiles and batrachians from Mexico (exchange) (33976); 7 specimens of invertebrates (gift) (34018); specimen of *Vespertilio fuscus miradorensis* (gift) (34153).

DUERDEN, J. E., Institute of Jamaica, Kingston, Jamaica: Four specimens of *Spartocera batatas* Fabr. and 7 specimens of *Cylas formicarius* Fab. 34009.

DUMBLE, Prof. E. T., Houston, Tex.: Twelve specimens, representing 3 species, of corals from either the Silurian or Devonian formation, near Cascite, Sonora, Mexico (33851); specimens of hubnerite and mesolite (34333); 2 specimens of Devonian fossils and 2 specimens of Upper Carboniferous fossils from the southeastern part of Arizona (34358).

DUNLAP, ROBERT, & Co., Jamesville, N. Y.: Specimens of gypsum. 34221.

DUBROW, G. W., Salton, Cal.: Specimen of *Rasahus biguttatus* Say. 35050.

DYAR, Dr. H. G., U. S. National Museum: Insects (34417, 34554) (gift); 125 moths from Venezuela (purchase) (34868).

EAKLE, A. E., Cambridge, Mass.: Specimen of erinite from Durkee, Oreg. 34755.

EARLE, J. W., Holland, S. C.: Two specimens of *Melanolestes picipes* H. Schf. 34992.

EARLE, F. S., Auburn, Ala.: Six hundred and seventy-four plants from the Rocky Mountain region (34691); 134 plants (34759). Purchase.

EASTMAN, Dr. C. R. (See under Museum of Comparative Zoology, Cambridge, Mass.)

EATON, A. A., Seabrook, N. H.: Three plants. Exchange. 35231.

EATON, A. B. (See under Agriculture, Department of.)

EDWARDS, Dr. J. J., Charleston, S. C.: Insect larvae from a cistern in Charleston. 33833.

EDMONDS, WALTER, Norfolk, Va.: Pupa of *Danaus archippus*. 33970.

ELDER, J. H. (See under Smithsonian Institution, Bureau of Ethnology.)

ELIOT, Sir CHARLES, British Embassy, Washington, D. C.: Specimens of invertebrates from Key West, Florida. 35107.

- ELLIS, J. E., San Francisco, Cal.: Lime-stone used for making quicklime. 34292.
- ELMER, A. D. E., Pullman, Wash.: Five hundred plants from Idaho and Washington (33795); 225 plants from Washington (34931). Purchase. (See under C. V. Piper.)
- ELROD, M. J., Missoula, Mont.: Land and fresh-water shells and mollusks from Montana, representing 9 species. 33926.
- EMME, D. H., Wympsgap, Pa.: Fire clay. 34195.
- EMMONS, S. F., U. S. Geological Survey: Fifty specimens of fossils from Payte, Peru. 35072.
- ENGLISH, G. L., & Co., New York City, N. Y.: Three specimens of jeffersonite with garnet, willemite, franklinite, and calcite, from Franklin, Sussex County, N. J. (34590); 2 specimens of triplite and 1 specimen of lepidolite from Had-dam, Conn. (34816).
- ENTWISLE, W. B., U. S. National Museum: Regulation belt and buckle of the U. S. Army, 1861-1865; 2 Minie rifle bullets, from the battlefield of Winchester, Va. 35091.
- ETTINGER, CHARLES S., Jersey City, N. J.: Kaolin from Texas. 34540. (See under Frio Kaolin Mining and Improvement Company, Dallas, Tex.)
- EUSTIS, G. H., Boston, Mass.: A remarkable oyster from Charles River, Massachusetts. 34304.
- EVANS, Capt. R. D., U. S. Navy: Section of plate, chain lockers, from the U. S. S. *Iowa*, perforated by a Spanish shell. 34076.
- EVANS, W. H., Tusiloff, Alaska, received through Department of Agriculture: Small collection of insects, consisting of about 75 specimens from Tusiloff (34182); 2 plants from Alaska (34584).
- EVERETT, WESLEY. (See under Leslie Copper Mining Company.)
- EVERMANN, Prof. B. W. (See under Fish Commission, U. S.)
- EVERMANN, T. B., Washington, D. C.: Thirty dragon flies and butterflies. 34434.
- FABER, JOHN, Dallas, Tex.: Insect. 33918.
- FAIRCHILD, D. G., Department of Agriculture: Five hundred specimens of Algae in alcohol and subtropical plants from the Mediterranean region (33764); collection of Javanese insects, a few lizards and snakes from Buitenzorg, Java, and the skin of a fruit-eating bat from the botanical gardens at Buitenzorg (34330).
- FALL, H. C., Pasadena, Cal.: Three species of *Acmaeodera*, new to the Museum collection. Exchange. 34692.
- FANNIN, JOHN, curator Provincial Museum, Victoria, British Columbia: Eleven birds' skins. 34093.
- FARMER, Miss S. J., Eliot, Me.: Collection of electrical apparatus. Deposit. 34583.
- FAXON, Dr. WALTER. (See under Museum of Comparative Zoology, Cambridge, Mass.)
- FEATHERSTONHAUGH, THOMAS, Washington, D. C.: John Brown pike and a Sharp's rifle. Deposit. 35097.
- FERRISS, J. H., Joliet, Ill.: Eight species of land shells from Tennessee and other localities (exchange) (34446); 15 species of land shells from Arkansas, Tennessee, and Indian Territory (gift) (34833).
- FEWKES, Dr. WALTER. (See under Smithsonian Institution, Bureau of Ethnology.)
- FIRE DEPARTMENT, FIRE-ALARM BRANCH, Boston, Mass., received through H. S. Russell, Fire Commissioner: Channing & Farmer fire-alarm telegraph signal box used in Boston in 1852; improved fire-alarm telegraph signal box used in Boston in 1867; fire-alarm telegraph repeater used in Boston in 1852. 34714.
- FISCHER, C. F. HERMANN, New Braunfels, Tex.: Specimen of glauconitic marl. 35124.
- FISH COMMISSION, U. S., Hon. George M. Bowers, Commissioner of Fish and Fisheries: Pipe-fish, *Fistularia tabacaria* (33951); seaweeds (33993); mollusks and marine invertebrates collected on the Pacific coast of North America in 1897 and 1898 (34060); Tile-fish (34128); type specimens of fishes, consisting of *Paraliparis rosaceus*, *Bathylagus milleri*, and *Ulocentra medvie* (34148); fishes from Lake Superior,

FISH COMMISSION, U. S.—Continued.

- Alaska, Kamchatka, and Florida (34287); aquatic animals, including crawfishes, crabs, shrimps, and other crustaceans, snakes, frogs, lizards, salamanders, turtles, mollusks, insects, and mammals (34316); alcoholic specimens of crustaceans, principally crayfishes, from different sections of the United States (34603); insects and larvæ of beetles from Unalaska (34635); 6 plants from Porto Rico, collected by Prof. B. W. Evermann (34772); reptiles and batrachians, collected in Porto Rico by the steamer *Fish Hawk* (34778); natural history specimens obtained during the expedition of the *Fish Hawk* to Porto Rico (34801); 20 alcoholic reptiles and a bat from Porto Rico and the Bahamas, collected by the *Fish Hawk* (34824); collection of shells, gorgonians, barnacles, bryozoans, sponges, geological specimens, and plants, collected by the Fish Commission steamer *Albatross* in 1887, 1888, 1889, and 1896 (34837); 9 plants collected by B. W. Evermann in Porto Rico (34969); collection of mollusks, brachyurans, anomurans, crustaceans, macrurans, and tectibranchs obtained during the expedition of the *Fish Hawk* to Porto Rico (34984); reptiles and batrachians from the Bahamas and Porto Rico, collected by the *Fish Hawk* (35095).
- FISHER, Dr. A. K., Department of Agriculture: Two birds' skins from Louisiana, including the type of *Ammodramus m. fisheri* Chapman (33959); plant (35136). (See under H. H. Hindshaw, C. W. Nash.)
- FLAISCHMAN, S. F. (no address given): Badge of the Second Army Corps, U. S. Army. 34746.
- FLOWERS, E. P., Bolling, Ala.: Specimen of *Lagoa opercularis* Abbott and Smith. 34090.
- FLOYD-JONES, DE LANCEY. (See under Aztec Club.)
- FLORIDA IRON MINING AND MANUFACTURING COMPANY, Orlando, Fla.: Sample of ocher. 34296.
- FOGH, H. P., Roslyn, Wash.: Copper ore from Dutch Miller Mine, King County, Wash. 34773.
- FOLSOM, J. W., North Cambridge, Mass.: Collection of Japanese Thysanura, including types of eight species described by Mr. Folsom, all new to the Museum collection. 34509.
- FOOTE, Dr. A. E., Philadelphia, Pa.: Four specimens of minerals. Purchase. 34191.
- FORNEY, A. H., U. S. National Museum: Adult skull of *Odocoileus americanus*. 34582.
- FOSTER, DAVIS, Ono, Wyo.: Six specimens of phosphate nodules from Ono. 34985.
- FOSTER, L. N., Strickland, Ga.: Specimen of *Citheronia regalis* Fab. 34101. Returned.
- FOWLER, Dr. S. M., Miami, Fla.: Specimens of *Amisomorpha buprestoides* De Geer. 34199.
- FRANKFURT-AM-MAIN, Germany, Museum Senckenbergianum, received through Dr. O. Boettger: Two specimens of *Silybura pulneyensis* from India and 2 specimens of *Phyllodoctylus stumpfi* from Madagascar. 34025.
- FREIE VEREINIGUNG TIROLER BOTANIKER. (See under Carinthia, Austria.)
- FRENCH, Capt. F. H., U. S. Army, Washington, D. C.: Clasp knife and a Spanish flag. (See under Porto Rico Collection 35201.)
- FRIERSON, L. S., Frierson, La.: Unios from the Southern States (33803); 3 species of Unionidae from the Southern States (34799).
- FRIO KAOLIN MINING AND IMPROVEMENT COMPANY, Dallas, Tex., received through C. S. Ettinger: Kaolin from Edwards County, Tex. 34309.
- FRISBIE, W. R., Washington, D. C.: Pair of regulation sandals issued to the Spanish soldiers in Cuba, obtained in Santiago on the day of the surrender. 34312.
- GANE, HENRY S. (See under Smithsonian Institution, Bureau of Ethnology.)
- GARLAND, C. C., Baltimore, Md.: Specimens of graphite from Shelby, Cleveland County, N. C. 35041.
- GARNER, E., Quincy, Cal.: Skin and skull of badger and skin and skull of mole. 34466.
- GARNER, R. L. (See under Hon. M. L. Ross.)

- GAYLE AND SEMPLE, Montgomery, Ala.: Sample of ocher. 34295.
- GEOLOGICAL SURVEY OF CANADA. (See under Ottawa, Canada.)
- GEORGESON, C. C., Washington, D. C.: Five nuggets of Alaskan and Klondike gold. Purchase. 34634.
- GIBSON, J. H., Coney Island, N. Y.: Photograph of a whale. 33843.
- GIBSON, THOMAS J., Scottsburg, Va.: "Moffet bell punch," Alamo knife, and an old saw. 35194.
- GILBERT, G. K. (See under Interior Department, U. S. Geological Survey.)
- GILMARTIN, Mr., gunner, U. S. Navy: Dummy cartridge used in target practice by the U. S. Navy. 34108.
- GILMON, W. J. (no address given): Identification medal. (See under Porto Rico Collection 35201.)
- GIRTY, Dr. G. H., U. S. Geological Survey: Fern from Indian Territory. 34622. (See under Interior Department, U. S. Geological Survey.)
- GLATFELTER, Dr. N. M., St. Louis, Mo.: Nine plants. 33955.
- GOERME, LUIS (no address given): Three photographs of the vertebra of a fossil elephant. 34364.
- GOLDMAN, E. A. (no address given): Five hundred and sixty-eight plants from Mexico. Purchase. 34796.
- GOODMAN, R. D., Washington, D. C.: Springfield rifle found in the trenches before Santiago; Spanish belt and cartridge case captured at Santiago; Mauser rifle clip; 2 Remington cartridges; Mauser cartridge; Mauser shell struck by a bullet, and uniform hat belonging to a volunteer from the District of Columbia. Loan. 34039.
- GORDON, R. H., Cumberland, Md.: Six specimens of Clinton and Niagara limestone with Ostracoda. 33816.
- GRAHAM, J. G., Anthony, Fla.: Moth. 34693.
- GRAHAMSTOWN, SOUTH AFRICA: Albany Museum, received through Dr. S. Schönland, director: Forty-four birds' skins from South Africa. Exchange. 34088.
- GRANIER, EMILE. (See under Smithsonian Institution, Bureau of Ethnology.)
- GRANT, Gen. FREDERICK, U. S. V., War Department, Washington, D. C.: Large idol. (See under Porto Rico Collection 35201.)
- GRAY HERBARIUM, Cambridge, Mass.: Twenty-four plants (34474); plant from Mexico (34762); 300 plants (35122). Exchange.
- GRAY, Mr. and Mrs. J. D., Washington, D. C.: Three hundred and thirty-five pearls from fresh-water mussels. 34049.
- GREEN, J. D., Seaside, Fla.: Specimen of *Dynastes tityus* Linnæus. 33801.
- GRIFFIN, W., Somerset, Ky.: Ninety stone implements, fossils, and a specimen of mineral (fossils returned) (33844); 23 archaeological objects from Pulaski County (33886); 25 specimens of Lower Carboniferous brachiopods (33903); 18 fossils from the Lower Carboniferous rocks of Somerset (34500).
- GRIFFITH, BERYL, Clay City, Ind.: Pottery clay. 34293.
- GRIFFITH, Dr. H. G., Manayunk, Pa.: Parasitic Hymenoptera from Arizona. 34636.
- GUERDRUM, Miss S. C., Anacostia, D. C.: Two young box turtles. 35177.
- GUILD, CHARLES, & SONS, Piedmont, Wyo.: Asphaltum. 34196.
- HAFERLANDT and Pippow, Berlin, Germany: Skull of *Ursus arctos*. Exchange. 34820.
- HAGANS, Hon. J. MARSHALL, Morgantown, W. Va.: Brown glazed jar from an early pottery in Morgantown, obtained by Dr. Walter Hough. 34053.
- HAGOOD, J. E., Pickens, S. C.: Mica. 34204.
- HALL, J. A., Morotock, Va.: Specimen of slate-colored silicified wood. 34596.
- HALL, J. S., Westport Point, Mass.: Specimen of *Botrychium linerioides* showing a peculiar division of the fertile frond. 34051.
- HALL, WILLIAM, Greensboro, Pa.: Glass dish made in Washington about the year 1833. 34209.
- HALLE, E. A., Dalton, Mass.: Specimen of *Platyrotera sabalinus* Scudder. 34533.
- HALLOCK, C. H., Fayetteville, N. C.: Guitar. 34639.

- HAMILTON, JAMES M., Marathon, Tex.: Species of *Elthus* belonging to the family *Cymidae*. 33773.
- HAMLIN, HOMER, Los Angeles, Cal.: Fossils, probably from the Miocene formation, Santa Monica Mountains. 34158.
- HAMMERS, J. E., Luray, Va.: Specimen of *Benacus griseus* Say. 34970.
- HAMMOND, E. W., Wimer, Oreg.: Four hundred and thirty-four plants from Oregon. Purchase. 34561.
- HANHAM, A. W., Winnipeg, Manitoba: Thirty-four specimens of Lepidoptera (gift) (34302); 12 specimens of Lepidoptera (gift) (34376); 17 specimens of Lepidoptera (exchange) (34535).
- HANSEN, GEORGE, Berkeley, Cal.: Plants. (34430, 34527). Purchase.
- HARBISON & WALKER COMPANY, Blandburg, Pa.: Fire clay. 34165.
- HARDEN, J. H., Phoenixville, Pa.: Hindu stone image from Mopani, Central provinces of India, and a photograph of the same. Purchase. 33780.
- HARPER, THOMAS, Bellevue, Pa.: Natural white oil from Holden Run, Armstrong County, Pa. 34827.
- HARRIES, Brig. Gen. GEORGE H. (See under District of Columbia Volunteers.)
- HARRINGTON, M. W., Washington, D. C.: Paper money. (See under Porto Rico Collection 35201.)
- HARRINGTON, N. R.: (See under Senff Zoological Expedition of Columbia College.)
- HARRINGTON, W. W., Ottawa, Canada, received through Department of Agriculture: Sixty-two specimens of Diptera, representing 50 species. 34726.
- HARRIS, E. D., New York City: Eighteen specimens of Cicindelas. 34664.
- HARRIS, I. F., Nashua, N. H.: Pewter lamp in use about one hundred years ago. 34313.
- HARRIS, J. C., Debeque, Colo.: Sphinx-moth, *Protoparce celeus* Hübner. 34063.
- HARRISON, Capt. E. B., Ponce, P. R.: Celt. (See under Porto Rico Collection 35001.)
- HARRISON, MRS. J. T., Pontiac, Mich.: Pupa of a dipterous insect representing the species *Erastalis tenax* Linnaeus. 34865.
- HARTLEY, J. SCOTT, New York City: Plaster cast of the death mask of Cyrus W. Field. Deposit. 35061.
- HARVARD UNIVERSITY, HERBARIUM OF, Cambridge, Mass.: Violets. 33954.
- HASSE, Maj. H. E., U. S. Army, Los Angeles, Cal.: Two hundred and thirty-three plants. 35232.
- HATCHER, J. B., Princeton University, Princeton, N. J.: Specimens, in alcohol, of flying-fishes from South America; specimen of Isopod (*Glossobius linearis* Dana) from the mouth of a flying-fish. 34764. (See under Smithsonian Institution, Bureau of Ethnology.)
- HAVENS, C. B., & Co., Omaha, Nebr.: Specimen of bituminous coal from Indian Territory. 34662. (O.)
- HAWES, A. C. (See under John Cordeira.)
- HAY, W. P., Washington, D. C.: Snakes from Virginia and Maryland (33750, 33940); jelly-fishes, crustaceans, and worms from Chesapeake Bay (34219); crustaceans (34271); 2 type specimens of *Haplophthalminus puteus* Hay, from a well at Irvington, Ind. (34886).
- HAYDEN, MRS. F. V., Philadelphia, Pa.: Medals presented to Dr. Hayden, consisting of a grand medal of the first class, Société de Topographie, Congrès de Paris en 1875; medal of honor, Société de Topographie, Congrès de Paris en 1875. Deposit. 34885.
- HAYMOND, MRS. DORCAS, Morgantown, W. Va.: Specimen of glazed ware from the Thompson pottery and a glass from the Albert Gallatin Glass Works, at Greensboro, Pa., obtained through Dr. Walter Hough. 34056.
- HAYS, T. R., Wickham, New South Wales, received through L. O. Howard: Collection of Australian insects. 34922.
- HEATH, E. F., Cartwright, Manitoba, Canada: The type specimen of *Asteroscopus borealis* Smith, new to the Museum collection. 34555.
- HEATH, HAROLD, Pacific Grove, Cal.: Isopods from California (gift) (34216); 100 specimens of crustaceans (purchase) (34872); 15 specimens of crustaceans, representing 3 species (gift) (35016); crustacean (gift) (35185).

- HEATHMAN, W. F., Santa Anna, Cal., received through the Department of Agriculture: Plant. 34530.
- HEATON, L. D., Victoria, Tex.: Luna Moth, *Actias luna* Linnaeus. 34842.
- HEBERT, V. F. (See under Agriculture, Department of.)
- HECKMAN, P. Y., Issaquah, Wash.: Fossil turtle. Exchange. 34819.
- HEIDEMANN, OTTO, Department of Agriculture: Six specimens of *Aradus niger* Stål, representing a rare species, new to the Museum collection. 35035.
- HEIDMAN, MRS. MICA, Washington, D. C.: Bust of Charles Darwin. 34263.
- HEIGHWAY, A. E. (See under Interior Department, U. S. Geological Survey; Old Abe Company.)
- HELLER, A. A., Lancaster, Pa.: Four hundred and seventy plants from Washington and Texas. Purchase. 34353.
- HENDERSON, A., & Co., Dundee, Scotland: Abnormal tooth of a Sperm whale. Purchase. 34732.
- HENDERSON, L. F., University of Idaho, Moscow, Idaho: Six specimens of Umbelliferae. 34340.
- HENNING, A. H., Silver Cliff, Colo.: Four fossil teeth of a mammal. 34427.
- HENNING, C. F., Boone, Iowa: Sennett's Nighthawk, *Chordeiles virginianus sennetti*. 34252.
- HENRY, MISS M. A., Washington, D. C.: Doll made by Mrs. Alexander Hamilton and by her presented to Mrs. Joseph Henry. 34543.
- HENSHAW, H. W., Hilo, Hawaii: Crabs and shrimps from Sandwich Islands (34019); 2 skins of a Flycatcher from Hawaii (34467); 3 specimens of *Leiolopisma noctua* from Hawaii (34653); Weaver-bird from Hawaii (34702); fishes, shells, crabs, shrimps, and worms from Hilo, Hawaii (34843).
- HERMAN, W. W., Boston, Mass.: Twelve specimens of marine shells from the Pacific Ocean and other localities. 34425.
- HEROLD, MRS. JAMES, Washington, D. C.: Two pieces of gun carriage from the U. S. S. *Media*, a participant in the bombardment of Fort Jackson, La., April 23, 1862. 34717.
- HERR, JOHN, Lebanon, Ind.: Specimen of waterbug (*Belostoma americana*). 35088.
- HERSEY, Capt. A. H., Ponce, P. R.: Grape-shot. (See under Porto Rico collection 35201.)
- HEWITT, J. Y. (See under Old Abe Company.)
- HIBBARD, D. R., Sturgis, Mich.: Shells, principally from Florida. 34979.
- HICHBORN, PHILIP, Chief Naval Constructor. (See under Navy Department.)
- HILDEBRANDT, J. J., Logansport, Ind.: Mexican playing cards. 34551.
- HILDER, F. F., Washington, D. C.: Knife obtained from the Icaiche branch of the Chichenas Indians of Yucatan. 34468.
- HILL, Hon. DAVID J. (See under State, Department of.)
- HILL, Lieut. Col. F. A., Ponce, P. R.: Spanish revolver and four cartridges. (See under Porto Rico collection 35201.)
- HILL, F. D., U. S. Consul, Santos, Brazil: Specimen of Walking-stick, an orthopterous insect. 34927.
- HILL, Dr. R. T., U. S. Geological Survey: Two species of land shells from San Juan Hill, Cuba (34648); collection of flint chips from Indian workshops in Travis County, Tex. (34831).
- HILLS, R. C., Denver, Colo.: Meteoric iron from Mount Oscura, New Mexico. Exchange. 34318.
- HINDSHAW, H. H., Baltimore, Md., received through Dr. A. K. Fisher: Skin of Point Barrow Gull, *Larus barrovianus*, from the State of Washington. 34424.
- HINE, Prof. J. S., Ohio State University, Columbus, Ohio: Twenty-three specimens of *Bittacus* and 70 specimens of *Odonata*, representing 25 species (34264); fly (34505).
- HITCHCOCK, A. S., Agricultural College, Manhattan, Kans.: Thirteen hundred plants. Exchange. 34379.
- HITCHCOCK, C. H., Hanover, N. H.: Phosphate rocks from Redonda and volcanic ashes from the Hawaiian Islands. Exchange. 33937.
- HIRT, J. E., Augusta, Ga.: Wheelbug (*Prionidus cristatus* Linnaeus). 33924.

- HODGE, F. W., Bureau of Ethnology, Washington, D. C.: Mexican notice of church services. 34134. (See under Anthropological Society of Washington, D. C.)
- HOGAN, GEORGE, Ennis, Tex., received through Department of Agriculture: Specimen of *Pentstemon murrawianus* from Texas. 34999.
- HOLM, THEO., Brookland, D. C.: Plant from Colorado. 34233.
- HOLMAN, C. H., Willard, Ill.: Beetle (*Plectodera scalator* Fab.). 33876.
- HOLMES, F. H., Berryessa, Cal.: Five skins of California vultures. Purchase. 34469.
- HOLMES, Prof. J. A., Chapelhill, N. C.: Twenty-six specimens, representing 9 species, of Cretaceous invertebrates from Wilmington, N. C. 34958.
- HOLMES, Prof. W. H. (See under Smithsonian Institution, Bureau of Ethnology.)
- HOLWAY, E. W. D., Decorah, Iowa: Type specimen of *Sida holwayi* Rose. 34683.
- HOLZINGER, J. M., Winona, Minn.: Forty-five plants from northwestern Montana. Exchange. 34760.
- HORNUNG, Dr. J., San Francisco, Cal.: Fifty-nine birds' skins from the western United States (exchange) (33890); 67 birds' skins from California (gift) (34258); 24 birds' skins from California (exchange) (34524).
- HOUGH, Dr. G. DeN., New Bedford, Mass.: Forty-five specimens of Diptera. 34536.
- HOUGH, Dr. WALTER, U. S. National Museum: Eight lanterns and lamps purchased for the Museum. 34034. (See under A. V. Boughner; William Boughner; Hon. J. Marshall Hagans; Mrs. Dorcas Haymond; Mayer Pottery Company; Miss Jennie Thompson.)
- HOUSE, H. D., Oneida, N. Y.: Plant. Exchange. 35234.
- HOWARD, E. E., Edgar, Nebr.: Specimen of *Mus musculus*. 35123.
- HOWARD, Dr. L. O. (See under Prof. Lawrence Bruner; T. R. Hays; G. W. Kirkaldy; Prof. E. L. Rice; F. W. Urich.)
- HOWARD, O. W., Los Angeles, Cal.: Egg of Olivaceous Flycatcher, *Myiarchus lawrencei olivaceus*, from Virginia. 34324.
- HOWELL, ARTHUR, Washington, D. C.: Plant from Alexandria. 34139.
- HOWELL, E. E., Washington, D. C.: Specimen of opal in the matrix from Barcoo River, Queensland, Australia (purchase) (34042); meteoric iron from Mount Joy Township, Adams County, Pa. (gift) (34317).
- HUDSON, Dr. A. S., Stockton, Cal.: Specimen in alcohol of *Heterakis perspicillum* (Rudolphi, 1803), taken from a fresh egg. 34996.
- HUDSON, J. W. (See under Smithsonian Institution, Bureau of Ethnology.)
- HUGHES, EDWARD. (See under Smithsonian Institution, Bureau of Ethnology.)
- HULBERT, Prof. H. E., Mount Vernon, N. Y.: Suit of armor worn by a Korean general in 1592. Purchase. 35228.
- HUMPHREY, CHARLES, Mount Catharine mine, Yerilla, West Australia: Twenty-eight specimens of Australian insects. 35006.
- HUNT, Mrs. E. G., Providence, R. I.: Scale insects infesting the English hawthorn. 33989.
- HUSTED, J. D., New York City: Onyx marble from Colorado. 34939.
- HYDE, L. H., Joliet, Ill.: Two hundred and eighty-seven specimens of Niagara fossils from the Chicago Drainage Canal. 33957.
- IHERING, Dr. H. von, Museu Paulista, Sao Paulo, Brazil: Collection of Tertiary fossils from Patagonia and Parana (33883); 15 species of shells from Argentina and Patagonia (34143).
- ILLINOIS BOTANICAL STATION, Urbana, Ill., received through Dr. C. A. Kofoid: Microscopic slide of type specimens of *Pleodorina illinoensis* belonging to the family *Volvocineae*. 34003.
- INGERSOLL, Mrs. M. W., Point Pleasant, N. J.: Six specimens of Schizoneurinae. 33858.
- INTERIOR DEPARTMENT, Hon. Ethan A. Hitchcock, Secretary: Received through Prof. F. W. Clarke: Chipewewa canoe. 34567.

INTERIOR DEPARTMENT—Continued.

United States Geological Survey, Mr. Charles D. Walcott, Director: Chipped and partly polished hatchet, arrow, and spearheads, etc., from Scioto County, collected by Wilbur Stout (33799); rocks illustrating the Pre-Cambrian geology of the Lake Superior region, obtained by Prof. C. Van Hise (33815); 599 specimens of elastic rocks illustrating the structure, petrography, and economic geology of the slate belt of eastern New York, western Vermont, and adjacent territory, collected by Prof. T. Nelson Dale (33820); collection of fossil vertebrates obtained by N. H. Darton (33823); collection of vertebrate fossils (returned from the estate of Prof. E. D. Cope) (33828); 1,150 specimens of Ordovician, Silurian, and Carboniferous fossils from Oklahoma Territory, collected by J. A. Taff (33840); 60 specimens of Devonian fossils from eastern Kentucky, collected by M. R. Campbell (33841); specimens showing contact of granite and gneiss from Stoll's quarry, Groton, Conn. (33860); 6 specimens of Tertiary fossils (33952); chrome ore and corundum in hornblende transmitted by A. E. Heighway (33977); specimen of *Platycrinus* and a specimen of *Poteriocrinus* from near Livingston, Mont. (34299); collection of rocks, concretions, etc., from Colorado, and fossils from Niagara County, N. Y., collected by G. K. Gilbert (34343); through O. C. Marsh, collection of fossil vertebrates (34346); fossiliferous silt from under gravel, from White River Valley, Northwest Territory, British Columbia, collected July 1, 1898, by the Peters-Brooks party of the Survey (34361); 2 specimens of sandstone containing markings of aborigines (34443); 3,990 specimens of Cambrian brachiopods (34481); fossil fish (34488); 18 specimens of Permian fossils from the Black Hills of South Dakota (34499); 13 specimens of either Devonian or Carboniferous fossils from the Tanana Basin, Alaska (34507); specimen of melanterite from

INTERIOR DEPARTMENT—Continued.

United States Geological Survey—Cont'd. Hayward, S. Dak., collected by N. H. Darton (34518); 2 specimens of priceite coated with aragonite and one specimen of priceite from Lone Ranch, Curry County, Oreg. (34519); 450 specimens of Chemung fossils collected by Dr. G. H. Girty in 1894 in the eastern portion of the Buckhannon quadrangle (34532); 99 specimens of minerals from various localities (34544) (0); specimens of jointed sandstones and calc tufa from Black Hills, S. Dak. (34546); 33 specimens of Devonian fossils from the Upper Kuskokwim River, Alaska (34547); 47 specimens of Upper Cretaceous Ammonites, Scaphites, Inoceramus, and other fossils from near Fairburn, S. Dak.; 9 specimens of Ammonites, Nautilus, Scaphites, and other fossils from the mouth of Elk Creek, Cheyenne River, collected by N. H. Darton (34559); 400 plants from California collected by J. B. Leiberger (34560); large collection of Carboniferous plant remains obtained by J. A. Taff and an assistant of the Geological Survey in the McAlester (Ind. T.) coal field (34565); 95 specimens of fossil invertebrates from eastern Tennessee, collected by Cooper Curtice; 75 specimens of Medina, Clinton, and Niagara fossils (34576); specimen of roscelite with native gold obtained by W. Lindgren from Stocklages Mine, El Dorado County, Cal. (34592); 70 specimens of Oriskany fossils from Cumberland, Md. (34604); 3 bowlders collected by G. K. Gilbert in Wilson, N. Y. (34612); about 10 species of fossil corals from 4 miles west of Lares, Porto Rico (34668); fossils collected by N. H. Darton in the White River beds southeast of Oelrich, S. Dak. (34672); rocks and ores from Tintic, Utah, collected in 1897 by George W. Tower and G. O. Smith (34708); sand in form of stalactites from a black sand mine in Cook County, Oreg., collected by J. S. Diller (34744); 3 species of land shells from McAlester, Ind. T. (34775);

INTERIOR DEPARTMENT—Continued.

United States Geological Survey—Cont'd.

black sand from the Pacific Ocean Beach, at the mouth of Pistol River, Oreg. (34797); specimen of albertite collected by David T. Day in Nova Scotia (34802); 130 specimens of Lower Silurian fossils, 63 specimens of Upper Silurian fossils, and 5 specimens of Devonian fossils collected by M. R. Campbell (34822); sand from Burnett and Johnson's Mine, Gilbert Creek, Smith River, Del Norte County, Cal., collected by David T. Day (34847); tooth of a mastodon (34867); rocks from Coon Butte and San Francisco Mountain, Arizona, collected by G. K. Gilbert (34891); sample of beach sand containing gold and platinum from Crescent City, Cal. (34920); 10 specimens of fish remains from Silver Peak Range, Esmeralda County, Nev. (34986); 3 skulls, 3 geological specimens from White Mountain, New Mexico; 5 small specimens of zonochocholate from the northern shore of Lake Superior, and a geological specimen from Galena, Ill., collected by F. X. Shulak (34971); specimens of asphaltic mineral from the southern part of the McAlester quadrangle, Choctaw Nation, Ind. T., collected by J. A. Taff (35018); a series of 158 specimens of Lower Cretaceous Gryphaea (35059); 75 specimens of fossils from the Cincinnati group of central Kentucky; 69 specimens of fossils from the Upper Carboniferous of Shasta County, Cal. (35064); 4 fossil plants from the coal measures of Sciotoville, Ohio (35079); 3 specimens of garnets collected by C. W. Cross in Ophir Loop, Telluride Quadrangle, Colo. (35084). (See under M. R. Campbell, Cooper Curtice, T. Nelson Dale, N. H. Darton, David T. Day, J. S. Diller, G. K. Gilbert, G. H. Girty, A. E. Heighway, J. B. Leiberger, Ig. Lucas, G. O. Smith, Wilbur Stout, G. W. Tower, J. A. Taff, J. A. Udden.)

IOWA, STATE UNIVERSITY OF, Iowa City, Iowa, received through Prof. C. C.

IOWA, STATE UNIVERSITY OF—Continued.

- Nutting: Five species of crabs. Exchange. 34407.
- JACKSON, Miss VICTORIA, Bowling Green, Ky.: Sixty specimens, representing 7 species of land and fresh-water mollusks (33899); 8 species of shells (34647).
- JACOBS, W. H., Lonaconing, Md.: Peacock. 34723.
- JACOBSON, C. A., Northfield, Minn.: Compacted mycelium of a wood-inhabiting fungus. 35030.
- JAMES, G. WHARTON, Pasadena, Cal.: Photograph of baskets made by the Cahuilla Indians, and photograph of a Navajo blanket weaver. 35168.
- JARBOE, Miss LEONORA, Baltimore, Md.: Cane used by Capt. James Jarboe, a soldier of the war of 1812; original letter written by Captain Jarboe, dated September 15, 1814. 34038.
- JELlicorse, R., Carthage, Tenn.: Seven pottery bowls. 33946.
- JENNINGS, J. H., Henderson, Tenn.: Three specimens of Myrmeleionids. 33857.
- JENSEN, A. S., Universitetets Museum, Copenhagen, Denmark: Six specimens of *Montacuta molleri* (Holböhl) Mörch, from Greenland. 34846.
- JERMY, JULIUS, San Antonio, Tex.: One thousand plants (34516); 325 plants from Hungary (34945). Purchase.
- JOHANSEN, O. A., Chicago, Ill.: Small collection of Acrididae. 34607.
- JOHNSON, A. J., Chetco, Oreg., received through Department of Agriculture: Seven plants from Oregon. 34964.
- JOHNSON, A. R., Whitesboro, N. Y.: Clasp knife, flint, 2 pieces of a military buckle, 2 buttons probably of British manufacture, picked up on the battlefield of Crown Point. 33763.
- JOHNSON, Hon. BENJAMIN. (See under State, Department of.)
- JOHNSON, C. F., Freeport, Ill.: One hundred specimens of violets (35067); 22 plants from Illinois (35148). Exchange.
- JOHNSON, Prof. C. W., Wagner Free Institute of Science, Philadelphia, Pa.: Specimen of *Coliodes schwarzi* (34024);

JOHNSON, Prof. C. W.—Continued.

35 specimens of Diptera (34537); specimens of *Phyca appendiculatus* Fab. (34640); 45 specimens of Hymenoptera (34881).

JOHNSON, Capt. M. L., U. S. N. (See under Navy Department.)

JOHNSTON, Mrs. H. D., San Pedro, Cal.: Ten species of marine shells. 34351.

JONES, Rev. D. (See under Smithsonian Institution, Bureau of Ethnology.)

JONES, M. E., Salt Lake City, Utah: Plant. 33984.

JONES, O. H. (See under G. E. H. Barrett-Hamilton.)

JONES, R. L., Burlington, Vt.: Five specimens of violets. Exchange. 34589.

JUDD, S. D., Biological Survey, Department of Agriculture: Amphipods from New England. 34225.

JUDEN, Mrs. AMABEL, New Orleans, La.: Twenty specimens of Cretaceous *Exogyra* and *Anomia*, from Jamestown, Ga. 34127.

JUNGEN, Lieut. C. W., U. S. N.: Marine telegraph cable cut by the U. S. S. *Wampatuck* June 1, 1898; marine telegraph cable cut by the same steamer on May 18, 1898; cartridge case fired from the *Wampatuck* June 30, 1898. 34075.

JOHNSON, C. F., Freeport, Ill.: Specimens of violets. (35067, 35148.) Exchange.

KARSHNER, H. I., Burnett, Wash.: Six Miocene nodules or concretions containing fossil crabs, from Washington. 34308.

KATO, KAISUKA, Imperial Department of State for Agriculture and Commerce, Tokio, Japan: Specimens of twinned native quartz, native arsenic, and other deposits from Japan. 34571.

KAVANAUGH, E. G. (See under Smithsonian Institution, Bureau of Ethnology.)

KEARFOTT, W. D., New York City, N. Y.: Fifteen specimens of Lepidoptera; 2 larvæ, 3 of pupæ, and a Tachinid-fly with case. 35152.

KEARNEY, T. H., jr., Washington, D. C.: Nine plants. Exchange. 33765.

KELCHER, THOMAS, Washington, D. C.: Specimen of *Tabanus trimaculatus*. 33791.

KELLOGG, Prof. V. L., Leland Stanford Junior University, Stanford University, Cal.: Sixty slides representing cotypes of Mallophaga. 35089.

KELSEY, F. W., San Diego, Cal.: Shells from San Diego Harbor, California. 34142.

KENGLA, L. A., San Francisco, Cal.: Collection of sea algae from Pigeon Point, San Mateo County, Cal. 34684.

KENNER, B., Manti, Utah: Fossil bones of a turtle. 35174.

KENT SCIENTIFIC INSTITUTE, Grand Rapids, Mich., received through L. S. Livingston: Thirty-two specimens of South American Lepidoptera. 34405.

KENTUCKY FIRE BRICK COMPANY, Portsmouth, Ohio: Fire clay. 34226.

KERBEY, J. O., Cocoanut Grove, Fla.: Plant. 34586.

KERR BROTHERS, Wrightsville, Pa.: Limestone used for making quicklime. 34159.

KEW, ENGLAND, ROYAL BOTANIC GARDENS, received through Dr. W. T. Thiselton-Dyer, director: Plants. 34651.

KILMER, F. B., New Brunswick, N. J.: Six plants. 35069.

KIMBLE, G. W., Placerville, Cal., received through H. W. Turner: Seven specimens of roscoelite from Stocklages mine, Eldorado County, Cal. 34593.

KINGSTON, JAMAICA: Public Gardens and Plantations, Botanical Department: One hundred and twelve plants from Jamaica. Exchange. 34137.

KIRKALDY, G. W., Wimbleton, Surrey, England, received through Dr. L. O. Howard: Ten species of exotic Hemiptera. 34993.

KIZER, Dr. D. T., Chillicothe, Mo.: Fresh-water shells from Missouri and Kansas. 33904.

KNIGHT, W. C., Laramie, Wyo.: Eight species of fresh-water shells. 35043.

KNOWLES, TAYLOR & KNOWLES COMPANY, East Liverpool, Ohio: Eleven pieces of pottery. 34492.

KNOWLTON, F. H., U. S. Geological Survey: Specimen of *Limnaea borealis* from Washington, D. C. (34111); 500 plants (34253); 5 specimens of *Mus musculus* (34455); white jasper scraper blade

- KNOWLTON, F. H.—Continued.
from Carbonado, State of Washington (34491); plant from the District of Columbia (34679).
- KOBER, Dr. G. M., Washington, D. C.: Headdress made of an otter skin obtained from the Bannock Indians of North Idaho, and a basket obtained from the Piute Indians of Southern Utah. Exchange. 34548.
- KOENIG, ADOLF, Pittsburgh, Pa.: Twenty-three plants. 35182. (See under Agriculture, Department of.)
- KOFOID, Dr. C. A.: (See under Illinois Botanical Station.)
- KOONS, B. F., Storrs, Conn.: Three pieces of brick clay in curious forms. 33910.
- KRANTZ, Dr. F., Bonn, Germany: Cast of an Archacopteryx. Purchase. 34344. "O."
- KREITE, R., Kansas City, Mo.: Twelve Upper Carboniferous crinoids. Purchase. 34109.
- KUNZ, G. F., New York City: Specimen of prosopite from Dugnay district, Utah; prosopite from near Park City, Summit County, Utah, and awarnite from the western coast of South Island, New Zealand. 34591.
- LACKLAND, SAMUEL, Bowie, La.: Two spiders (33893), specimen of *Argyropeira hortorum* Hentz (34266).
- LACOE, R. D., Pittston, Pa.: Two specimens of *Belinurus lacoei* and 2 specimens of *Euproöps danae* from Mazou Creek, Illinois (34541); 26 boxes containing Carboniferous plants from the vicinity of Morris, Ill. (35093).
- LAIDECKER, N. E., Greencastle, Ind.: Cuban cockade. (See under Porto Rico collection 35201.)
- LAMA, R. W., Norfolk, Va.: Mauser clip recovered from the wreck of the Spanish ship *Reina Mercedes*. (See under Norfolk collection 35187.)
- LAMPREY, J. P., Kensington, N. H.: Plow made by Henry Lamprey in 1732. 34769.
- LAMSON, C. H., Portland, Me.: Lilienthal air-sailer. 34952.
- LANG, J. G., New Market, Tenn.: Zinc ore. 34311.
- LANGDALE, J. W., Washington, D. C.: Specimen of mesolite from Ireland (gift) (34556); rutile and actinolite in quartz (exchange) (34940).
- L'ANGLAISE, Rev. L. H., Paincourtville, La.: Larva of an insect. 33881.
- LAURRAUZI, Capt. JULIO M., Coamo, P. R.: Shrapnell shell. (See under Porto Rico collection 35201.)
- LEARY, Capt. R. P., U. S. N.: Piece of a settee from the cabin of the *San Francisco*; knife made from the armor shot of the ship; cartridge case belonging to a Hotchkiss rapid-firing machine gun (33994); ceiling fixture of an electric lamp in the cabin of the *San Francisco*, wrecked by a shell fired from Morro Castle; 2 cartridge cases from the *San Francisco* (34121).
- LEE, H. A., Denver, Colo.: Cast of a silver nugget from Mollie Gibson Mine (purchase) (34803); photograph of a nugget of native silver from Smuggler Mine, Aspen, Colo. (gift) (35060).
- LEECH, J. F., Washington, D. C.: Specimen of *Cyrtia tenuiola* Hentz. 35199.
- LEHMAN, W. V., Tremont, Pa.: Twelve specimens of Carboniferous fossil plants from the southern anthracite field, Schuylkill County, Pa. 34642.
- LEIBERG, J. B. (See under Interior Department, U. S. Geological Survey.)
- LEIDEN, HOLLAND: Rijks Ethnographisch Museum, received through Dr. L. Serurier, director: Collection of ethnological objects from the East Indies. Exchange. 33997.
- LEMON, Dr. J. H., New Albany, Ind.: Plaster cast of stone carvings; metal cast of stone carvings (34503); fluted brick from a mound in Washington County, Miss. (34618).
- LEON, P. M. DE, U. S. Consul-General, Guayaquil, Ecuador, received through Alexandro Santos, Consul-General of Bolivia, New York City: Stuffed snake. 33761.
- LESLIE COPPER MINING COMPANY, received through Wesley Everett, Wallace, Idaho: Specimen of hematite iron ore from Montana. 35235.
- LESUEUR, ALEX., San Juan, P. R.: Dutch copper coin. (See under Porto Rico Collection 35201.)

- LEUTZE, Commander E. H. C., U. S. N. (See under Navy Department.)
- LINCOLN, H. D., Cottage Grove, Oreg.: Larval form of a female Lampyrid representing the genus *Zarhipis*. 33877.
- LINDGREN, W. (See under Interior Department, U. S. Geological Survey.)
- LINDSAY, MRS. WILLIAM. (See under National Society of the Daughters of the American Revolution.)
- LINNEMEYER, D. F., Brooklyn, N. Y.: Blue-checked homer pigeon with four legs. 33871.
- LISACK, Major, U. S. V., Jewell, Ind.: Mauser clip. (See under Porto Rico Collection. 35201.)
- LISLE, Dr. J. D., Philadelphia, Pa., received through T. W. Stanton: Cast of a gold nugget from Reid Mine, North Carolina. 34479.
- LITTLEBRANT, Lieut. W. T., U. S. A., Fort Bayard, N. Mex.: Four photographs of a cliff dwelling on Gila River, N. Mex. 33845.
- LIVINGSTON, L. S. (See under Kent Scientific Institute.)
- LLOYD, D. P. & Co., Fostoria, Ohio: Limestone used for making quicklime. 34278.
- LLOYD, H. W., Charleston, S. C.: Tineid case bearer. 33758.
- LONDON, ENGLAND: British Museum (Natural History), South Kensington: One hundred and ninety specimens, representing 63 species, of fossil corals, principally Post-Paleozoic, from England (34510); received through George Murray, 1,049 plants, consisting of Set No. 4 of F. Rugel's Florida plants, collected in 1842-1849 (34771); received through Dr. Henry Woodward, 3 casts of skulls (34839); Exchange.
- LONG, M. E. (See under Museum Public Library, Kansas City.)
- LOOMIS, Rev. H., Yokohama, Japan: Twenty-two specimens, representing 22 species of marine, fresh water, and land shells from Japan (33908); shells and barnacles (34179); land and marine shells from Japan (34610); collection of Japanese Lepidoptera (34873).
- LOPEZ, E. MARTINES, Bayamon, P. I.: Cartridge box, belt, and buckle. (See under Porto Rico Collection 35201.)
- LORING, J. ALDEN, London, England: One hundred and seventy-eight mammals and a bird skin from Upsala, Sweden (34073); 230 mammals from Braunschweig, Germany (34155); 451 European mammals and 3 birds' skins (34422). These specimens were purchased by Mr. Loring from a special allotment furnished by the National Museum.
- LOVELL, J. H., Waldoboro, Me.: Twenty-five specimens of aculeate Hymenoptera. 34688.
- LOVETT, EDWARD, Croydon, England: Eight specimens of tallies and lighting apparatus. Exchange. 34368.
- LOWE, H. N., Long Beach, Cal.: Nine specimens of shells, representing 4 species (33854); 7 species of marine shells from California (34186); 7 species of marine shells (34709).
- LUCAS, IG., Passaic, N. J., through the Interior Department, U. S. Geological Survey: Four specimens of fossil corals. 34245.
- LUCAS, F. A., U. S. National Museum: Skull of a crocodile. 34125.
- LUDLOW, Capt. Nicoll, U. S. N. (See under Navy Department.)
- LUKENTY, N. B., Portland, Oreg., received through Department of Agriculture: Plant. 34621.
- LYON, M. W., Jr., U. S. National Museum: Thirty-seven mammals and 2 birds from Washington, D. C. (34435); 2 frogs from Virginia (35103); toad from Bay Ridge, Md. (35142).
- MCCANN, J. J., Punta Gorda, Fla.: Io moth, *Saturnia io*. 34230.
- MCCOMB, G. T., Lockport, N. Y.: Two specimens of Niagara fossils. 34072.
- MCCARTHY, J. B., Washington, D. C.: Geological material from Italy (33842); specimens of asbestos and sulphur from Italy and hematite from England (34241). Collected by F. W. Crosby.
- MCCLENDEN, Dr. E. F., Trinity, Tex.: Drinking horn, Krag shells, and the fragment of a shell. (See under Porto Rico collection, 35201.)
- MCCREEHY, J. H., Oceanport, N. J.: Pounding bowl more than 150 years old. 34899.

- McDOUGAL, D. T., Minneapolis, Minn.: Three hundred and ninety-five plants from Arizona. Purchase. 34401.
- McELFRESH, F. M., Illinois Biological Station, Urbana, Ill.: Eggs of Katydid, representing the species *Antigaster mirabilis* Walsh, with parasites. 34396.
- McFADDEN, J. E., Sterling, N. Y.: Sphinx moth. 33767.
- McFARLAND, DANIEL, Los Angeles, Cal.: Four specimens of *Conorhinus protractus*. 33915.
- McGILLIVRAY, Prof. ALEX., Ithaca, N. Y.: Two species of Cynipids (*Philonix fulvicollis* Fitch and *Philonix nigricollis* Fitch). 34579.
- McGREGOR, R. C., Palo Alto, Cal.: One hundred and sixteen birds' skins (gift) (33866); 34 birds' skins (deposit) (35085).
- McGUIRE, F. B., Washington, D. C.: Pottery vase from Peru, South America. 34894.
- McKANN, Mr. (no address given): Coal, petroleum, and other deposits. 34658. (O.)
- McKINLEY, Hon. WILLIAM, President of the United States: A copy of a memorial, transmitted to the President of the United States by Emperor William of Germany, commemorative of the consecration on October 31, 1898, of the Church of the Savior in Jerusalem. 34935.
- McKNIGHT, A. J., San Francisco, Cal.: Specimen of *Sirex areolatus* Cresson. 34183.
- McMAHAL, J. E., Diamond, Ariz.: Two specimens of Cottonwood Beetle, *Lina scripta* Fab. 35074.
- McNUTT, FRANCES, Rockbridge Baths, Va.: Five specimens of *Thyriopteryx ephemeriformis* Hall. 33964.
- MACOUN, J. M., Geological Survey, Ottawa, Canada: Ninety-eight plants from Canada (34673); 22 plants from Pribilof Islands (34770). Exchange.
- MAGINNIS, Judge W. L., Ogden, Utah: Specimen of mica from Latah County, Idaho. 35076.
- MAGRANE, R. W., New York City: Remington (Spanish) rifle captured at the surrender of Ponce de Porto Rico; also 12 Remington cartridges. Deposit. 34102.
- MAGRAW, A. R., Washington, D. C.: Specimen of Upper Devonian sandstone containing casts of shells, from Bay Ridge, Va. 34458.
- MAHOOD, F. W., Washington, D. C.: Siliceous sand for glass making from near Stapleton Mills, Va. 34406.
- MANTON, H. B., Akron, Ohio: Kaolite slip used as a glaze in the manufacture of pottery. 35065.
- MAREAN, ———, Washington, D. C.: Two barn owls. 35196.
- MARSH, Prof. O. C., New Haven, Conn.: Nineteen polished spheres of Japanese breccia. 34643. (See under Interior Department, U. S. Geological Survey.)
- MARSHALL BRICK COMPANY, Rapid City, S. Dak.: Specimens of raw and burnt clay. 34496.
- MARSHALL, ERNEST, Laurel, Md.: Fishes and leeches. 34911. (See under George Marshall.)
- MARSHALL, GEORGE, U. S. National Museum: Maynard revolver manufactured by the Massachusetts Arms Company (34026); Pine Mouse, *Microtus pinetorum*, from Washington, D. C. (34382); specimen of *Microtus pennsylvanicus* (34736); fishes and leeches obtained in Laurel, Md., by Henry and Ernest Marshall (34911); Jumping Mouse, *Zapus hudsonius*, from Laurel (35027).
- MARSHALL, H., U. S. National Museum: Nest of a wasp. 34181. (See under George Marshall.)
- MARTIN, Prof. K., Director des Geologischen Museums, Leyden, Holland: Fossil corals representing 25 localities on the island of Curaçao. Exchange. 34194.
- MASON, GEORGE E., London, England: Eleven frogs from England. Exchange. 35238.
- MASON, Mrs. LUCY ORD, Washington, D. C.: Sword of Lieut. J. Garesché Ord, Sixth United States Infantry, killed at the battle of San Juan Hill, Santiago de Cuba, July 1, 1898. Deposit. 34126.
- MAXON, Mrs. S. A., Oneida, N. Y.: One hundred plants (35052); 150 plants from New York (35104).

- MAXON, W. R., U. S. National Museum: Three ferns from Jamesville, N. Y. (34380); plants (34681); fern (34685); 12 plants (34954); collection of insects (35140).
- MAXSON, H. B., Reno, Nev.: Ores, marbles, and petrified wood. 34659. (O.)
- MAYER POTTERY COMPANY, Beaver Falls, Pa.: received through Dr. Walter Hough: Eight specimens of colored glassware. 34052.
- MEADOWS, E. W., Pamplin, Va.: Moth, *Cherocampus tersa* Linnaeus. 34130.
- MEANS, T. H., Department of Agriculture: Specimen of fuller's earth from Quincy, Fla. 34534.
- MEARNS, DR. E. A., U. S. A.: Collections of natural history specimens and ethnological objects (33829, 33874); fishes, insects, and shells from Fort Clark, Tex. (34429); 5 beetles and 39 skulls of mammals from Lexington, Ky. (34461); birds' skins from Lexington, Ky., and plants from Chickamauga National Park, Georgia (34482); natural history specimens from Texas and Georgia (34611, 34676); mollusks from Newport, R. I. (35062).
- MEARNS, LOUIS DI ZEREGA, Fort Clark, Tex.: Fifty-six birds' skins from Texas (deposit) (33880); 3 plants from Texas (gift) (34083); skin and skull of Gray Squirrel, *Sciurus carolinensis* (deposit) (34483); 28 mammal skins and 30 mammal skulls (deposit) (34706).
- MEEK, A. K., Washington, D. C.: Twelve specimens of fungi. 34874.
- MELFORD, Miss A. I., Washington, D. C.: Three plants from New Mexico. 34145.
- MELVILLE, W. P., Sault Ste. Marie, Mich.: Four birds' skins from Angola. Exchange. 34907.
- MERCER, W. J. (See under Smithsonian Institution, Bureau of Ethnology.)
- MEREDITH, H. C. (See under Smithsonian Institution, Bureau of Ethnology.)
- MERIVALE, WALTER, Bridgeton, Barbados, West Indies: Specimen of Merivale manjak, or mineral bitumen, from Barbados, West Indies. 34897.
- MERRIAM, DR. C. HART, Department of Agriculture: Yellow Rail, *Porzana noveboracensis* Audubon. 34415.
- MERRIAM, E. D., Conneaut, Ohio: Skull of a Catfish, *Ameiurus lacustris*. 33981.
- MERRILL, E. D., Orono, Me.: received through Dr. T. H. Bean: Three specimens of Stickleback, *Gasterosteus atkinsii*. 34925.
- MERRILL, Dr. G. P., U. S. National Museum: Drift boulder from Lincoln, N. H. 33832.
- METCALF, J. K., Silver City, N. Mex.: Seven plants. 34452.
- MEYERS, MAX, Sheridan, Mont.: Specimen of wad. 35108.
- MEXICAN AMOLA SOAP COMPANY, Peoria, Ill.: Collection of yucca roots. 33887.
- MICHELSSEN, Hon. CHRIS., received through Capt. J. W. Collins, U. S. Fish Commission: Model of the steamship *Merrimac*, sunk by Lieutenant Hobson at Santiago. 34490.
- MIDDLETON, Mrs. J. J., Washington, D. C.: Shell representing the genus *Anomia*. 34462.
- MIGUEL, JEAN, Barroubio, Hérault, France: Seven hundred and ninety-eight specimens of European fossils from the Paleozoic, Mesozoic, and Cenozoic horizons. Exchange. 34712.
- MILLER, A. W., Portland, Oreg.: Ores, building stones, ochers, and petrified wood. 34654. (O.)
- MILLER, B. D., Peterboro, N. Y.: Specimen of albinistic Red Squirrel, *Sciurus hudsonicus*, from Peterboro, N. Y. 35160.
- MILLER, C. L. (See under Smithsonian Institution, Bureau of Ethnology.)
- MILLER, E. E., Canton, Ohio: Plant. 34116.
- MILLER, GERRIT S., jr., U. S. National Museum: Plant (33742); 14 plants from the District of Columbia (33913); spiders (33923); skin of *Coccyzus bairdi* from Jamaica (33931); small collection of fishes from North Truro, Mass., and from the Shenandoah River (33974); snake from Maryland (33985); 2 plants from Maryland (34085); 2 specimens of bats (*Pipistullus subflavus* and *Lasiurus borealis*) (34095); 2 specimens of *Mus musculus* and a specimen of *Scalops aquaticus* from Forest Glen, Md. (34189); 11 mammals (34290); snake from Maryland (34538); specimen of Night Hawk,

- MILLER, GERRIT S., jr.—Continued.
Chordeiles virginianus (35056); mole
(Scalopus aquaticus) and Flying Squirrel,
Sciuropterus volucella (35092).
- MILLER, Dr. J., U. S. National Museum:
 Spider (*Epeira domicitiana* Hentz).
 34553.
- MILLS, Gen. Anson, U. S. Army: Tent
 made from buffalo skin. Loan. 34880.
- MILLS, R. A., Orlando, Fla.: Hammer-
 stone from Mammoth Cave, Kentucky.
 34895.
- MILLS, R. P., St. Petersburg, Fla.: Crab-
 spider, *Gasteracantha cancer* Hentz.
 34506.
- MINNESOTA, GEOLOGICAL SURVEY OF,
 Minneapolis, Minn., received through
 Prof. W. H. Winchell: Sixty specim-
 ens of Lower Helderberg fossils from
 New York. Exchange. 35096.
- MINNESOTA, UNIVERSITY OF, Minneapolis,
 Minn.: One hundred and thirteen
 plants. Exchange. 35022.
- MIRICK, Miss NELLIE, Oneida, N. Y.:
 Twenty plants. Exchange. 35233.
- MITCHELL, Dr. C. T., Canandaigua, N. Y.:
 Three specimens of mollusks represent-
 ing the genus *Goniobasis*. 34962.
- MITCHELL, G. E., Washington, D. C.:
 Four specimens of *Carpodectes nitidus*
 from Nicaragua. 34202.
- MITCHELL, Hon. J. D., Victoria, Tex.:
 Specimen of *Callinectes sapidus* from near
 Dupuy Lake, Texas (34017); 2 species of
 fresh-water shells from Texas (34392);
 6 specimens of *Callinectes sapidus* with
 parasites from Old Indianola, Tex.
 (34729); 8 species of marine shells
 (34735); marine and land shells from
 Texas (34833); 20 crabs (13 with para-
 sites) from Texas (34871).
- MOAK, C. C., Corning, Iowa: Brass pipe-
 hatchet. Purchase. 34641.
- MOHR, Dr. CHARLES, Mobile, Ala.: Specim-
 ens of *Viola carolina* Greene (ex-
 change) (34449); plant from Lookout
 Mountain, Mentone, Tenn. (gift)
 (34529); 7 plants (exchange) (34623).
- MONTEITH, Miss CLARA, New Orleans,
 La.: Caterpillar of *Empretia stimulea*
 Clemens. 34010.
- MONTREAL RIVER IRON MINING COMPANY,
 Hurley, Wis.: Iron ore. 34173.
- MOON, E. P., Palmer, Colo., received
 through Isaac Winston: Specimen of
 sandstone. 33884.
- MOORE, B. B., Washington, D. C.: Flying
 Squirrel, *Sciuropterus volucella*. 35161.
- MOORE, C. B., Philadelphia, Pa.: Six
 counterfeit ceremonial crooks. 33824.
- MOORE, Dr. H. D., New Lexington, Pa.:
 Specimen of *Clintonia umbellata*. 35146.
- MOORE, J. E., Seattle, Wash.: Specimen
 of molybdenum. 33846.
- MOOREHEAD, JAMES, Pecos High Bridge
 (Lozier post-office), Tex.: Five plants.
 34161.
- MOOREHEAD, WARREN K. (See under
 Thomas Wilson.)
- MORELIA, MEXICO, MUSEO MICHÓACANO,
 received through Dr. Manuel Martinez
 Solórzano: Seven birds' skins and 90
 specimens of insects from Mexico. Ex-
 change. 34305.
- MORGAN, Dr. E. L., Washington, D. C.:
 Specimens of Flying Squirrel, *Sciuropterus volucella* (34280, 34644).
- MORRIS, G. F. (See under Smithsonian
 Institution, Bureau of Ethnology.)
- MORRISON, E. H. (See under Walker
 Electric Company.)
- MORTON, Mrs. A. E., Olney, Colo.: Specim-
 en of Mantis, *Stagmomantis carolina*
 Linnaeus; 2 tarantulas, and a specimen
 of Holbrook's Lizard, *Holbrookia macu-
 lata*. 34129.
- MOSS, WILLIAM, Ashton-under-Lyne,
 England: Shells from Lifu, Loyalty
 Islands, Oceania (34887); 3,000 specim-
 ens of minute marine and land shells
 from the same locality (35113).
- MULFORD, Miss A. I., Washington, D. C.:
 Three plants from New Mexico. 34145.
- MUNIZ, Dr. M. A. (See under Smithson-
 ian Institution, Bureau of Ethnology.)
- MURDAUH, Mrs. H. I., Luray, S. C.:
 Crab Spider, *Gasteracantha cancer*
 Hentz. 34100.
- MURFELDT, Miss MARY, Kirkwood, Mo.:
 Fourteen specimens of insects. 35007.
- MURRAY, GEORGE. (See under London,
 England, British Museum.)
- MUSÉE D'HISTOIRE NATURELLE. (See un-
 der Paris, France.)

MUSEO MICHÓACANO. (See under Morelia, Mexico.)

MUSEUM OF COMPARATIVE ZOOLOGY, Cambridge, Mass. Received through Dr. C. R. Eastman: Cast of an egg of a fossil ostrich (*Struthiolithus chersonensis*); teeth of fossil fishes (Ceratodonts) (gift) (33755). Received through Dr. Walter Faxon: 77 specimens of decapod crustaceans, representing 21 species (exchange) (34156); 90 specimens, representing 26 species of crabs (exchange) (34789).

MUSEUM PUBLIC LIBRARY, Kansas City, Mo., received through M. C. Long: Electrotypes of the Washington Peace Medal, bearing date 1793. 34980.

MUSEUM SENCKENBERGIANUM. (See under Frankfurt-am-Main.)

NASH, C. W., Toronto, Canada, received through Dr. A. K. Fisher: Snake (*Storeria dekayi*) from Toronto. 34284.

NATIONAL SOCIETY OF THE COLONIAL DAMES OF AMERICA, Miss Elizabeth Bird Nicholas, Treasurer-General. Received through Mrs. William Henry Browne and Gen. Joseph Wheeler, chair used by William Henry Harrison, President of the United States; coat worn by Lord Fairfax of Greenway Court, Va.; bellows owned by Elizabeth Bradford; silver candlestick owned by the Delancey family; silver spoon owned by the Cooper family; silver teaspoon owned by Elizabeth Langdon; silver salt-cellar without the glass, 1745; 2 silver spoons owned by William Byrd; china tea caddy owned by Robert Carter; silver tablespoon, 1745, owned by William Byrd, and a soup plate also owned by William Byrd (34972). Received through Mrs. William Henry Browne, hand embroidery on home-made linen woven by Mrs. L. W. Knowlton; pastel portrait, on vellum, of Hon. Oliver Wolcott, Paris, 1783 (35040). Received through Mrs. Lucy Carter Trent, in behalf of the Richmond branch of the society, collection of historical relics consisting of letter, glassware, silverware, etc. (35082). Received through Mrs. Charles Washington Coleman, autograph letters and papers of 13 signers of the

NATIONAL SOCIETY OF THE COLONIAL DAMES OF AMERICA—Continued.

Declaration of Independence (35087). Received through Mrs. Elizabeth Byrd Nicholas, collection of historical relics (35162).

NATIONAL SOCIETY OF THE DAUGHTERS OF THE AMERICAN REVOLUTION. Received through Mrs. William Lindsay: Piece of the British ship *Somerset*; 3 letters from daughters of Revolutionary soldiers; order for payment of money to General Lafayette; 3 dinner plates, a frame and photograph (33792); coat worn by Charles Carroll, of Carrollton, on the occasion of his signing the Declaration of Independence (34307); buff silk embroidered waistcoat worn by Copeland Parker, a descendant of the Earls of Macclesfield, surveyor and inspector of the customs of the port of Norfolk, Va., by appointment of President George Washington; wood from home of John Hancock, Boston, Mass., built in 1737 and destroyed in 1863; letters, viz, from Anna Morse, Emily Allen, A. I. H. Dyer, and members of Old South Chapter, Boston, daughters of soldiers of the war of the Revolution (34613); snuffbox used in the Jones family, silver loving cup of Captain Parker, 2 cut-glass wine glasses brought from England in 1750; colonial miniature gilt portrait frame, pewter tankard brought from England in 1639, a pair of epaulettes owned by Gen. Weir Smallwood, Revolutionary War, pewter candlestick brought from England in 1750, colonial lantern brought from England in 1750, oil portrait of Susan Coates Jones (34731); 2 engravings, small gilded shield, block of wood with 2 bullets embedded, found on Cowpens battlefield, plate, cup, and saucer (34743); collection of historical relics (34851); blue and white china platter with strainer (35137).

NATIONAL GEOGRAPHICAL SOCIETY, Washington, D. C.: Harpoon head, taken from a whale in Bering Sea. Deposit. 34838.

NAVY DEPARTMENT, Hon. John D. Long, Secretary: Received from Admiral George Dewey, 2 brass trophy guns

NAVY DEPARTMENT—Continued.

captured from the Spanish arsenal at Cavite, P. I., on May 1, 1898 (34752). Received through Bureau of Ordnance, from the battleship *Maine*, arms and munitions, also sample of powder obtained from the wreck of the *Maine* (33948). Received through Capt. Nicoll Ludlow, U. S. S. *Massachusetts*, electric fan used for driving smoke from the bores of heavy guns, piece of a Spanish shell (34192), soup tureen with cover and 2 vegetable dishes with covers presented to the *Maine* by the citizens of the State of Maine in 1895, also a silver loving cup presented to the ship by natives of the State of Maine residing in New Orleans March 10, 1897 (34345). Received from Capt. M. L. Johnson, commanding United States Navy-Yard, Boston, Mass., binnacle and compass from the captured Spanish gunboat *Sandalor* (34423); received through Hon. Charles H. Allen, Assistant Secretary of the Navy, shield, crown, and scrolls comprising the stern ornament of the *Christobal Colon* (34521). Received from Commander R. B. Bradford, small steering binnacle and compass from the conning tower of the torpedo boat *Winslow* (34671). Received through Rear-Admiral Charles O'Neill, two 3-inch cartridge cases (34753). Received from Chief Naval Constructor Philip Hichborn, steering wheels of the *Maine* (34860); collection of historical relics incident to the battle of Manila, collected by Commander E. H. C. Leutze (35081). Deposit.

NEHRING, H., Milwaukee, Wis.: Three photographs of the skull of a Humpback Whale. 33972.

NEITZY, W. M., Washington, D. C.: Specimen of *Astroscopus y-gracum*. 34291.

NELSON, AVON, Laramie, Wyo.: Ninety-two plants from Wyoming. Exchange. 34690.

NELSON, CHRIS, Fort Hamilton, N. Y.: One hundred and twenty-three arrow points of flint and obsidian, pendants and ornaments of shell and turquoise, and fragments of painted pottery from

NELSON, CHRIS—Continued.

near Fort Grant, Arizona (34930); 3 grooved stone axes and an arrow-shaft polisher from near Fort Grant (35038).

NELSON, E. W. (See under Mrs. N. M. Brown; Smithsonian Institution, Bureau of Ethnology.)

NEWCOMB, Capt. F. H., U. S. R. C. S., New York City: Rope bolt from the wreck of the Spanish cruiser *Viscaya*; 4-inch cartridge case from the U. S. S. *Suwanee*; cartridge case of a 6-pound shot fired from the U. S. S. *Hudson* at the time of the rescue of the *Winslow*, on May 11, 1898. 33995.

NEW ENGLAND TALC COMPANY, Stockbridge, Vt.: Talc. 34294.

NEW MEXICO AGRICULTURAL EXPERIMENT STATION, Mesilla Park, N. Mex., received through Prof. T. D. A. Cockerell: Eighteen plants (33804); specimen of *Eremopedes scudderi* Ckll., from *viridis* Ckll. (2 topotypes) (33895); 2 specimens of *Helix miorhyssa* Dall from White Mountain, New Mexico (34170); 12 specimens of Hymenoptera, including one type specimen (34355); New Mexican Hymenoptera, Hemiptera, and other specimens (34904); specimen of *Zonites* representing a new species (35023).

NEW YORK UNIVERSITY, University Heights, New York City, received through Dr. C. L. Bristol: Polyps and other specimens from the Bermudas. Exchange. 34478.

NIBLACK, Lieut. A. P., U. S. Navy. (See under *Winslow*, U. S. torpedo boat.)

NICHOLAS, Miss ELIZABETH BYRD. (See under National Society of the Colonial Dames of America.)

NORFOLK COLLECTION, obtained through Paul Beckwith: Collection of war relics from Porto Rico and Cuba. 35187. The names of persons who contributed to this collection occur alphabetically in this list.

NORMAN, W. W., Austin, Tex., received through the Department of Agriculture: Three specimens of *Panorpa rufa* Gray, and 2 specimens of *Lipolexis rapæ* Curtis. 34728.

NORTH RIVER GARNET COMPANY, North River, N. Y.: Garnet rock. 34369.

- NORTHWESTERN IRON COMPANY, Milwaukee, Wis.: Specimen of iron ore. 34175.
- NORTON, Miss M. L., Marine, Ill.: Specimens of *Cecropia* Moth, *Attacus cecropia* Linnaeus. 35127.
- NOYES, Miss C. E., U. S. National Museum: Two unsigned ten-dollar notes of the Commercial Bank of Florida (34387); 6 envelopes with historical designs used during the civil war, 1861-1865 (35229).
- NUTTING, Prof. C. C. (See under Iowa, State University of.)
- NYE, WILLARD, jr., New Bedford, Mass.: Six specimens of mantis shrimp from Acushnet River. 34705.
- NYLANDER, O., Caribou, Me.: Specimens of *Margaritanas* (33831); amphipods from Maine (34362); 20 specimens of Cambrian fossils from near Newport, R. I., and 4 specimens of *Monograptus clintonensis* from Aroostook County, Me. (34725).
- O'CONNOR, J. J., Washington, D. C.: Peat from near the Lakes of Killarney, County Kerry, Ireland. 34436.
- O'NEIL, Rear-Admiral CHARLES, U. S. N., Bureau of Ordnance, Navy Department: Model of the new 4.7-inch shrapnel, U. S. A. 34000.
- O'ROURKE, BERNADOU, Paterson, N. J.: Schenkl shell (patented October 10, 1861), found in Virginia about 4 miles from Dumfrie, in dividing the line between Stafford and Prince William counties. 34951.
- OFFER, WILLIAM, Miami, Fla.: Fifty-five species of shells from Florida. 35021.
- OHIO CEMENT COMPANY, Lisbon, Ohio: Cement rock. 34168.
- OLD ABE COMPANY, White Oaks, N. Mex., received through J. Y. Hewitt, and A. E. Heighway: Three specimens of gold in selenite from Old Abe mine, White Oaks, N. Mex. 34701.
- OLD DOMINION MINING COMPANY, Spokane, Wash.: Silver ore. 34247.
- OLDROYD, Mrs. T. S., Los Angeles, Cal.: Five species of marine shells from Cuba. 34649.
- OLDS, H. W., Woodside, Md.: Thirty-nine plants from Brookside, W. Va. (34084); 22 plants (34140); plant from the District of Columbia (35121).
- ORD, J. T., Monterey, Mexico: Relics of the Spanish-American war. Deposit. 34080.
- ORR, H. D., Washington, D. C.: One-pound cartridge case and a one-pound shell. (See under Porto Rico collection 35201.)
- OSBORN, Prof. HENRY. (See under Agriculture, Department of.)
- OTTAWA, CANADA: GEOLOGICAL SURVEY OF CANADA, received through Prof. J. F. Whiteaves: Twenty-four specimens of Trenton fossils from Akpatok Island, Hudson Bay. Exchange. 34989.
- OTTOLENGUI, Dr. R., New York City: Forty-five specimens of Lepidoptera. 34107.
- OWEN, W. O., Washington, D. C.: Fourteen pieces of ancient pottery, a stone slab; a portion of a shell bracelet found among the ruins at Fort Bayard, N. Mex. 34522.
- OWENS, M. J., Mathias Point, Va.: Snake (33979); 2 vertebrae of a fossil whale (34371).
- PACKARD, A. S., Providence, R. I.: Fossil, genus *Astacus*, from Idaho. 33756.
- PAINE, R. G., Washington, D. C.: Seaside Sparrow from South Carolina. 34953.
- PALMER, EDWARD, Washington, D. C.: Specimens of *Bulimus* from Salteo, Mexico; crustaceans and worms from Mexico (34602); 550 plants from Mexico (purchase) (34853). (See under Smithsonian Institution, Bureau of Ethnology.)
- PALMER, Dr. T. S., Department of Agriculture: Skull of Razor-billed Auk. 33935.
- PALMER, WILLIAM, U. S. National Museum: Pine-mouse, *Microtus pinetorum*, from Hampstead, Md. (33778); 17 birds' skins from the western section of the United States (33941); 14 birds' skins from various localities (34180); crabs, worms, jelly-fish, and holothurian from Smiths Island, Virginia (34486); 6 skins and skulls of mammals from Smiths Island, Virginia (34597); 2 skins of *Microtus pennsylvanicus nigrans* (34633); plant from the District of Columbia (34983); 15 bats from Maryland (35184); collection of isopods, sponges, shells, fishes, and plants from Virginia (35186).

- PAN-AMERICAN MEDICAL CONGRESS, 1896: A miscellaneous collection of medicinal plants received in response to a circular issued by the Smithsonian Institution at the request of the promoters of the meeting of the Pan-American Medical Congress held in the City of Mexico in November, 1896. 35178.
- PARKER, L. C., Saltpetre Cave, Va.: Black marble. 34609.
- PARIS, FRANCE, MUSÉE D'HISTOIRE NATURELLE. Received through Léon Vailant. Collection of fishes in alcohol from north and central Asia, obtained by M. Chaffanjon (34363). Received through E. L. Bouvier, crustaceans, representing 80 species obtained from the dredgings of the *Travailleur* and *Talisman* (35078). Exchange.
- PARLIN, J. C., North Berwick, Me., received through Department of Agriculture: Twelve plants from Maine. 34943.
- PARMENTER, C. S. (See under Baker Institute.)
- PARRATA-DORIA, MIGUEL DE, Ponce, P. R.: Rough idol and a storm collar, leg shackles, pistol holsters, and a revolver. (See under Porto Rico collection 35201); copper ore, lead ore, auriferous quartz, graphite, and phosphate (34884).
- PARRITT, H. W., London, England: Seventeen specimens of marine invertebrates. Exchange. 35010.
- PARSONS, Dr. W. B., Missoula, Mont.: Specimen of substance, apparently a form of carbon, found on the edge of a stream in Missouri. 33944.
- PARSONS, W. D. (See under Treasury Department, U. S. Life-Saving Service.)
- PAVONA, Prof. C. F., Museum of Natural History, University of Turin, Turin, Italy: One hundred and sixty-seven specimens, representing 95 species, of fossil corals from the Italian Tertiary deposits. Exchange. 34448.
- PAYNE, E. J., Olympia, Wash.: Mineral from Index, Wash. 34058.
- PEABODY, Mrs. H. M., Bluff, Utah: Eighty-four specimens of Lepidoptera and Neuroptera. 34375.
- PEARSON, A. Y., Omaha, Nebr.: Ostrich skin. Purchase. 34133.
- PEARY, Lieut. R. E. (See under American Museum of Natural History.)
- PECK, C. H., Albany, N. Y.: Five specimens of plants, representing the genus *Houstonia*. 34352.
- PECKHAM, Prof. G. W., Hartland, Wis.: Insect, representing the genus *Crabro* (33813); 2 wasps (33892).
- PENNSYLVANIA, UNIVERSITY OF, DEPARTMENT OF ETHNOLOGY AND PALEONTOLOGY, Philadelphia, Pa.: Skull of a fossil bison. Deposit. (Returned.) 33847.
- PERKINS, A. F., Catatunk, N. Y.: Specimen of Walking Stick, *Diapheromera ferrmorata* Say. 34059.
- PETERS-BROOKS PARTY. (See under Interior Department, U. S. Geological Survey.)
- PHELPS, Miss ELLEN, Nitta Yuma, Miss.: Wings of a Seventeen-year Locust, *Cicada septendecim* Linnaeus. 34203.
- PHILADELPHIA COMMERCIAL MUSEUM, Philadelphia, Pa.: Forty specimens of violets. Exchange. 35166.
- PHILLIPS, Dr. W. A., Evanston, Ill., received through W. A. Carter, Brandon, England: Collection of flint implements from England. Exchange. 33933.
- PILSBRY, H. A., Philadelphia, Pa.: Specimens of *Somatogygus* from Alabama and *Paludestrina* from California. 34595.
- PINE, GEORGE, Aripeka, Fla.: Fifteen specimens of shells, representing 4 species (33885); 12 specimens of *Amphularia* from the Homosassa River, Florida, representing a new species (34169).
- PIPER, C. V., Pullman, Wash.: Plant (34408); 2 specimens of Umbelliferae, collected by A. D. E. Elmer in Washington (34601); 13 moths (34923); 295 specimens of Lepidoptera, including 2 specimens of *Arctonotus lucidus*, a rare species (35049).
- PITCHER, J. E., Custer City, S. Dak.: Skull of mammal, representing the genus *Oreodon* (purchase) (34459); ores, mica, clays, and other geological specimens (gift) (34460).
- PITTIER, H. F., Director del Instituto Físico-Geográfico Nacional, San José, Costa Rica: Two hundred plants (33930, 34006); 102 plants from Central America (34686). Purchase.

- PLANK, E. N., Kansas City, Mo., received through Department of Agriculture: Three plants. 34966.
- PLASKETT, R. A., Gorda, Cal.: One hundred and sixty-seven plants from California. Purchase. 34955.
- PLECKER, W. A., Hampden, Va.: Specimens of *Lagoa opercularis* Ashd. 34070.
- PLITT, C. C., Baltimore, Md., received through Department of Agriculture: Three plants from near Baltimore. 34029.
- POLLARD, C. L., U. S. National Museum: Violet (33743); 50 plants from Maryland and the District of Columbia, and 300 plants from Florida (33835); specimens of *Vespertilio fuscus* (33836); 9 plants from Long Island (33953); 13 plants from near Boston, Mass. (33983); 26 specimens of Lepidoptera (34994).
- POLLARD, EDWARD, Washington, D. C.: Japanese dagger. Exchange. 35100.
- POPE, C. A., Trenton, N. J., received through Bureau of Ethnology: Specimens of "Inca" pottery. 35145.
- Porto Rico Collection, obtained by Paul Beckwith: Collection of Spanish war relics. A collection of natural specimens was also obtained by Mr. Beckwith in Porto Rico. 35201. The names of persons who contributed to this collection occur in alphabetical order in the accession list.
- POST, E. J., Tampa, Fla.: Nine species of shells from Florida and Honduras (34136); 5 species of marine shells from Florida (34975); 6 species of marine shells (35042).
- POSTEL, HENRY. (See under Smithsonian Institution, Bureau of Ethnology.)
- POUNDSTONE, Lieut. H. C., U. S. N., received through Lieut. J. B. Bernadou: Specimens of powder from the Spanish ships *Oquendo* and *Maria Theresa*. 34193.
- POWELL, J. B. (See under Smithsonian Institution, Bureau of Ethnology.)
- POWELL, W. F. (See under State, Department of.)
- PRATT, F. C., Department of Agriculture: Seventeen specimens of miscellaneous insects. 35154.
- PRATT, J. H., Chapel Hill, N. C.: Two specimens of wellsite from a mine near
- PRATT, J. H.—Continued.
- Buck Creek, and two specimens of anthophyllite from near Bakersville (34666); anorthite in forrelenstone from Buck Creek (34733); kyanite and anorthite in forrelenstone (34734).
- PREBLE, E. A., Department of Agriculture: Three plants (33865); 5 specimens of *Mus musculus* (34350); 6 frogs (34956).
- PRENTISS, D. W., Jr., Washington, D. C.: Mammals, snakes and batrachians, and shells. 34012.
- PRESTON, J. W., Baxter, Iowa: Hawk from Manitoba. 35128.
- PRICE, Miss S. F., Bowling Green, Ky.: Two species of fresh-water shells (34113); plant from Warren County, Ky. (34224); species of *Goniobasis* from Kentucky (34485); 7 specimens of violets (35135). (See under J. K. Small.)
- PRINGLE, C. G., Charlotte, Vt.: Two hundred and fifty plants from Mexico (34030); type specimens of *Polianthes pringlei* (34234).
- PRITCHETT, H. S. (See under Treasury Department, U. S. Coast and Geodetic Survey.)
- PUBLIC GARDENS AND PLANTATIONS, BOTANICAL DEPARTMENT. (See under Kingston, Jamaica.)
- PURPUS, C. A., San Diego, Cal.: Plants. (35080, 35106, 35181.) Purchase.
- QUAINANCE, A. L., and P. H. Rolfs, Lake City, Fla.: Specimens of *Coccidae americanæ*, representing 20 species of North American scale insects. 34377.
- RAMIREZ, Dr. José, Instituto Medico Nacional, City of Mexico, Mexico: Thirty water-lily bulbs from Mexico. Exchange. 34562.
- RAMSAY, T. R., Dublin, Ga.: Moth (*Attacus cecropia* Linneus). 34933.
- RANDALL, F. A., Warren, Pa.: Specimens of *Echinocaris socialis*; 2 specimens of *Tropidocaris bicarinata*; 1 specimen of *Elhymocaris siliqua*, and 7 specimens of *Lingula* from the Chemung formation, Warren, Pa. Exchange. 34480.
- RANDLEMAN, Mrs. A. B., Lewis, Iowa.: Tooth of a mastodon found in Cheyenne County, Nebr. Purchase. 34442.
- RANDOLPH, P. B., Seattle, Wash.: Shells from Alaska (33889, 34398).

- RANKIN, E. W. (See under Gerard Troost, estate of.)
- RATHBUN, Miss M. J., U. S. National Museum: Collection of marine invertebrates, mullusks, fishes, millepores, and algae from Grand Manan, New Brunswick. 34048.
- READING, H. G., Franklin, Pa.: Two specimens of stone-flies, representing the species *Acraneuria arida* Hagan. 35118.
- REESE, HAMMOND & Co., Bolivar, Pa.: Sample of fire clay. 35055.
- REEVES, J. A., Joplin, Mo.: Specimen of calamine after calcite from Aurora, Mo. (34605); fire clay from St. Louis, Mo., and mineral water from Bowling Green, Mo. (34695) "O".
- REINECKE, Dr. F., Breslau, Germany: Five hundred plants from the Samoan Islands. Purchase. 34276.
- REYNOLDS, A. J., Connersville, Ind.: Sixty specimens of quarry rejects (exchange). 33839.
- RHOADS, Dr. Thomas Leidy, U. S. N., Washington, D. C.: Skull transfixed with an arrow point. 34306.
- RICE, Prof. E. L., Delaware, Ohio; received through Dr. L. O. Howard: Three specimens of amphipods. 34730.
- RICHARDS, W. A., Cheyenne, Wyo.: Ores, clays, coals, petroleum, and silicified palm trunk. 34655. "O."
- RICHARDSON, Dr. D. A., Denver, Colo.: Two plants from Washington. 34115. (Returned.)
- RICHARDSON, H., Trail, Oreg.: Sample of ocher. 34262.
- RICHMOND, C. W., U. S. National Museum: Five birds' skins from Smiths Island, Va. (34105); skeleton of Black Skimmer (34315); skin of Snowy Owl (exchange) (34626).
- RICKER, Prof. Maurice, Burlington, Iowa: Butterfly (*Agraulis vanillæ* L.); bumblebee (*Bombus americanorum* Fab). 34581.
- RIDENOUR, W. B., Scranton, Pa.: Specimen of *Dymastes titus* Linnaeus. 33973.
- RIJKS ETHNOGRAPHISCH MUSEUM. (See under Leiden, Holland.)
- RIKSMUSEUM. (See under Stockholm, Sweden.)
- RILEY, J. H., U. S. National Museum: Specimen of *Nycticejus humeralis* from
- RILEY, J. H.—Continued.
- Falls Church, Va. (33879); set of eggs of Broad-winged Hawk (35011); 29 batrachians, representing the species *Plethiodon cinereus* from Virginia (35109); mole (*Scalops aquaticus*), and a red squirrel (*Sciurus hudsonicus*); 2 birds' skins and 5 eggs of Henslow's Bunting (35115); 7 birds' eggs (35129); bat (*Vespertilio fuscus*) (35144); 6 birds' skins from North Carolina (exchange) (35169).
- RIZER, Mrs. H. C., Washington, D. C.: Twenty-five plants from Florida. 34830.
- ROBERTS, C. H., Paris, Ontario, Canada: Plaster cast of a bird amulet. Exchange. 34502.
- ROBERTS, W. G., Middletown, Ohio: Fossil skull of a bear. Purchase. 34866.
- ROBERTS, W. J., Harrisville, Pa.: Specimen of *Corydalis cornutus*. 33856.
- ROBINSON, Dr. B. L., Cambridge, Mass.: Three specimens of violets from Massachusetts. 34081.
- ROBINSON, S. A., Orlando, Cal.: Two teeth of *Bison latifrons* and a tooth of *Procamelus*. 33830.
- ROBINSON, W. RUSSELL, Wingina, Va.: Nest, 5 eggs, and a specimen of Migratory Shrike (*Lanius ludovicianus migrans*) (34937, 34948).
- ROEBLING'S, J. A., Sons & Co., Trenton, N. J.: Twenty-one specimens of electrical cables and wires. 34724.
- ROGERS, Maj. E. J., Michigan National Guard, Port Huron, Mich.: Copy of the first newspaper published in Santiago, as "Company F Enterprise." 33950.
- ROLFS, Prof. P. H., and A. L. Quaintance, Lake City, Fla.: Specimens of *Coccidae americanae*, representing 20 species of North American scale insects. 34377.
- ROON, VAN, G., Rotterdam, Holland: Collection of beetles from Java and South Africa. Exchange. 34381.
- ROSALSKY, W., Clackamas, Oreg., received through Department of Agriculture: Plant from Oregon. 34982.
- ROSE, J. N., U. S. National Museum: Plants (33762, 33818, 34035, 34223).
- ROSS, Hon. M. L., Knoxville, Tenn., received through R. L. Garner: Fossil tooth of a mammal. 33942.

- ROSSER, L. K., Luray, Va.: Two specimens of *Dynastes tityus* Linnaeus. 34765.
- ROTHROCK, Dr. THOMAS, Howard, Pa.: German fat-lamp, piece of fossil rock, and stone implements. 34974.
- ROWLES, W. W., Cornell University, Ithaca, N. Y., received through Department of Agriculture: Fifty-eight plants from the northwestern part of the United States. 35034.
- ROYAL BOTANIC GARDENS. (See under Kew, England.)
- RUFF, Mrs. T. B., Laurel, Md.: Three specimens of *Mus musculus*. 34566.
- RUHL, J. W., Covington, Ohio: Lime-stone used for making quicklime. 34205.
- RUSCHEWEYH, G., Buenos Ayres, Argentina: Collections of Lepidoptera (34267, 35155). Exchange.
- RUSH, R. C., Hudson, Ohio: Specimens of *Sphærium*. 33807.
- RUSSELL, H. S. (See under Fire Department, Fire Alarm Branch, Boston, Mass.)
- RUSSELL, Mrs. M. E., Pomeroy, Pa.: Specimen of *Corydalis cornutus* Linnaeus, and a specimen of *Desmocerus palliatus* Forster. 33802.
- RUSSELL, SAMUEL, U. S. volunteer, Telford, Tenn.: Mauser clip with fixed ammunition complete, captured near Coama, P. R.; brass bullet, fixed ammunition, used by the Spanish troops, and captured at Santiago de Cuba during the campaign. 34149.
- RUST, H. N. (See under Smithsonian Institution, Bureau of Ethnology.)
- RUTH, Prof. A., West Knoxville, Tenn.: Six hundred plants from East Tennessee and Alabama. Purchase. 35105.
- RYDING, H. W., Thorsby, Ala.: Larval specimen of *Papilio troilus* Linnaeus. 33960.
- RYERSON, HARRY, Larchmont Manor, N. Y.: Specimen of 100-pound rail, 5 inches long, used by the New York and New Haven Railroad Company, with standard angle splice-bars and bolt attached. 34157.
- SAEGER, C. M., Coplay, Pa.: Cement rock and products. 34919.
- SAFFORD, Prof. J. M., Vanderbilt University, Nashville, Tenn.: Ninety-six specimens of fossils from the Calciferous formation; 143 specimens from the Lower Helderberg, and 51 miscellaneous specimens from the Wells Creek Basin of Tennessee. 34878.
- SALINE RIVER PAINT COMPANY, Saline River, Kans.: Sample of ocher. 34332.
- SANDERS, W. C., jr., Luverne, Ala.: Lime-stone used for making quicklime. 34297.
- SANDERSON, Prof. E. DWIGHT, Collegepark, Md.: Twelve specimens of neuropteroid insects. 35198.
- SANDUSKY PORTLAND CEMENT COMPANY, Cleveland, Ohio: Sample of marl. 34242.
- SANFORD, Mrs. E. L., Watertown, Conn.: Specimen of *Citheronia regalis* Fabr. 33766.
- SANFORD, J. A., Stockton, Cal.: Two plants. 34162.
- SANTOS, ALEXANDRO. (See under P. M. de Leon.)
- SARDESON, F. W., Minneapolis, Minn., received through Hon. C. D. Walcott: Eighty-five specimens of Middle Cambrian brachiopoda. Exchange. 34763.
- SAUNDERS, M. B., East Norwalk, Conn.: Hemipterous eggs belonging to the family Coreidae. 34011.
- SAVAGE MOUNTAIN FIRE BRICK WORKS, Frostburg, Md.: Fire-clay. 34178.
- SAWYER, E. L., Winchendon, Mass.: Fifty specimens of Australian Lepidoptera. Exchange. 34438.
- SCHAUM & UHLINGER, Philadelphia, Pa.: Six shuttles for textile machinery. 33805.
- SCHAUPP, F. G., Shovel Mount, Tex.: Plant from Texas. 34942.
- SCHLARBAUM, PAUL, Loveland, Colo.: Two specimens of *Euhagena nebraskæ*. Exchange. 34419.
- SCHMID, E. S., Washington, D. C.: Marmoset. 34787.
- SCHNECK, Dr. J., Mount Carmel, Ill.: Old-squaw duck. 34722.
- SCHOENEMANN, W. C., Philadelphia, Pa.: Collection of shells for the exhibit in the Children's Hall. Purchase. 34674.
- SCHOENRICH, OTTO, Baltimore, Md.: Spanish flag carried through the battle at

SCHOENRICH, OTTO—Continued.

- Guayama, P. R.; 2 maracas, or native rattles, used as a musical instrument; native pottery and a vase from Porto Rico. 34869.
- SCHÖNLAND, DR. S. (See under Grahams-town, South Africa, Albany Museum.)
- SCHOOLY, I. P., Herndon, Va.: Specimen of *Strix pratineola*. 33822.
- SCHUCHERT, CHARLES, U. S. National Museum: Three hundred specimens of Choteau fossils (33744); 100 specimens of Lower Oriskany fossils from Beecrafts Mountain, near Hudson, New York (34606). (See under R. A. Blair.)
- SCHUYLER, COLFAX, South Amboy, N. J.: Wingless parasitic moth or mutillid, representing the species *Mutilla occidentalis* Linnaeus. 33967.
- SCHWARZ, E. A., Department of Agriculture, Washington, D. C.: Collection of exotic beetles from Java, Borneo, Africa, and other localities. 34689.
- SCHWARZ, H., Washington, D. C., and St. Louis, Mo.: One hundred and ninety-five specimens of Lepidoptera from Texas and Mexico (exchange) (34119); 45 moths and butterflies (exchange) (34232); 33 specimens of Mexican Hesperidae (gift) (34289); 2 specimens of Hymenoptera (gift) (34393).
- SCOTT, Capt. L. A., San Juan, P. R.: Ship's plate, and a poem, "Remember the Maine." (See under Porto Rico Collection 35201.)
- SCOTT, RALEIGH, Mountain Ranch, Irma, Oreg.: Specimen of priceite from Curry County, obtained by Dr. David T. Day. 34569.
- SEAL, W. P., Delair, N. J.: Specimen of *Callichthys fasciatus* from Argentina (34391); specimens of *Mesogonistius chetodon*; *Aphredoderus sayanus*; *Boleosoma*; *Erinomyzon suetta*; *Callichthys fasciatus* (34719); collection of fishes, reptiles, and a shrimp from Wilmington, N. C. (34997).
- SEAMAN, DR. L. L., New York City: Insignia of the Engineer Corps of the United States Army. (See under Porto Rico Collection 35201.)
- SEARS, J. H., Salem, Mass.: Specimens of fayalite from Rockport, Mass. (34041, 34557).
- SELYS-LONGCHAMPS, BARON EDMOND DE, Liege, Belgium: Twenty-four mammals. 34421.
- SEMPERS, J. F., Aikin, Md., received through Department of Agriculture: Plant. 34680.
- SENFF ZOOLOGICAL EXPEDITION OF COLUMBIA COLLEGE, received through N. R. Harrington: Specimen of *Polyterus bichir*. Exchange. 34898.
- SERRURIER, DR. L. (See under Leiden, Holland, Rijks Ethnographisch Museum.)
- SEYMOUR, HENRY, Norfolk, Va.: Three-pound cartridge and a metal label recovered from the wrecks of the Spanish ships *Reina Mercedes* and *Maria Teresa*. (See under Norfolk Collection 35187.)
- SHAFFER, O. E. (See under Gus Wycoff and Cleo Backus.)
- SHAREN, J. M., Rocky Ridge, Md.: Barn Owl (*Strix pratineola*). 34428.
- SHARP, MRS. J. E. D. (See under Prof. O. F. Cook.)
- SHAW, R. E., Alberene, Va.: Snake. 33827.
- SHEAR, C. L., Washington, D. C., received through Department of Agriculture: Seven plants from Colorado. 34965.
- SHEETS, HENRY, Norfolk, Va.: Articles recovered from the wrecks of the Spanish ships *Cristobal Colon*, *Reina Mercedes*, *Maria Teresa*, and *Almirante Oquendo*. (See under Norfolk Collection 35187.)
- SHELDON, E. P. (See under Agriculture, Department of.)
- SHORT, S. H. (See under Walker Electric Company.)
- SHRIVER, HOWARD, Cumberland, Md.: Plant. 34028.
- SHULAK, FRANK X. (See under Interior Department, U. S. Geological Survey.)
- SIMMER, HANS. (See under Freie Vereinigung Tiroler Botaniker, Carinthia, Austria.)
- SIMPSON, J. A., Manatee, Fla.: Seven hundred and three plants from Florida (33749, 33982, 34110, 34124, 34236, 34274, 34321, 34432). Exchange.

- SINGLEY, J. A., Giddings, Tex.: Marine shells from the Gulf of California. 33779.
- SKINNER, Dr. H., Philadelphia, Pa.: Four specimens of Alaskan Arctiidae. 34288.
- SLACK, Rev. W. S., Musson, La.: Larva of moth (*Empyria stimulea*). 34044.
- SLOCUM, A. W., Milwaukee, Wis.: Post-Pliocene marl and fossils. 33850.
- SLOSSON, Mrs. A. T., New York City, N. Y.: Two specimens of *Anthonomus leucoparsis* Linell. 35024.
- SMALL, J. K., New York City, N. Y.: Plant obtained by Miss Sadie F. Price, of Bowling Green, Ky. 34345.
- SMITH, Mrs. ALONZA, Carthage, N. Y.: Three specimens of minerals from St. Lawrence County, N. Y. 34929.
- SMITH, C. E., Philadelphia, Pa.: Specimens of *Cinolepiga racemosa dissecta*. 34126.
- SMITH, Prof. F. D., University of Montana, Missoula, Mont.: Parasite from Florence, Mont. 34520.
- SMITH, G. O. See under Interior Department, U. S. Geological Survey.
- SMITH, HENRY, clerk of supreme court, Honolulu, Hawaiian Islands: Silver dollar of the issue of 1883, used during the reign of Kalakaua I. King of Hawaii. 33909; 13 Hawaiian coins. 34620.
- SMITH, H. F., Washington, D. C.: Bronze medal given to Gen. John Anderson by the city of New York in recognition of his defense of Fort Sumter. Deposit. 34748.
- SMITH, H. L., New York City, N. Y.: Amphipods. 34588; invertebrates, mollusks, and fishes from Fort Rupert, British Columbia. 34711.
- SMITH, Dr. H. M., U. S. Fish Commission: Five species of land and fresh-water shells. 35125.
- SMITH, Mrs. J. A., Menapville, Tex.: Unios. 34731, 34928.
- SMITH, Prof. J. R., New Brunswick, N. J.: Four plaster casts of burrows made by *Lepus texianus*. 33888; 23 moths, including 20 type specimens. 34688; 26 specimens of Hymenoptera. 34777-34799. Plates illustrating the structural characters of the Noctuidae, Acronycta, Hydrulids, Cnecilia, etc. 34888; 2 type specimens of *Campoplex minor* Smith. 35005.
- SMITH, JOHN DONNELL, Baltimore, Md.: Plant from Costa Rica. 34678.
- SMITH, JARED G., Department of Agriculture: Specimen of allium from New Mexico (33770); plant from Wyoming (34625); 28 plants (35120).
- SMITH, L. E., Buffalo, N. Y.: Corps badge of the First Division, Third Army Corps. 34902.
- SMITHSONIAN INSTITUTION, Mr. S. P. Langley, Secretary:
- Bronze reproduction of the Bruce gold medal. Deposit. 34255.
- Specimen of citrine quartz (cut stone) from Florissant, Colo. Received from Dr. L. T. Chamberlain, New York City, for addition to the Lea Collection. 34279.
- Specimens of ores from the Zanendo mines, near Medellin, Colombia, South America. Received through Hon. Charles Burdett Hart, United States minister. 34374.
- Ninety-seven birds' eggs from various parts of the United States. Received through Dr. W. L. Ralph, Utica, N. Y. 34698.
- Starry flag of the *Bon Homme Richard* and letter of James Meyler, dated December 13, 1784, presenting the flag from the Marine Committee to Lieutenant Stafford. Received through Mrs. H. R. P. Stafford, Cottage City, Mass. 34490.
- Boarding sword of the *Bon Homme Richard* and musket captured from the *Scipio* by John Paul Jones. Received through Mrs. H. R. P. Stafford. 34599.
- Pocket telegraph instrument in an oval mahogany case; Morse telegraph relay; Morse telegraph sounder. Received through Mr. D. Wilmot Smith, Breckinridge, Minn. 34790.
- Twenty-one gemis sapphires from Montana, and 2 gemis (rhodolites) from North Carolina. Received from Dr. L. T. Chamberlain, New York City, for the "Lea collection." 35077.
- Specimen of *Buteo borealis* from Florida. Received from Dr. W. L. Ralph, Utica, N. Y. 35080.

SMITHSONIAN INSTITUTION—Continued.

Seventy-nine birds' eggs from California and Arizona, and 31 birds' eggs from Florida. Received from Dr. W. L. Ralph, Utica, N. Y. (35110, 35114.)

Two specimens of *Crotophaga* and from Florida. Received from Dr. W. L. Ralph, Utica, N. Y. 35170.

Transmitted from the Bureau of Ethnology, Maj. J. W. Powell, Director:

Cirripes taken from the French-American cable by the steamship *Minia*; also a piece of the cable, received through Dr. J. Walter Fewkes (33753); collection of potsherds from the talus of Katzima, or the Enchanted Mesa, near the pueblo of Acoma, in Western-Central New Mexico (33794); stone ceremonial spear, also fibers, corncobs, etc., from Cebollita Valley, New Mexico (33806); collection of mound pottery and other objects obtained through G. F. Morris (33919); necklace made of greenstone beads, panther made of greenstone beads, and 2 mirrors made of pyrites of iron, obtained through G. F. Morris (33928); double frog pipe carved in sandstone, found in a mound in Crittenden County, and a pottery vessel from a mound in Mississippi County, Ark., obtained through G. F. Morris (33934); collection of Indian relics, obtained through Rev. D. Jones (33939); saddles, horse trappings, skins used for bedclothing, cradles, obtained through J. B. Hatcher from the Tuelches Indians of Patagonia (33958); blanket wrapping for Kiowa shield and a calendar painted on buckskin by the Kiowa Indians of Oklahoma (34001); collection of pottery vessels, bone implements, wooden tray, basketwork, and other objects from Cliff Ruins in San Juan County, Utah, obtained through Henry S. Gane (34002); ethnological objects from the Indians of the plains and Rocky Mountains and 2 skulls of *Antilocapra* and a pair of antlers, obtained through Emile Granier (34005); 18 trephined skulls from Peru, obtained through Dr. M. A.

SMITHSONIAN INSTITUTION—Continued.

Muniz (34004); collection of ancient pottery from San Juan region (Montezuma Valley), obtained from Mrs. W. L. Stauffer (34006); ethnographical collection from Mexico, obtained by E. W. Nelson (34807); ethnological objects from Mexico, obtained from Edward Palmer (34808); anthropological objects from California, obtained through W. H. Holmes (34809); stone implements, objects of burned clay, bone, shell, etc., obtained through Edward Hughes, Stockton, Cal. (34810); mound relics of shell, bone, and stone, obtained through H. C. Meredith, Stockton, Cal. (34811); stone implements and objects of baked clay, obtained through J. A. Barr, Stockton, Cal. (34812); human bones and fossil bones of mammals, obtained through W. J. Mercer, Murphy, Cal. (34813); net and headband used for carrying baskets, used by the Pomo Indians, obtained through W. H. Holmes from J. W. Hulson, Ukiah, Cal. (34814); set of gambling bones from the same tribe, obtained from C. F. Briggs, San Francisco, Cal. (34815); stone mortar from California, obtained from E. G. Kavanaugh, Forest Hill, Cal. (34816); 4 stone implements, obtained through J. B. Pownall, Columbia, Cal. (34817); stone implements and utensils from Pasadena, Cal., obtained from H. N. Rust, South Pasadena, Cal. (34818); costume of an Ojibwa warrior, Kway gway ye way be nung, from Minnesota (34912); mug from a pueblo in Cebollita (34908); Shawnee wampum belt, received through Willis N. Tobias, Moraviantown, Ontario, Canada (34924); discoidal stone found in Cherokee County, Ga., received from C. L. Miller, Coulterville, Tenn. (35068); antiquities from Mexico and Texas, collected by Mr. Holmes (35101); obtained through Henry Postel, New York City, collection of Mexican and Peruvian relics (35172); obtained through J. H. Elder, Rutledge, Ga., a carved stone pipe (35176).

SMITHSONIAN INSTITUTION—Continued.

(See under James Crockett; C. A. Pope; Rev. I. P. Whittemore.)

Transmitted from the National Zoological Park, Dr. Frank Baker, superintendent:

Skeletons of parrot and water snakes (33748); specimen of *Erethizon dorsatus* (33776); Owl Monkey and a Loon (33783); specimen of *Nasua narica* and a Porcupine (*Erethizon dorsatus*) (33867); Ostrich in the flesh (33868); iguana from the Bay of Honduras (33966); Black Buck (*Antelope cervicapra*) (33965); Gila monster and Otter (33966); California Sea-lion, *Zalophus californianus* (34104); specimen of *Canis lupus griseo-albus* (34218); 5 mammals in the flesh (34366); specimen of *Oreortyx pictus* (34373); Wolf (*Canis lupus griseo-albus*) (34378); 3 mammals in the flesh (34445); Sea-lion, Beaver, California Jay, Plumed Partridge, Snake bird, Rattlesnake, and Pine Snake (34454); peccary (*Dicotyles*) (34614); specimens of *Mephitis mephitis*, *Zalophus californianus*, and *Lynx rufus maculatus* (34738); 2 kangaroos (34788); partridge (*Oreortyx pictus*) (34855); partridge (*Oreortyx pictus*) (34856); Mandarin Duck, *Aix galericulata* (34858); Sand-hill Crane, *Grus mexicana* (34857); specimens of *Felis leo*, *Macacus cynomolgus*, and *Canis lupus griseo-albus* (35004); specimen of *Pituophis melanoleucus* from Florida (35012); Wood Ibis, *Tantalus loculator* (35087); specimen of *Caica xanthomera* from the Upper Amazons (35171); specimen of *Halicetus leucocephalus* and specimen of *Geococcyx californianus* (35175); Antelope (35172); Spoonbill, *Ajaia ajaja* (35197).

SNYDER, Prof. A. J., Belvidere, Ill.: Fourteen specimens of butterflies. 35153.

SNYDER, Dr. ELIZABETH, Philadelphia, Pa.: Thirty-four photographs of Havasupais, Navaho, Moki, and Laguna Indians. 34697.

SOLÓRZANO, Dr. MANUEL MARTINEZ. (See under Morelia, Mexico, Museo Michoacano.)

SOLTAN, HUGO, Louisville, Ky.: Insects, myriapods, and spiders. 34013.

SOUTHERN ICE EXCHANGE, Apalachicola, Fla., received through George H. Whiteside: Original letters of patent and specification of Dr. John Gorrie; also bound volume of the "Commercial Advertiser" of Apalachicola issued during the year 1844, containing the original articles written and published by Dr. Gorrie on the ice machine. 33784.

SPENCE, R. S., Paris, Idaho: Ten specimens of Triassic fossils. 34834.

SPENCER, Mrs. GERTRUDE, Hooper, Colo.: Specimen of *Epeira sylvestica*. 34061.

SPORTSMAN'S EXPOSITION NEW YORK (QUEBEC EXHIBIT), Glens Falls, N. Y., received through A. N. Cheney: Specimen of brook trout (*Salvelinus fontinalis*) from Lake Edward, Canada. 34870.

SPOTTSWOOD, H. N., U. S. National Museum: Two bobolinks. 35048.

STABLER, J. P., Sandy Spring, Md.: Sharp-shinned Hawk, *Accipiter velox*. 34908.

STAFFORD, Mrs. W. L. (See under Smithsonian Institution, Bureau of Ethnology.)

STANDISH, B. H., Minneapolis, Minn.: Collections of ants (33746, 33786); specimens of *Tupinoma sessile* Say and *Messor andrei* Mayr (33917).

STANTON, T. W., U. S. Geological Survey: Four plants from Texas (34007); specimens of *Holospiras* from Texas (33925). (See under J. D. Lisle.)

STANTON, Rev. W. A., St. John's College, Belize, British Honduras: Crustaceans and a lizard from British Honduras (35700); collection of natural history specimens (34976).

STANTON, Mr., Central Mine, Houghton County, Mich.: Copper bowlder with native silver (34456); crystallized copper silver nugget (34457). Purchase.

STAR CLAY COMPANY, Mertztown, Pa.: Clay for chinaware and paper manufacture. 34391.

STATE, DEPARTMENT OF, received through Hon. David J. Hill: Two specimens of ores from Haiti obtained by Hon. W. F. Powell, United States minister (34967); received through Hon. T. W.

STATE, DEPARTMENT OF—Continued.

- Cridler, piece of a 6-inch shell fired at Cavite; letter from Consul Wildman; Spanish shell captured at Cavite arsenal and a small Spanish shell from Cavite (deposit) (33906); fragments of pottery from Honduras obtained by Hon. Benjamin Johnson, United States consul (35158). (See under Hon. A. D. Barlow; Marquis Visuddha.)
- STEARNS, FREDERICK, Detroit, Mich.: Eighty-three casts of Oriental seals. 34188.
- STEARNS, DR. R. E. C., Los Angeles, Cal.: Four specimens of *Crepidula glauca* Say from beds of oysters transplanted from the Atlantic coast to San Francisco Bay (34776); insects and 8 specimens of *Gemma purpurea* from Alameda, Cal. (34905).
- STEELE, E. S., Washington, D. C.: Plant (gift) (34400); 244 plants from West Virginia (purchase) (34514); plant (exchange) (34682); violet (gift) (35133).
- STEIMAN, AUG., Swiss Alps, Tex., received through Department of Agriculture: Plant from Texas. 34938.
- STEINER, ROLAND, Grovetown, Ga.: Weapon used by runaway slaves to protect themselves from bloodhounds (34917); double-barreled flint-lock gun, and 6 flints (35158).
- STEITZ, A., Baltimore, Md.: Eight photographs of orchids. 34235.
- STEINEGER, DR. LEONHARD, U. S. National Museum: Four frogs from Bergen, Norway (34023); mouse (*Mus musculus*) from Brookland, D. C. (34190).
- STEINEGER, MISS THORA, Department of Agriculture: Fifty-three mammal skins and skulls from Norway. Purchase. 33901.
- STERKI, DR. V., New Philadelphia, Ohio: Amphipods. 34206.
- STEVENSON, J. A., Miami, Fla.: Five specimens of marine shells (34774); 9 species of land and marine shells (34845).
- STITT, E. E., Columbus, Ohio: Limestone used for making quicklime. 34160.
- STOCKHOLM, SWEDEN, RIKSMUSEUM, received through Dr. Oscar Carlgren: Twenty-nine species of Actinians. Exchange. 34020.
- STONE, R. L., U. S. National Museum: Seven photographic prints of pictures of ostriches and a large photograph of an ostrich. 34372.
- STOUT, WILBUR. (See under Interior Department, U. S. Geological Survey.)
- STRECKER, DR. HERMAN, Reading, Pa.: Specimens of Lepidoptera (34781, 34795, 35156). Exchange.
- STROBRIDGE, MRS. I. M., Humboldt, Nev.: Thirteen specimens of petrified wood from Humboldt County (34147); 11 mounted photographs (blue prints), representing views in the "Virgin Valley Forest," showing fossil tree-trunks in position (34172).
- STUBBS, A. P., Ware, Mass.: Fossil shells from Winterport, Massachusetts. 34821.
- SUHR, KIN B., U. S. National Museum: Korean flute. 33894.
- SUKSDORF, W. N., Bingen, Wash.: Forty-three plants. 35032.
- SUMPTER, I. W., Elliston, Va.: American Silk-moth *Attacus cecropia* Linné. 34990.
- SUTHERLAND, DR. L. D., Canandaigua, N. Y.: Specimen of *Epeira domiciliana* Hentz. 34231.
- SUTTON, W. H., Philadelphia, Pa.: Program of concerts given by the Young Men's Christian Association to the soldiers in camp at Chickamauga in 1898; also newspapers. (See under Porto Rico Collection 35201.)
- SWAIN, C. O., Roslyn, Wash.: Fossils from Washington. 34852.
- SWAIN, THOMAS, Paradox, Colo.: Specimens of uranium ore from "Yellow Bay," La Sal Creek, and from "Copper Prince," Roe Creek. 34823.
- SWAN, ETHELYN, Dallas City, Pa.: Specimen of *Diapheromera femorata* Say. 34064.
- SWARTA STONE AND LIME COMPANY, Swarta Station, Pa.: Specimen of limestone used for making quicklime. 34420.
- SWEET, C. J., Fisher, Minn.: Meteorite. Purchase. 34244.
- SWEETWATER COAL MINING COMPANY, Rock Springs, Wyo.: Coal. 34558.
- SYRACUSE COAL AND SALT COMPANY, Syracuse, Ohio: Specimen of common fine salt made from Syracuse brines. 34914.

- SZOLD, Miss HENRIETTA, Baltimore, Md.: Photograph of a synagogue of the Ohel Shalom Congregation in Baltimore. 34628.
- TABER, JOHN, Dallas, Tex.: Specimen of *Spharophthalmus occidentalis*. 33918.
- TAFF, J. A. (See under Interior Department, U. S. Geological Survey.)
- TAIT, J. A., Floral City, Fla.: Plant. 34050.
- TALBOT, D. H., Sioux City, Iowa: Specimen of wolfram from near Lead City, S. Dak. 34963.
- TASSIN, Mrs. MARY, Washington, D. C.: Sword, sword knot, and belt presented to the late Col. A. S. Tassin, U. S. A. (sword case and packing box). 33986.
- TASSIN, WIRT, U. S. National Museum: Diamond crystal from De Beers Mine, South Africa. 34987.
- TATE, W. B., U. S. National Museum: Specimen of *Vespertilio fuscus*. 33878.
- TAYLOR, J. G., Owensboro, Ky.: Skin of a Passenger Pigeon. 33875.
- TAYLOR, WILLIAM, Rockcreek, Wyo.: Specimens of bentonite or taylorite. 34370.
- TEHAMA CONSOLIDATED CHROME COMPANY, Red Bluff, Cal.: Sample of ocher. 34210.
- TENNESSEE CENTENNIAL EXPOSITION, Nashville, Tenn.: One hundred and thirteen photographs from negatives of views of buildings and grounds of the Exposition in 1897. 35237.
- TENNESSEE COAL, IRON AND RAILROAD COMPANY, Birmingham, Ala.: Coal. 34177.
- TERRY, C. A. (See under Westinghouse Electric and Manufacturing Company.)
- TEXAS COAL AND FUEL COMPANY, Weatherford, Tex.: Coal. 34212.
- THISELTON-DYER, Dr. W. T. (See under J. B. Baker: Kew, England, Royal Botanic Gardens.)
- THOMPSON, E. S., New York City, N. Y.: Two specimens of *Cervus canadensis*; 2 specimens of *Odocoileus hemionus*; 3 specimens of *Oris carvina*, and 1 specimen of *Antilocapra*. Purchase. 34977.
- THOMPSON, Miss JENNIE, Morgantown, W. Va.: Collection of molding tools, molds and dies, etc., obtained by Dr. Walter Hough from the Thompson Pottery, at Morgantown. 34057.
- THOMPSON, Capt. WILLIAM, Norfolk, Va., received through W. A. Wilcox: Three deformed claws of *Callinectes sapidus*. 33768.
- THURSTON, G. P., Nashville, Tenn.: Fifteen skulls of Stone grave Indians. 34696.
- THURLOW, F. W., Harvester, Tex.: Medicinal plants (33808); received through Department of Agriculture, 10 plants (34876); 19 plants (35033).
- TIFFANY & Co., New York City, N. Y.: Four cut opals. Purchase. 35163.
- TILDEN, Miss JOSEPHINE, University of Minnesota, Minneapolis, Minn.: One hundred specimens of American algæ. Purchase. 34238.
- TINGLE, G. R., Snug Harbor, Cook Inlet, Alaska: Hair worm, representing the genus *Gordius*. 35149.
- TINSLEY, J. D., Mesilla Park, N. Mex.: Myriapod. 33916.
- TOBIAS, W. N. (See under Smithsonian Institution, Bureau of Ethnology.)
- TONGUE, Miss AMY, Washington, D. C.: Specimen of *Psorophora ciliata* Fabr. 33891.
- TORES Y TORES, Guayanillo, Porto Rico: Sword, or hanger. (See under Porto Rico collection, 35201.)
- TOTTEN, W. K. D., jr., Cincinnati, Ohio: Fish-moth, *Lepisma saccharina*. 34200.
- TOWER, G. W. (See under Interior Department, U. S. Geological Survey.)
- TOWNSEND, C. H. TYLER, Mesilla Park, N. Mex.: Land shells and mollusks (34120); 2 species of *Polygyra* from Sierra Blanca (34214); 10 specimens of Hymenoptera (34903).
- TOWNSEND, E. C., Columbus, N. C., received through Cornell University: Four hundred plants. Purchase. 35165.
- TRACY, Prof. S. M., Biloxi, Miss., received through Department of Agriculture: Plants (34568, 34740, 34793, 34875) (exchange); 700 plants from the Gulf coast (35063) (purchase).
- TRASK, Mrs. BLANCHE, Avalon, Santa Catalina Island, Cal.: One hundred and two plants. Purchase. 35000.
- TREASURY DEPARTMENT, Hon. Lyman S. Gage, Secretary:
U. S. Coast and Geodetic Survey, received through Henry S. Pritchett, superin-

TREASURY DEPARTMENT—Continued.

- tendent: Specimen of the first trans-Atlantic cable laid in 1858 from Ireland to Newfoundland (34198); 4 plaster medallions struck in commemoration of Prof. John E. Watson (35200).
- U. S. Life-Saving Service, received through W. D. Parsons, keeper, Hither Plain Station, N. Y.: Piece of whalebone from a finback whale that floated ashore at Montauk. 34841.
- TRELEASE, Prof. WILLIAM, Missouri Botanical Garden, St. Louis, Mo.: Agave leaves from Mexico. 34389.
- TRENT, Mrs. LUCY CARTER. (See under National Society of the Colonial Dames of America.)
- TROOST, GERARD, estate of, received through E. W. Rankin, acting administrator of the estate of James Hall, Albany, N. Y.: "Troost collection of crinoids," consisting of 294 specimens; also manuscript and drawings of 107 species. 34282.
- TRUE, J. M., Branch, Pa.: Beetle (*Cassida guttata* Oliv.) 34998.
- TRUEDELL & FREAREY, West Stockbridge, Mass.: Limestone used in making quicklime. 34207.
- TURNER, S. H., White Sulphur Springs, W. Va.: Photograph of a mirror struck by lightning. 33992.
- TURNER, H. W. (See under G. W. Kimble.)
- TURNER, W. D., Ferguson's Wharf, Va.: Specimen of Hartford Fern, *Lygodium palmatum* (34314); specimen of phosphatic marl (34464).
- TURRILL, C. B., San Francisco, Cal.: Marine and fresh-water shells from Lower California and western North America (34257, 34359).
- UDDEN, Prof. J. A., Rock Island, Ill.: Three specimens of *Cardiocaris*, 1 specimen of *Orthoceres*, 1 bryozoan, and a sponge (34498); received through U. S. Geological Survey, two cut specimens of a structure obtained from Cedar Valley limestone. 35001.
- UMBACH, L. M., Naperville, Ill.: Plants (34322, 34758, 34794, 34829, 35094). Exchange.
- UNION SAND AND EMERY WHEEL COMPANY, Boston, Mass.: Garnets used for abrasive purposes. 34418.
- UNION SOAPSTONE COMPANY, Chester Depot, Vt.: Specimen of soapstone. 34431.
- URICH, F. W., Port of Spain, Trinidad, British West Indies: Collection of Venezuelan Lepidoptera and Diptera (35008); received through Dr. L. O. Howard, fishes from Trinidad (35102).
- VAILLANT, LEON. (See under Paris, France, Musée d'Histoire Naturelle.)
- VAN ARSDALE, Mrs. ELLEN BRAINARD (See under Lieut. F. R. Brainard.)
- VAN HECKEREN, Baron, Sinagar, Java: One large Scoliid. 34385.
- VAN HISE, Prof. C., Madison, Wis. (See under Interior Department, U. S. Geological Survey.)
- VAN KIRK, J. W., Pottsgrove, Pa.: Four stone implements; mammal skulls; beaded money purse, wooden chair, and a specimen of lime deposit from a teakettle. 34067.
- VAN PELT, J. C., Woodstock, Va.: Confederate paper money. 33862.
- VANNEMAN, WILLIAM, U. S. National Museum: Miniature ship's anchor, manufactured at the Washington Navy Yard from sights and sight boxes recovered from the wreck of the "Maine". 34805.
- VASEY, Miss FLORA, U. S. National Museum: Plant. 34739.
- VAUGHAN, T. WAYLAND, U. S. Geological Survey: Set of negatives¹ of Duchassaing and Michelotti's types of Symphylliid corals in the Museum of Turin (33848, 33849); 2 species of land shells from Texas (35819); 50 specimens of shells, representing 12 species from Texas; 2 beetles and 6 specimens of Homoptera from the same locality (33861).
- VERD ANTIQUE MARBLE COMPANY, Chicago, Ill.: Slab and cubes of verd antique marble from Holly Springs, Ga. 34934.
- VERRILL, Prof. A. E., Yale University Museum, New Haven, Conn.: Fourteen specimens of Gorgonians and corals. Purchase. 34472. "O."

¹ These negatives were presented to Mr. Vaughan by Count Peracca, and transferred by Mr. Vaughan to the National Museum.

- VERY, C. F., New Albany, Ind.: Two Horn-tailed Sawflies, representing the species *Tremex columba* Linnaeus. 33872.
- VINEYARD OCHER COMPANY, Boston, Mass.: Ocher. 34151.
- VISUDDHA, Marquis, Siamese legation, London, England, received through Department of State: Model of the monastery of Wat Chang at Bangkok. 34650.
- VORN, Dr. H. R., Field Columbian Museum, Chicago, Ill.: Six dozen small arrow points from Arizona. 35143.
- VRIÈRE, BARON RAOUL R. DE, Chateau de Bacs-Veld, Zedelghem, Belgium: Collection of Belgian Coleoptera. Exchange. 35026.
- VROMAN, A. C., Pasadena, Cal.: One hundred and twenty photographs of California missions. Exchange. 33932.
- WADSWORTH, Miss MATTIE, Hallowell, Me.: Ninety-two dragon flies. Exchange. 34439.
- WAGHORNE, Rev. A. C., Bay of Islands, Newfoundland: Plants from Labrador. Purchase. 33796.
- WALCOTT, Hon. C. D., Director, U. S. Geological Survey: Photograph of an elk from Yellowstone National Park (gift) (34437); 10 rugs made of mammalskins (deposit) (35044.) (See under F. W. Sardeson.)
- WALKER, BRYANT, Detroit, Mich.: Specimens of *Unio superiorenensis* from Michigan. 34141.
- WALKER, C. H., Galion, Ohio: Specimen of *Argiope riparia*. 33962.
- WALKER ELECTRIC COMPANY, Cleveland, Ohio, received through S. H. Short and E. H. Morrison: Bound volume containing photographs of the Short electric railway motors and other objects. Deposit. 34608.
- WALLACE, WILLIAM, Ansonia, Conn.: Three Wallace arc lights, a pair of electric connecting rods, and a facsimile of a letter of Benjamin Franklin to Mr. Strahan, dated July 5, 1775. 35164.
- WALLINGSFORD, W. W., U. S. National Museum: Hand looking-glass and a copy of the New Testament, issued and used during the Cuban campaign in the volunteer service of the United States. 34747.
- WAMSLEY, F. W., Bridgeton, N. J.: Forty-eight specimens of coral polyps etc. Purchase. 34473. "O."
- WAR DEPARTMENT, Hon. R. A. Alger, Secretary: Received through Ordnance Office, 2 Mauser rifles, bayonet, and scabbard captured at the surrender of Santiago (34096); received through the Army Medical Museum, reptiles in alcohol (34465). (See under Driggs-Seabury Gun and Ammunition Company.)
- WARD, Prof. Lester F., U. S. Geological Survey: Plants from Kansas and other localities (33947, 34027, 35139).
- WARD, M. J., Unadilla, N. Y.: Water bug, *Belostoma americanum*. 35116.
- WARD'S NATURAL SCIENCE ESTABLISHMENT, Rochester, N. Y.: Nine Indian and African mammals (purchase) (33793); 160 specimens of Carboniferous cephalopods (exchange) (33863); 924 specimens of fossils of the Trenton and Silurian formation from Tennessee and of the Carboniferous formation from Texas (exchange) (33945); cast of skull of *Castoroides ohioensis* (purchase) (34166); 14 specimens of Gorgonians and 16 casts of Protozoans (purchase) (34471). (O.)
- WARING, G. W., Tyrone, Pa.: Specimen of *Epeira domiciliana* Hentz. 34184.
- WARNER, Miss A. P., Maywood, Nebr.: Fragments of pottery. 34501.
- WASLEKAR, N. N., Washington, D. C.: Scarf of Nana Sahib from India; turban worn by the Mohammedans; turban of Ibrahim from the Deccan; turban of Parsee and a skirt of muslin (34319); silk and gold turban belonging to a Rajah; 11 photographs of Hindoos (34879). Purchase.
- WATTERSON, R. I., Kings Mountain, N. C.: Specimen of Mantis, *Stagmomantis carolina* L. 34335.
- WEAVER, J. M., Oakshade, Va.: Moth (*Charocampa tersa* L.). 34150.
- WEAVER, W. B., Lakeland, Fla.: Specimen of *Cassida guttata* Oliv. 34447.
- WEBER, L. R., Eureka Springs, Ark.: Specimens of Arkansas fossils (34716); 2 specimens of siliceous limestone containing fossils of the Calciferous age (34913).

- WEBSTER, Prof. F. M., Wooster, Ohio: Eight specimens of Hymenoptera. 34921.
- WEED, W. H., U. S. Geological Survey: Sapphire in lamprophyre dike rock from Yogo sapphire mines, Little Belt Mountains, Montana. 34882.
- WEEDEN, W. C., U. S. National Museum: Bat (*Vespertilio fuscus*). 34667.
- WEEKS, A. J., Akron, Ohio: Slip clay. 35066.
- WEITH, R. J., Elkhart, Ind.: Wasp (*Pelecinus polyturator* Drury), new to the Museum collection. 33812.
- WELLS, R. L., Humeston, Iowa: Star, or headquarters badge of the Seventh Army Corps, United States Volunteers, 1898-99, used as the official badge of the Seventh Corps Association and worn by the donor during the Cuban campaign. 35039.
- WESLEY, WILLIAM, & SONS, London, England: Prints of synagogues, print portrait of a rabbi, leather manuscript of prayers on Purim, 4 photographs of synagogues, 7 souvenirs of the Zionists Congress, and a leather manuscript of the Book of Esther (34414); print of German synagogue at Amsterdam and a print of a Portuguese synagogue at Amsterdam (34508). Purchase.
- WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, New York City, received through C. A. Terry, secretary: Collection of electric motors, car models, and other objects. Deposit. 34632.
- WHEELER, Gen. JOSEPH. (See under National Society of the Colonial Dames of America.)
- WHEELER, J. A., Milford, N. H.: Medicinal plants. 34269.
- WHITAKER, S. F., Ogden, Utah: Ores, clays, hydrocarbons, and other material from Utah. 34661. "O."
- WHITE, Dr. C. A., Washington, D. C.: Framed specimen of a rose showing the transformation of the flower parts into leaves (33869); sun-glass used by Daniel Corey, of Dighton, Bristol County, Mass., in 1790-1800 (35112).
- WHITE, DAVID, U. S. Geological Survey: Eight specimens of violets. 35053.
- WHITE, E. H., Clearwater Harbor, Va.: Larva of *Lagou opercularis* S. & A. 34354.
- WHITE, JAMES, Norfolk, Va.: Articles recovered from the wrecks of the Spanish ships *Reina Mercedes*, *Viscaya*, *Cristobal Colon*, *Maria Teresa*, and *Almirante Oquendo*. (See under Norfolk collection 35187.)
- WHITE, J. J., Rockledge, Fla.: Five species of land and marine shells. 34489.
- White, MARK, Winfield, Kans.: Plants. 34525.
- WHITEAVES, J. F. (See under Ottawa, Canada, Geological Survey of.)
- WHITED, KIRK, Ellensburg, Wash.: Medicinal plants. 33811.
- WHITE PINE ZINC COMPANY, Louisville, Ky.: Lead and zinc ore. 34211.
- WHITESIDE, G. H. (See under Southern Ice Exchange.)
- WHITESIDES, Mrs. N. J. (See under Joseph M. Callis.)
- WHITING, Dr. C. A., University of Utah, Salt Lake City, Utah: Fresh-water invertebrates from Utah. 33760.
- WHITTEMORE, Rev. ISAAC T., Florence, Ariz., received through Smithsonian Institution, Bureau of Ethnology: Collection of cliff dwellers' objects from Arizona (34065); plaster cast of a footprint in the Casa Grande ruin, made by Mr. Whittemore, the finder of the impression (35167).
- WICKERSHAM, Prof. H. F., Iowa City, Iowa: Specimens of Termites. 34539.
- WICKERSHAM, JAMES, Tacoma, Wash.: Six plaster casts of carved stone and bone clubs. 34523.
- WILBUR, E. P., Titusville, Fla.: Specimen of *Epitragus tomentosus*. 33911.
- WILCOX, W. A. (See under William Thompson.)
- WILD, A., Loveland, Colo.: Specimen of gypsum. 34594.
- WILD, EDWARD, Aschaffenburg, Bavaria, Germany: Photograph of the Tower of Babel. 34037.
- WILES, GEORGE, Stratford, N. C.: Specimen of mineral. 33968.
- WILEY, Mrs. J. M., Atkinson, Kans.: Specimen of *Stagmomantis carolina* Linnaeus, belonging to the family *Mantide*. 34069.

- WILEY, ROY, Palestine, Tex.: Skin of Ruby-throated Hummingbird, *Trochilus colubris*. 34167.
- WILLCOX, JOSEPH, Philadelphia, Pa.: Eocene fossils from Santiago de Cuba. 34849.
- WILLIAMS, C. K., & Co., Easton, Pa.: Ocher. 34320.
- WILLIAMS, F. H., Bristol, Conn.: Three specimens of beetle, representing the species *Odontata rubra* Web. 33988.
- WILLIAMSON, E. B., Carnegie Museum, Pittsburg, Pa.: Two specimens of dragon flies, representing the species *Ischnura kellicotti* Williamson (cotypes). 35036. (See under Carnegie Museum.)
- WILLIAMSON, Mrs. M. B., Los Angeles, Cal.: Four species of marine shells from California (34710); specimen of *Calliostoma canaliculatum* (34863); shell, representing a species of the genus *Anodontia* (35070).
- WILLISTON, Prof. S. W., Lawrence, Kans.: Two specimens of *Estheria* from Oklahoma (34260); photograph of White River Miocene, Bad Lands, South Dakota (34266).
- WILLMAN, ARIEL, South Berlin, N. Y.: Water beetle, *Dytiscus verticalis* Say. 34227.
- WILSON, COMPTON, U. S. V.: Medal. (See under Porto Rico collection 35201).
- WILSON, Capt. H. C., U. S. V., Washington, D. C.: Collection of relics of the Porto Rican campaign (34742); part of a metal shoulder knot belonging to the uniform of a Spanish staff officer (34936). Deposit.
- WILSON, K. D., Industry, Pa.: Six eggs (one set) of Sharp-shinned Hawk, *Accipiter velox*. 34859.
- WILSON, THOMAS, U. S. National Museum: Archaeological objects from Egypt (34329); 111 flint scrapers from various localities along the Ohio River, collected by W. K. Moorehead (34384); 2 terra-cotta figures of Watcombe Torquay pottery (34476). Deposit.
- WILSON & BRO., Hanoverville, Md.: Sample of ocher. 34249.
- WIMAN, L. E., Schenectady, N. Y.: Caterpillar (*Empretia stimulea*). 34099.
- WINCHELL, Prof. W. H. (See under Minnesota Geological Survey.)
- WINSER, J. H. (See under American Museum of Natural History.)
- WINSLOW, U. S. torpedo boat, received through Lieut. A. P. Niblack, U. S. Navy: Wire hand-railing from the *Winslow*, and a section of boiler plate perforated by a Spanish shell. 34077.
- WINSTON, ISAAC. (See under E. P. Moon.)
- WINTER'S METALLIC PAINT COMPANY, Iron Mountain, Wis.: Mineral paint. 35046.
- WOLCOTT, R. H., University of Nebraska, Lincoln, Nebr.: Co-types of *Acarina*. 34825.
- WOLTZ, GEORGE, U. S. National Museum: Brewer's candlestick (gift) (33837); soldier's combination folding spoon and fork (deposit) (33882); 2 Krag-Jørgensen rifle cartridges, a Remington 45-caliber revolver used during the Spanish-American War in Santiago de Cuba (gift) (33905); badge of the Third U. S. Cavalry worn by the soldiers of the Santiago campaign (gift) (33907); metal tag of the American Army Registry of New York, in use during the Spanish-American War (gift) (33987).
- WOLTZ, Miss SADIE, Washington, D. C.: Specimen of hard-tack furnished the United States Army in Santiago de Cuba during the Spanish-American War; crossed cannon of the Fifth U. S. Artillery, and crossed swords of the First Cavalry. 34021.
- WOOD, C. F., Boston, Mass.: Documents relating to the early history of the electro-magnetic telegraph. 34365.
- WOOD, N. R., U. S. National Museum: Eighty-three dragon flies. 35126.
- WOODSTOCK IRON WORKS, Rock Springs, Ala.: Limestone used for making quicklime. 34386.
- WOODWARD, Dr. H. W. (See under London (England) British Museum.)
- WOOTON, E. O., New York City: Five hundred and eighty-seven plants from New Mexico. Purchase. 33797. "O."
- WORTHEN, C. K., Warsaw, Ill.: Four skins and skulls of moles, representing the species *Scapanus orarius*. 34045.
- WRIGHT, B. H., Penn Yan, N. Y.: Four species of Southern unios (34131); 2

- WRIGHT, B. H.—Continued.
species of Unionidae (34325); 3 species of Unionidae (34426); 6 species of Unionidae from the Southeastern States (34494); unio (34629); 12 species of shells from the Southern States (34832); 3 species of unios (34906; unios from the Southern States (35019.)
- WRIGHT, J. O., & Co., New York City: Lithograph of Louis Agassiz. Purchase. 34341.
- WYCOFF, GUS, Port Townsend, Wash., received through O. E. Shaffer: Specimen of *Rhamphocottus richardsoni* from Port Townsend Bay. 34947.
- YAKELEY, FRANK, Gebo, Mont.: Specimen of *Anabrus purpuratus* Uhler. 33785.
- YOUNG, CHESTER, Ellenville, N. Y.: Three species of saw-fly larvae, new to the Museum collection. 34687.
- YOUNG, E. E., Wickford, R. I.: Specimen of Sea Hare, representing a species of *Tethys*. 34097.
- YOUNG, R. T., Ann Arbor, Mich.: Three mice, 4 shrews, and a chipmunk. 34713.
- YOUNG, W. F., Fairview City, Utah, received through Dr. David T. Day: Crude magnesian silicate. 34766.
- YOUNGS, ELPHONZO, Washington, D. C.: Specimen of *Canis familiaris*. 34737.
- ZEILLER, Prof. R., Paris, France: Three Carboniferous plants. 33943.
- ZELEDON, JOSÉ C., San José, Costa Rica: Two birds' skins from Costa Rica. 34032.
- ZELEDON, Mrs. JOSÉ, San José, Costa Rica: Cast of a crab-shaped mortar. 34493.
- ZELL, Mrs. L. D., Lancaster, Pa.: Plant. 34138.
- ZOLLIKOFER, ERNST, St. Gallen, Switzerland: Collection of skins and specimens in alcohol from Switzerland and Sardinia. Purchase. 33902.

APPENDIX III.

STATEMENT OF THE DISTRIBUTION OF SPECIMENS DURING THE FISCAL YEAR ENDING JUNE 30, 1899.

AFRICA.

- Albany Museum, Grahamstown, South Africa: Alaskan moose (1 specimen). Exchange. (D. 12720.)
Wood, J. Medley, Port Durban, Natal: Plants (209 specimens). Exchange. (D. 12063.)

AMERICA.

NORTH AMERICA.

CANADA.

- Canadian Geological Survey, Ottawa: Fossils (5 specimens). Gift. Plants (254 specimens); fossils (17 specimens). Exchange. (D. 12278, 12534, 12646.)
Cox, Philip, Chatham: Frog (1 specimen). Exchange. (D. 12313.)
Roberts, C. H., Paris, Ontario: Casts of stone objects (3 specimens); casts of amulets. Exchange. (D. 12419, 12712.)

MEXICO.

- National Medical Institute, Mexico: Mexican plants (659 specimens). Exchange. (D. 12514.)

UNITED STATES.

Alabama.

- Baker, Carl F., Auburn: Isopods and Amphipods. Exchange. (D. 12229.)
Earle, F. S., Auburn: Plants (14 specimens). Exchange. (D. 12602.)
Mell, P. H., Auburn: Plants (3 specimens). Exchange. (D. 12065.)
Mohr, Charles, Mobile: Plants (41 specimens). Exchange. (D. 12045, 12671.)
Museum of the University of Alabama, Tuscaloosa: Alcoholic fishes (64 specimens). Gift. (D. 12414.)

Arkansas.

- McNeill, Jerome, Fayetteville: Orthoptera (15 specimens). Lent for study. (D. 12426.)

California.

- Brandegge, T. S., San Diego: Plants (3 specimens). Exchange. (D. 12066.)
Hornung, J., San Francisco: Bird skins (107 specimens). Exchange. (D. 12128, 12437.)
Jordan, D. S., Stanford University: Fishes (2 specimens). Lent for study. (D. 12173, 12554.)
Leland Stanford Junior University, Palo Alto: Plants (111 specimens). Exchange. (D. 12044.)
Stearns, R. E. C., Los Angeles: Small shells (about 1,000 specimens). Lent for study. (D. 12739.)
University of California, Berkeley: Plants (50 specimens). Exchange. Annelids (71 specimens, 21 species.) Gift. (D. 12043, 11967.)

Colorado.

- Hills, R. C., Denver: Meteorites (2 specimens). Exchange. (D. 11984.)
Schlarbaum, Paul, Loveland: Moths (2 specimens). Exchange. (D. 12339.)

Connecticut.

- Gulliver, F. P., Norwich: Salts (5 specimens). Exchange. (D. 12033.)
Marsh, O. C., New Haven: Potomac breccia (1 specimen); Japanese marbles (15 specimens). Lent for study. (D. 12400, 12401.)
Wesleyan University Museum, Middletown: Pueblo pottery (20 specimens). Exchange. (D. 12431.)
Yale University Museum, New Haven: Crinoids (14 specimens). Exchange. (D. 12212.)

Delaware.

Canby, William M., Wilmington: Plants (117 specimens). Exchange. (D. 12087, 12299, 12639.)

District of Columbia.

Catholic University, Washington: Plants (93 specimens). Exchange. (D. 12050.)

Central High School, Washington: *Pen-tactinus decorus* (1 specimen). Gift. (D. 12329.)

Chesnut, V. K., Washington: Medicinal plants. Lent for study. (D. 12778.)

Crosby, W. O., Washington: Geological and natural history material. Exchange. (D. 12666.)

Greene, E. L., Washington: Plants (26 specimens). Exchange. Plants (57 specimens). Lent for study. (D. 12428, 12627.)

Holm, T., Brookland: Plants (60 specimens). Lent for study. Plants (92 specimens). Exchange. (D. 12112, 12575.)

Kober, George M., Washington: Zuffi pottery vase. Exchange. (D. 12395.)

McGee, W. J., Washington: Ethnological specimens. Lent for study. (D. 12140.)

Richmond, C. W., Washington: Snowy owl (1 specimen). Exchange. (D. 12453.)

Twedy, Frank, Washington: Plants (44 specimens). Exchange. (D. 12427.)

U. S. Fish Commission, Washington: Marine invertebrates (309 specimens, series vi, set 54); alcoholic fish (1 specimen); shells (2 specimens); crustaceans (16 specimens). (D. 11973, 12146, 12175, 12622.)

Florida.

Simpson, J. H., Manatee: Minerals. Exchange. (D. 12548.)

Illinois.

Carthage College, Carthage: Marine invertebrates (303 specimens, series vi, set 61). Gift. (D. 12103.)

Coulter, John M., Lake Forest: Plants (3 specimens). Exchange. (D. 12064.)

Elliot, D. G., Chicago: Mammals (3 specimens). Exchange. (D. 12587, 12590.)

Illinois—Continued.

Ferriss, James H., Joliet: Shells (41 specimens). Exchange. (D. 12360.)

Field Columbian Museum, Chicago: Plants (142 specimens). Exchange. (D. 12051.)

Illinois Female College, Jacksonville: Marine invertebrates (303 specimens, series vi, set 78). Gift. (D. 12436.)

Loucks, W. E., Peoria: Bird skins (62 specimens). Lent for study. (D. 12683.)

Millsbaugh, C. F., Chicago: Plants (161 specimens). Exchange. (D. 12675.)

Northwest Division High School, Chicago: Marine invertebrates (306 specimens, series vi, set 71). Gift. (D. 12371.)

Phillips, W. A., Evanston: Flints (120 specimens). (D. 12371.)

Snyder, A. J., Belvidere: Butterflies. Lent for study. (D. 12710.)

Udden, J. A., Rock Island: Samples of sea bottom (84 vials). Exchange. (D. 12570.)

University of Chicago, Chicago: Plants. Exchange. (D. 12032.)

Indiana.

Bartlett, Charles H., South Bend: Cast of inscribed tablet. Gift. (D. 12258.)

High school, Jeffersonville: Marine invertebrates (312 specimens, series vi, set 67). Gift. (D. 12233.)

Indiana University, Bloomington: Plants (64 specimens). Exchange. (D. 12046.)

Iowa.

Agricultural Experiment Station, Ames: Plants (300 specimens). Exchange. (D. 12059.)

Boepple, J. E., Muscatine: Quartz crystal (1 specimen). (D. 12434.)

Charles City College, Charles City: Marine invertebrates (103 specimens, series vi, set 63); casts of stone implements (98 specimens, set 62). Gift. (D. 12133.)

High school, Early: Rocks and ores (104 specimens, set 11). Gift. (D. 12495.)

High school, Lake Mills: Rocks and ores (104 specimens, set 17). Gift. (D. 12336.)

Iowa—Continued.

High school, Manchester: Marine invertebrates (303 specimens, series VI, set 76); rocks and ores (104 specimens). Gift. (D. 12404.)

High school, Sac City: Rocks and ores (104 specimens, set 22). Gift. (D. 12138.)

Miller, Benjamin L., Oskaloosa: Samples of sea bottom (10 vials). For study. (D. 12591.)

Putnam, Mrs. M. D., Davenport: Eskimo costume. Exchange. (D. 12632.)

Kansas.

Beede, J. W., Lawrence: Fossils (5 specimens). Exchange. Fossils (8 specimens). Lent for study. (D. 12222, 12445.)

Hitchcock, A. S., Manhattan: Plants (921 specimens). Exchange. (D. 12545.)

University of Kansas, Lawrence: Cambrian fossils (51 specimens). Exchange. Corals (4 specimens). Gift. (D. 11986, 12094.)

Kentucky.

Williamsburg Institute, Williamsburg: Rocks and ores (104 specimens, set 20). Gift. (D. 12248.)

Maine.

Bowdoin College, Brunswick: Crabs (60 specimens). Gift. (D. 12287.)

Wadsworth, Miss Nettie, Hallowell: Dragon flies (19 specimens). Exchange. (D. 12452.)

Maryland.

Western Maryland College, Westminster: Marine invertebrates (306 specimens, series VI, set 69); rocks and ores (104 specimens, set 18). Gift. (D. 12267.)

Massachusetts.

Bangs, Outram, Boston: Bird skins (35 specimens); one specimen belonging to the genus *Sciurus*. Lent for study. Mammal skins and skulls (14 specimens). Exchange. Deer skull (1 specimen). Lent for study. (D. 12179, 12182, 12239, 12314, 12369, 12392, 12442, 12565.)

Botanic garden, Cambridge: Plants (553 specimens). Exchange. (D. 12056.)

Massachusetts—Continued.

Brewster, William, Cambridge: Bird skins (94 specimens). Lent for study. (D. 12361, 12368, 12611.)

Cummings, Miss Clara E., Wellesley: Plants (15 specimens). Exchange. (D. 12661.)

Davenport, George E., Medford: Plants (3 specimens). Lent for study. Plants (84 specimens). Exchange. (D. 12381, 12535.)

Eastman, C. R., Cambridge: Fossils (10 specimens). Lent for study. (D. 12380.)

Emerson, B. K., Amherst: Thin sections of rocks (116 specimens). Lent for study. (D. 12595.)

Fernald, M. L., Cambridge: Plants (104 specimens). Lent for study. (D. 12386.)

Harvard University, Cambridge: Rocks and ores. Exchange. (D. 12615.)

Howe, Reginald Heber, jr., Brookline: Bird skins (13 specimens). Lent for study. (D. 12628.)

Johnson, Roswell H., Cambridge: Double-headed snakes (3 specimens). Lent for study. (D. 12531.)

Museum of Comparative Zoology, Cambridge: Crustacea (39 specimens; crabs (21 specimens); photographs of type specimens in foreign museums. Exchange. (D. 12296, 12609, 12754.)

Peabody Museum, Cambridge: Collection of stone implements, fragments of pottery, etc. Gift. (D. 12451.)

Peck, James I., Woods Hole: specimens of foraminiferal sand and infusorial earth. Gift. (D. 12024.)

Robinson, B. L., Cambridge: Plants (447 specimens). Lent for study. Plants (55 specimens). Exchange. (D. 12203, 12231, 12282, 12460, 12550, 12598, 12623, 12660.)

Sargent, C. S., Jamaica Plain: Plants (59 specimens). Lent for study. Plants (2 specimens). Exchange. (D. 12636.)

Sawyer, E. L., Winchendon: Lepidoptera (54 specimens). Exchange. (D. 12358.)

State Normal School, Westfield: Marine invertebrates (306 specimens, series VI, set 65). Gift. (D. 12187.)

Massachusetts—Continued.

Strong, R. M., Cambridge: Shrikes (76 specimens). Lent for study. (D. 12566.)

Michigan.

Melville, W. P., Sault Ste Marie: Bird skins (6 specimens). Exchange. (D. 12701.)

Mulliken, W. Earle, Grand Rapids: Bird skin (1 specimen). Lent for study. (D. 12501.)

Minnesota.

Brower, J. V., St. Paul: Stone implements and pottery (146 specimens). Exchange. (D. 12556.)

Gustavus Adolphus College, St. Peter: Rocks and ores (104 specimens, set 12). Gift. (D. 12508.)

Heatwole, Joel P., Northfield: Zuñi and Chiriqui pottery (35 specimens). Exchange. (D. 11970.)

High School, Worthington: Casts of stone implements (98 specimens, set 64). Gift. (D. 12176.)

Holzinger, J. M., Winona: Plants (72 specimens). Exchange. (D. 12546.)

Hyde, Louis H., Lake Benton: Fossils (218 specimens). Exchange. (D. 12197.)

McDougal, D. T., Minneapolis: Plants (9 specimens). Lent for study. (D. 12144.)

Sardeson, F. W., Minneapolis: Fossils (2 specimens). Exchange. (12543.)

University of Minnesota, Minneapolis: Cambrian fossils (43 specimens); plants (274 specimens). Exchange. (D. 11985, 12061, 12180.)

Mississippi.

Mississippi Agricultural and Mechanical College, Agricultural College: Marine invertebrates (303 specimens, series vi, set 80). Gift. (D. 12511.)

Missouri.

Ayres, Howard, Columbia: Alcoholic fishes (22 specimens). Lent for study. (D. 12439.)

Glatfelter, N. M., St. Louis: Plants (8 specimens). Lent for study. Plants (50 specimens). Exchange. (D. 11999, 12041.)

Missouri Botanical Garden, St. Louis: Plant (living specimen). Exchange. (D. 12098.)

Missouri—Continued.

Plattsburg Public School, Plattsburg: Marine invertebrates (306 specimens, series vi, set 72). Gift. (D. 12372.)

Public Schools, Macon: Marine invertebrates (309 specimens, series vi, set 74). Gift. (D. 12370.)

Schwarz, H., St. Louis: Butterflies (99 specimens). Exchange. (D. 12214.)

Trelease, William, St. Louis: Plants (252 specimens). Lent for study. (D. 12224.)

Montana.

Helena High School, Helena: Marine invertebrates (312 specimens, series vi, set 52). Gift. (D. 11974.)

State Historical Library, Helena: Marine invertebrates (306 specimens, series vi, set 79); alcoholic fishes (75 specimens). Gift. (D. 12455.)

University of Montana, Missoula: Shells (409 specimens). Gift. (D. 12230.)

Nebraska.

Bruner, Lawrence, Lincoln: Mexican and Central American Orthoptera (176 specimens); insects (5 specimens). Lent for study. (D. 12408, 12486.)

Gates College, Neligh: Lamprey, eel, and skate (1 specimen each). (D. 12525.)

Public School, Fort Calhoun: Bird skins (31 specimens); insects (531 specimens); marine invertebrates (55 specimens); mollusks (98 specimens); minerals (4 specimens); fossils (8 specimens); archaeological objects (64 specimens). Gift. (D. 12417.)

University of Nebraska, Lincoln: Plants (402 specimens). Exchange. (D. 11969.)

Ward, Henry B., Lincoln: Gephyreans (570 specimens). Lent for study. (D. 12422.)

New Hampshire.

Literary Institution, New Hampton: Marine invertebrates (309 specimens, series vi, set 68); minerals (57 specimens, set 194). Gift. (D. 12247.)

New Jersey.

Edwards, Arthur M., Newark: Infusorial earth (7 specimens). Lent for study. (D. 12462.)

New Jersey—Continued.

- Smith, John B., New Brunswick: Moths (2 specimens). Lent for study. (D. 12478.)
 Kilmer, F. B., New Brunswick: Plants (14 specimens). Lent for study. (D. 12558.)

New York.

- Allen, J. A., New York: Small mammal skins and skulls (14 specimens). Exchange. (D. 12301.)
 American Museum of Natural History, New York: Ethnological material (13 specimens). Gift. (D. 12770.)
 Bicknell, E. P., New York: Plants (202 specimens). Lent for study. (D. 12321.)
 Bird, Henry, Rye: Larvæ of *Hydracia*. Exchange. (D. 12177.)
 Britton, Mrs. E. G., New York: Mosses (20 specimens). Exchange. (D. 12562.)
 Britton, N. L., New York: Plants (435 specimens). Exchange. (D. 12060.)
 Colgate University, Hamilton: Marine invertebrates (306 specimens, series vi, set 62). Gift. (D. 12160.)
 Cornell University, Ithaca: Plants (140 specimens). Exchange. Granite (7 specimens). Gift. (D. 12042, 12058, 12474.)
 Brown, Mrs. John Crosby, New York: Facsimile of musical instrument (1 specimen). Exchange. (D. 12680.)
 Dwight, Jonathan, jr., New York: Bird skins (60 specimens). Lent for study. (D. 12667, 12714, 12777.)
 Ely's School, The Misses, New York: Marine invertebrates (303 specimens, series vi, set 64). Gift. (D. 12169.)
 Erasmus Hall High School, Brooklyn: Marine invertebrates (303 specimens, series vi, set 77); casts of stone implements (98 specimens). Gift. (D. 12416, 12454.)
 Gilbert, B. D., Clayville: Plants (88 specimens). Lent for study. (D. 12490, 12513.)
 High School, Hancock: Marine invertebrates (306 specimens, series vi, set 75); rocks and ores (104 specimens, set 15). Gift. (D. 12394.)
 Holland Purchase Historical Society, Batavia: Casts of prehistoric stone implements (90 specimens, set 67). Gift. (D. 12744.)
 Hulst, George D., Brooklyn: Moths (157 specimens). Lent for study. (D. 12202.)
 Miller, Gerrit S., jr., New York: Skins with skulls of *Erotomys alascensis* (6 specimens). Lent for study. (D. 12461.)
 Mirrick, Miss Nellie, Oneida: Plants (20 specimens). Exchange. (D. 12784.)
 Osborn, H. F., New York: Skull of *Oreodon* (1 specimen). Lent for study. (D. 12576.)
 Porter, George F., New York: Electrical apparatus (5 pieces). Lent for study. (D. 12647.)
 Putnam, F. W., New York: Left scapula of male and female musk ox (1 specimen each). Lent for study. (D. 12642.)
 Small, J. K., New York: Mounted specimens of plants (17 specimens). Lent for study. (D. 12262, 12663, 12772.)
 Underwood, L. M., New York: Plants (2 mounted specimens); plants (24 specimens). Lent for study. (D. 12208, 12507.)
 Ward's Natural Science Establishment, Rochester: Two collections of fossils. Exchange. (D. 12130, 12398.)
 Waugh, F. H., Ithaca: Plants (3 specimens). Lent for study. (D. 12382.)
 Webster Free Library, New York: Casts of stone implements (98 specimens, set 66). Gift. (D. 12620.)

North Carolina.

- Ash, W. W., Raleigh: Plants (319 specimens). Exchange. (D. 12049.)
 Beadle, C. D., Biltmore: Plants (707 specimens). Exchange. (D. 12542.)
 Biltmore Herbarium, Asheville: Plants (378 specimens). Exchange. (D. 12096.)
 Trinity College, Durham: Marine invertebrates (306 specimens, series vi, set 81). Gift. (D. 12567.)

North Dakota.

- Mager, Miss Ernestine, Walhalla: Plant (1 specimen). Exchange. (D. 12266.)

Ohio.

- Case School of Applied Science, Cleveland: Plants (15 specimens). Exchange. (D. 12053.)
- High School, Logan: Casts of stone implements (98 specimens, set 63). Gift. (D. 12162.)
- Lindahl, Joshua, Cincinnati: Salamander (1 specimen). Lent for study. (D. 12438.)
- Piwonka, Thomas, Cleveland: Foraminifera (3 lots). Lent for study. (D. 12228.)
- Ricker, Maurice, Burlington: Insect (1 specimen). For study. (D. 12432.)
- Western College, Oxford: Marine invertebrates (306 specimens, series VI, set 66); marine invertebrates (306 specimens, series VI, set 70). Gift. (D. 12207, 12281.)

Pennsylvania.

- Calvert, Philip P., Philadelphia: Dragon flies (1072 specimens). Lent for study. (D. 12489.)
- Carnegie Museum, Pittsburg: Ethnological material (29 specimens). Exchange. (D. 12166.)
- Clarion State Normal School, Clarion: Marine invertebrates (309 specimens, series VI, set 3). Gift. (D. 12014.)
- Crawford, Joseph, Philadelphia: Plants (97 specimens). Exchange. Plants (19 specimens). Lent for study. (D. 12672, 12780.)
- Culin, Stewart, Philadelphia: Collection of games. Lent for study. (D. 12456.)
- Fox, William J., Philadelphia: Insects (322 specimens). Lent for study. (D. 11987.)
- High School, Harrisburg: Rocks and ores (104 specimens, set 13). Gift. (D. 12413.)
- High School, York: Marine invertebrates (306 specimens, series VI, set 73). Gift. (D. 12510.)
- Moore, J. Percy, Philadelphia: Leeches (54 specimens); *Desmognathus brimleyorum* (1 specimen). Lent for study. (D. 12174, 12359.)
- Pilsbry, H. A., Philadelphia: Slugs (2 specimens). Lent for study. (D. 12729.)

Pennsylvania —Continued.

- State Normal School, Mansfield: Marine invertebrates (303 specimens, series VI, set 82). Gift. (D. 12592.)
- Stone, Witmer, Philadelphia: Bird skins (41 specimens). Lent for study. (D. 12456.)
- Strecker, Hermann, Reading: Lepidoptera (60 specimens). Exchange. Lepidoptera (2 specimens). Lent for study. (D. 12569, 12776.)

Rhode Island.

- Collins, J. Franklin, Providence: Plants (28 specimens). Exchange. (D. 12052.)

Tennessee.

- Library and Reading Room, Erin: Rocks and ores (104 specimens, set 21). Gift. (D. 12186.)

Texas.

- Price, R. H., College Station: Plants (62 specimens). Exchange. (D. 12673.)
- San Antonio Female College, San Antonio: Rocks and ores (104 specimens, set 16). Gift. (D. 12373.)

Utah.

- Jones, Marcus E., Salt Lake City: Plants (250 specimens). Exchange. (D. 12040.)

Virginia.

- Hampden-Sidney College, Hampden-Sidney: Rocks and ores (104 specimens, set 19). (D. 12266.)

Washington.

- Heckman, P. Y., Issaquah: Fossil plants and crinoids (36 specimens). Exchange. (D. 12573.)
- Wickersham, James, Tacoma: Plaster cast of stone club. For examination. (D. 12374.)

West Virginia.

- Pollock, W. M., Buckhannon: Plants (50 specimens). Exchange. (D. 12057.)

Wisconsin.

- Adams, C. K., Madison: Plants (162 specimens). Lent for study. (D. 12523, 12544.)
- High School, Janesville: Rocks and ores (104 specimens, set 26). Gift. (D. 12085.)
- High School, Kenosha: Rocks and ores (104 specimens, set 23). Gift. (D. 12106.)

Wisconsin—Continued.

High School, Monroe: Rocks and ores (104 specimens, set 25). Gift. (D. 12108.)

High School, Racine: Rocks and ores (104 specimens, set 24). Gift. (D. 12107.)

WEST INDIES.

Connell, E. Y., Basse Terre, St. Kitt's, and Nevis: Stone implements (62 specimens). Exchange. (D. 12139.)

Public Gardens and Plantations, Kingston, Jamaica: Plants (78 specimens). Exchange. (D. 12553.)

SOUTH AMERICA.

ARGENTINA.

Ruscheweyh, G., Buenos Ayres: Lepidoptera (113 specimens). Exchange. (D. 12280.)

Silvestri, Filippo., Buenos Ayres: *Argulus* (10 specimens). For examination. (D. 12711.)

PERU.

Colunga, M. F., Lima: Bird skins (26 specimens). Exchange. (D. 12696.)

ASIA.

CHINA.

Bergen, Paul D., Chefoo: Bird skins (48 specimens); mammal skins (2 specimens). Exchange. (D. 12475.)

Chinanfu Museum, Chinanfu: Minerals (57 specimens, set 195); rocks and ores (113 specimens). Exchange. (D. 12738.)

INDIA.

Indian Museum, Calcutta: Decapod crustaceans (171 specimens); bird skins (4 specimens). Exchange. Decapod crustaceans (124 specimens). Gift. (D. 12334, 12653, 12765.)

Royal Botanic Garden, Bengal: Plants (240 specimens). Exchange. (12689.)

EUROPE.

AUSTRIA.

Simmer, Hans, Carinthia: Plants (296 specimens). Exchange. (12688.)

BAVARIA.

Geological-Paleontological Institute, Munich: Cambrian fossils (76 specimens). Exchange. (D. 12000.)

BELGIUM.

Selys-Longchamps, Baron Edmund de, Liege: Skins and skulls of Microtine rodents. For examination. (D. 12724.)

Vrière, Baron R. de, Zedelghem: Coleoptera (112 specimens). Exchange. (D. 12753.)

BOHEMIA.

Fritsch, Anton, Prague: Fossils (6 specimens). Lent for study. (D. 12184, 12630.)

DENMARK.

Meinert, F., Copenhagen: Pycnogonida (120 specimens). Lent for study. (D. 12536.)

Warming, Eugenius, Copenhagen: Plants (500 specimens). Exchange. (D. 12084.)

FRANCE.

Miguel, Jean, Barroubio, Hérault: Fossils (272 specimens). Exchange. (D. 12613.)

Trocadero Museum, Paris: Thirteen casts of ethnological specimens. (D. 12446.)

GERMANY.

Haferlandt and Pippow, Berlin: Skull of Bison (1 specimen). Exchange. (D. 12619.)

GREAT BRITAIN.

ENGLAND.

Baker, E. G., London: Collection of plants. Exchange. (D. 12650.)

Barrett-Hamilton, G. E. H., London: Mammals, mice, and squirrels (112 specimens). Lent for study. (D. 12502.)

British Museum, London: Plants (246 specimens). Exchange. Plants (12 specimens). Lent for study. Tertiary Corals (229 specimens); cretaceous bryozoa (5 vials); skins and skulls of mammals (19 specimens); mollusks (27 specimens); invertebrates (9 specimens). Exchange. (D. 11992, 12209, 12320, 12343, 12504.)

- Brunetti, E., London: Diptera (278 specimens). Exchange. (D. 12494.)
- Gamble, T. W., Manchester: Collection of Annelids. Lent for study. (D. 12005.)
- Hampson, Sir George F., London: Moths (12 specimens). Lent for study. (D. 12418.)
- Masters, T. Maxwell, London: Plants (18 specimens). Lent for study. (D. 12069.)
- Parritt, H. W., London: Echinoderms and crustaceans (28 specimens). Exchange. (D. 12726.)
- Royal Gardens, Kew, London: Plants (3 sets). Lent for study. Plants and seeds (5 sets). Exchange. Living plants (*Agave*) (2 specimens). Gift. (D. 12148, 12251, 12363, 12529, 12574, 12649, 12664.)
- Rudler, F. W., London: Onyx marble (1 specimen). Exchange. (D. 12105.)
- Thomas, Oldfield, London: Skins and skulls of African rodents (17 specimens). Lent for study. (D. 12168.)
- University College, Liverpool: Marine invertebrates (series v, set 97, 475 specimens); invertebrates (5 specimens and 1 vial). Exchange. (D. 12006, 12210.)
- Woodward, Henry, London: Cranium and cast of cranium of *Castoroides*. Exchange. (D. 12279.)

SCOTLAND.

- Chilton, Charles, Edinburgh: Blind crustaceans (15 specimens). Exchange. (D. 12232.)

ITALY.

- Gestro, R., Genoa: Fish (1 specimen). Exchange. (D. 12743.)
- Mayer, P., Naples: Small crustaceans (1,154 specimens). Lent for study. (D. 12493.)
- University of Turin, Turin: Fossils (77 specimens). Exchange. (D. 12612.)

NETHERLANDS.

- Royal Ethnographic Museum, Leyden: Ethnological objects (195 specimens). Exchange. (D. 12741.)
- Von Roon, G., Rotterdam: Coleoptera (100 specimens). Exchange. (D. 12553.)

SWEDEN.

- Royal Swedish Academy of Sciences, Stockholm: Plants (361 specimens). Exchange. (D. 12086.)

SWITZERLAND.

- Autran, Eugene, Geneva: Plants (663 specimens). Exchange. (D. 12533.)
- Candolle, M. Casimir de, Geneva: Plants (23 specimens). Lent for study. (D. 12433.)

OCEANICA.

AUSTRALIA.

- Grant, F. H. McK., Melbourne, Victoria: Casts of stone pipes (3 specimens). Exchange. (D. 12393.)

APPENDIX IV.

BIBLIOGRAPHY OF THE U. S. NATIONAL MUSEUM FOR THE FISCAL YEAR ENDING JUNE 30, 1899.

PUBLICATIONS OF THE MUSEUM.¹

ANNUAL REPORT.

Annual Report | of the | Board of Regents | of the | Smithsonian Institution, | Showing | the Operations, Expenditures, and Condition | of the Institution | for the | year ending June

30, 1896. | — | Report | of the | U. S. National Museum. | — | Washington: | Government Printing Office. | 1898.
Svo, pp. 1-XXIV, 1-1107, 198 pls., 555 figs.

PROCEEDINGS.

Smithsonian Institution. | United States National Museum. | — | Proceedings | of the | United States National Museum. | — | Volume XX. | — | Pub-

lished under the direction of the Smithsonian Institution. | — | Washington: | Government Printing Office. | 1898.
Svo, pp. 1-XII, 1-932, pls. 1-XCVII, figs. 1-149.

BULLETINS.

Smithsonian Institution. | United States National Museum. | — | Bulletin | of the | United States National Museum. | No. 47. | — | The Fishes | of | North and Middle America: | A descriptive catalogue of the species of fish-like vertebrates found in | the waters of North America, north of the Isthmus of Panama. | By | David Starr Jordan, Ph.D., | President of the Leland Stanford Junior University and of the | California Academy of Sciences, | and | Barton Warren Evermann, Ph. D., | Ichthyologist of the United States Fish Commission. | Part II. | Washington: | Government Printing Office. | 1898.

Svo, pp. 1-XXX, 1241-2183.

Smithsonian Institution. | United States National Museum. | — | Bulletin | of the | United States National Museum. | No. 47. | — | The Fishes | of | North and Middle America: | A descriptive catalogue of the species of fish-like vertebrates found in | the waters of North America, north of the Isthmus of Panama. | By | David Starr Jordan, Ph. D., | President of the Leland Stanford Junior University and of the | California Academy of Sciences, | and | Barton Warren Evermann, Ph.D., | Ichthyologist of the United States Fish Commission. | Part III. | Washington: | Government Printing Office. | 1898.

Svo, pp. 1-XXIV, 2184-3136.

PAPERS BY OFFICERS OF THE NATIONAL MUSEUM AND OTHERS, BASED UPON MUSEUM MATERIAL.

ADLER, CYRUS, and CASANOWICZ, I. M. Biblical antiquities.

Rep. Smithsonian Inst. (U. S. Nat. Mus.),
1896 (1899), pp. 943-1023, pls. 1-46.

AMERICAN ORNITHOLOGISTS' UNION (Committee on Classification and Nomenclature). Ninth Supplement to the Ameri-

AMERICAN ORNITHOLOGISTS' UNION—Con. can Ornithologists' Union Check-list of North American Birds.

Auk, XVI, No. 1, Jan., 1899, pp. 97-133.

More than 150 additions, changes in nomenclature, etc., are here made. A list of proposed changes and additions not acted upon at this session of the committee is included.

¹ The titles of the papers from the Report and Proceedings which were published in separate form during the year are given in Appendix V.

ASHMEAD, WILLIAM H. A generic synopsis of the Blennocampidae.

Journ. N. Y. Ent. Soc., VI, No. 2, July, 1898, pp. 126-129.

Twenty-two genera are characterized, 4 of which are new, viz, *Isodygetium*, *Parazarea*, *Erythraspidus*, and *Calozarea*.

— Classification of the Horn-tails and Saw-flies, or the suborder Phytophaga. Paper No. 2.

Canadian Entomologist, xxx, No. 7, July, 1898, pp. 177-183.

Gives generic tables of the Oryssidae, Siricidae, Xiphydriidae, and Cephidae. Twenty-four genera and 3 new species are characterized.

— Classification of the Horn-tails and Saw-flies, or the suborder Phytophaga. Paper No. 3.

Canadian Entomologist, xxx, No. 8, Aug., 1898, pp. 205-213.

Gives generic tables of the Xyelidae, Lydidae, and Hylotomidae. Forty genera are tabulated, 7 of which are new, viz, *Liolyda*, *Pseudocoryphona*, *Caloptilia*, *Acanthoplenos*, *Neoptilia*, *Gymnopterus*, and *Micarge*.

— Thynnidae in the United States.

Psyche, VIII, No. 268, Aug., 1898, p. 251.

Describes 1 new genus (*Glyptomotopa*) and 2 new species: *Telephoromyia anthracina* and *Glyptomotopa americana*.

— Classification of the Horn-tails and Saw-flies, or the suborder Phytophaga. Paper No. 4.

Canadian Entomologist, xxx, No. 9, Sept., 1898, pp. 225-232.

Gives generic tables of the Lophyridae, Perreyiidae, Pterygophoridae, and Pergidae. Thirty genera are tabulated, of which 7 are new, viz, *Lophyridea*, *Lophyrotoma*, *Pterygophorinus*, *Syzygonidea*, *Paraperga*, *Pseudoperga*, and *Neoperga*.

— Classification of the Horn-tails and Saw-flies, or the suborder Phytophaga. Paper No. 5.

Canadian Entomologist, xxx, No. 10, Oct., 1898, pp. 249-257.

This paper treats of the family Selandriidae, which is divided into 4 subfamilies. Generic tables of all the genera are given. Thirty-seven genera have been recognized, of which 9 are new, viz, *Monopadnuoides*, *Paraselandria*, *Periclistoptera*, *Endelomyia*, *Ericampoides*, *Tetraneura*, *Pacilostomidea*, *Zaschizonyx*, and *Macgillivraya*.

— Two new genera of Sand Wasps.

Entomological News, IX, No. 8, Oct., 1898, pp. 187-189.

ASHMEAD, WILLIAM H.—Continued.

Describes 2 new genera and 4 new species of Sand Wasps, viz, *Faria pacifica*, *Micophinus laticrps*, *M. californicus*, and *M. texanus*.

— Classification of the Horn-tails and Saw-flies, or the suborder Phytophaga. Paper No. 6.

Canadian Entomologist, xxx, No. 11, Nov., 1898, pp. 281-287.

Treats of the family Nematidae, which is divided into 2 subfamilies, (1) Cladiniæ and (2) Nematiniæ; and of the family Dineuridae, which is also divided into 2 subfamilies, (1) Hemichroiniæ and (2) Dineuriniæ. In all 28 genera are tabulated, of which 2 are new, *Opisthoncura* and *Marlattia*.

— Some new genera of bees.

Psyche, VIII, No. 271, Nov., 1898, pp. 282-285.

Gives a generic table of the Stelididae, in which 5 genera are tabulated. In this paper 8 new bee genera and 1 new species are described, viz, *Zacosmia*, *Melanostelis betheli*, *Neopasites*, *Hoplopasites*, *Hyllosoma*, *Cockerellia*, *Philoxanthus*, and *Nomadopsis*.

— Classification of the Horn-tails and Saw-flies, or the suborder Phytophaga. Paper No. 7.

Canadian Entomologist, xxx, No. 12, Dec., 1898, pp. 305-316.

This paper, which is the last of the series, treats of the families Tenthredinidae and Cimbicidae. The first is divided into 4 subfamilies, the last into 2. In all, 48 genera are tabulated, 11 genera being new, viz, *Pseudosiobla*, *Strongylogastroidea*, *Dimorphopteryx*, *Parasiobla*, *Aomolyctium*, *Aphlodactium*, *Polystichophagus*, *Hypotaxonus*, *Hemilaxonus*, and *Homocneura*.

— Reports upon the insects, spiders, mites, and myriapods collected by Dr. L. Stejneger and G. E. H. Barrett-Hamilton on the Commander Islands.

Report of Fur Seal Investigations 1896-1897, Part IV, 1898, Appendix I, pp. 328-351.

This report is edited by Mr. Ashmead, and is the joint work of several of the specialists connected with the National Museum (*vide* Banks, Cook, Coquillett, Dyar, Linell, and Schwarz.)

Mr. Ashmead contributed the report upon the Hymenoptera and Rhynchota. In the former, 11 species are recorded, 8 being new; in the latter, 3 species are noted, only 1 being new.

— Four new entomophilous wasps.

Entomological News, x, No. 1, Jan., 1899, pp. 9, 10.

Describes *Pisonopsis triangularis*, *Niteliopsis striatipes*, *Harpactus howardi*, and *H. cockerelli*.

ASHMEAD, WILLIAM H.—Continued.

— Three new species in the genus *Diplectron* Fox.

Entomological News, x, No. 3, Mar., 1899, pp. 55, 56.

Gives a table of the known species and describes as new *Diplectron ferrugineus*, *D. bidentatus*, and *D. foxii*.

— Superfamilies in the Hymenoptera, and generic synopses of the families Thynnidae, Myrmosidae, and Mutillidae.

Journ. N. Y. Ent. Soc., vii, No. 1, Mar., 1899, pp. 45-60.

In this paper Mr. Ashmead has divided the Hymenoptera into ten superfamilies: (I) Apoidea, (II) Sphegoidea, (III) Vespoidea, (IV) Formicoidea, (V) Proctotrypoidae, (VI) Cynipoidea, (VII) Chalcidoidea, (VIII) Ichneumonoidae, (IX) Siricoidea, and (X) Tenthrinoidea. Generic tables are given for the families Thynnidae, Myrmosidae, and Mutillidae.

Fifty-three genera are tabulated. Sixteen new genera are defined: *Isacaroides*, *Ephutomma*, *Typhoctes*, *Odontomutilla*, *Dolichomutilla*, *Bothriomutilla*, *Nomicphagus*, *Pyrrhomutilla*, *Eurymutilla*, *Hoplomutilla*, *Dasymutilla*, *Allomutilla*, *Trogaspidia*, *Alloncurion*, and *Micromutilla*.

— Four new species belonging to the genus *Plenoculus* Fox.

Psyche, viii, No. 275, Mar., 1899, pp. 337-339.

Gives a synoptic table for recognizing the known species of *Plenoculus* and describes 4 new species: *P. punctatus*, *P. abdominalis*, *P. niger*, and *P. albipes*.

— On the genera of the Cleonyminae.

Proc. Ent. Soc. Wash., iv, No. 3 (issued May 24, 1899), pp. 200-206.

Mr. Ashmead separates this family into 4 subfamilies (1) Chalcedectinae, (2) Cleonyminae, (3) Pelecinellinae, and (4) Colotrechinae. Thirty-six genera are tabulated, of which 3 are new: *Chalcidiscetis*, *Tomicobia*, and *Eutrichosoma*.

— On the genera of the Eucharidae.

Proc. Ent. Soc. Wash., iv, No. 3 (issued May 24, 1899), pp. 235-242.

Tabulates all the known genera, 23 in number. Two genera are new: *Pseudometagea* and *Dicathorax*.

— Classification of the old family Chalcididae.

Proc. Ent. Soc. Wash., iv, No. 3 (issued May 24, 1899), pp. 242-249.

In this paper Mr. Ashmead treats the old family as a superfamily, Chalcidoidea, and then divides it into 14 distinct minor families, as already proposed by him in a previous paper. Tables for recognizing these families,

ASHMEAD, WILLIAM H.—Continued.

and the subfamilies into which they are again divided, are given: Agaonidae, Torymidae with 5 subfamilies, Chalcidoidea with 2 subfamilies, Eurytomidae, Perilampidae, Eucharidae, Miscogasteridae with 4 subfamilies, Cleonymidae with 4 subfamilies, Encyrtidae with 3 subfamilies, Pteromalidae with 5 subfamilies, Elasmidae, Eulophidae with 4 subfamilies, Trichogrammatidae with 2 subfamilies, and Mymaridae with 2 subfamilies.

— Classification of the entomophilous wasps, or the superfamily Sphegoidea. Paper No. 1.

Canadian Entomologist, xxxi, No. 6, June, 1899, pp. 145-155.

Mr. Ashmead gives an introduction on the arrangement of these wasps by previous authors, exhibits the scheme of arrangement proposed by Dr. Franz Kohl, and divides the superfamily into 12 families, giving a table for their recognition. The families are: Oxybelidae, Crabronidae, Pamphredonidae, Bembecidae, Larridae, Philanthidae, Trypoxylidae, Mellinidae, Nyssonidae, Stizidae, Sphegidae, and Ampulicidae.

— A generic table of the family Panurgidae; a reply to Mr. Cockerell's critique on the segregation of *Perdita* Cockerell.

Psyche, viii, No. 278, June, 1899, pp. 372-376.

In this paper Mr. Ashmead points out particularly the differences between *Cockerellia* and *Perdita*; shows that four of Mr. Cockerell's recent new bee genera belonging in this group are synonyms, and concludes by tabulating the genera of the Panurgidae. Nineteen genera are thus tabulated.

— Classification of the bees, or the superfamily Apoidea.

Trans. Am. Ent. Soc., Phila., xxvi, May-June, 1899, pp. 49-100.

Divides the Apoidea into 14 families, some of which are again divided into subfamilies. Dichotomous tables for recognizing the families, subfamilies, and the bee genera of the world are given. In all, 216 genera are tabulated, of which 19 are new.

BANGS, OUTRAM. On some birds from Pueblo Viejo, Colombia.

Proc. Biol. Soc. Wash., xii, Aug. 10, 1898, pp. 157-160.

An account of 28 species of birds collected by W. W. Brown, jr., in Colombia. *Elania browni*, *Automolus ruficeps*, *Euarremon basilicus*, and *Thryothorus latus* are described as new. Based partly upon Museum material.

— On some birds from the Sierra Nevada de Santa Marta, Colombia.

Proc. Biol. Soc. Wash., xii, Oct. 31, 1898, pp. 171-182.

BANGS, OUTRAM—Continued.

Notes on 66 species of birds collected by W. W. Brown, jr., in Colombia, of which the following are diagnosed as new: *Ncoeræ colombianus*, *Aulacorhampus latus*, *Leucuria* (new genus), *Leucuria phalerata*, *Elenia sororia*, *Grallaria spatulator*, *Spinus pinescens capitaneus*, *Diglossa nicticolor*, *Merula phæopyga minuscula*, and *Merula gigas cacozela*. Based partly upon Museum material.

— On the subspecies of *Manacus manacus* (Linn.).

Proc. New England Zool. Club, I, Mar. 31, 1899, pp. 33-37.

This species is divided into four forms, viz: *Manacus manacus manacus* (Linn.), *M. M. abdellivus* (new subspecies), *M. M. purus* (new sub-species), and *M. M. gutturosus* (Desm.). Based partly upon Museum material.

— A new Rail from Southern California.

Proc. New England Zool. Club, I, June 5, 1899, pp. 45, 46.

Rallus levipes is described as new. Based partly upon Museum material.

BANKS, NATHAN. Some new spiders.

Canadian Entomologist, xxx, No. 7, July, 1898, pp. 185-188.

Descriptions of 7 new species from various parts of the United States.

— Some Mexican Phalangida.

Journ. N. Y. Ent. Soc., vi, No. 3, Sept., 1898, pp. 181, 182.

Descriptions of 5 new species from Mexico.

— Three myrmecophilous mites.

Canadian Entomologist, xxx, No. 10, Oct., 1898, pp. 265, 266.

Descriptions of 3 new mites associated with ants.

— Descriptions of new North American neuropteroid insects.

Trans. Am. Ent. Soc., xxv, No. 3, Dec., 1898, (Jan., 1899), pp. 199-218.

Descriptions of 5 new genera and 44 new species; synopses of 1 family and 3 genera.

— [Plecoptera, Trichoptera, and Arachnida.]

Report of Fur Seal Investigations 1896-1897, Part IV, 1898, Appendix I, pp. 346-350, pl. A.

These notes are included in "Reports on the insects, spiders, mites, and myriapods collected by Dr. L. Stejneger and Mr. G. E. H. Barrett-Hamilton on the Commander Islands," edited by W. H. Ashmead. Seven new species are described.

— A classification of the North American Myrmeleonidae.

Canadian Entomologist, xxxi, No. 3, Mar., 1899, pp. 67-71.

Synopses of the genera; descriptions of 2 new genera and 1 species.

BANKS, NATHAN—Continued.

— Some spiders from northern Louisiana.

Proc. Ent. Soc. Wash., iv., No. 3 (issued May 24, 1899), pp. 188-193.

A list of 127 species. Seven new species are described.

— A new species of the genus *Halarachne*.

Proc. Ent. Soc. Wash., iv, No. 3 (issued May 24, 1899), pp. 212-214, fig. 15.

A new species found in a West Indian seal.

— An American species of the genus *Caculus*.

Proc. Ent. Soc. Wash., iv, No. 3 (issued May 24, 1899), pp. 221, 222, fig. 16.

A new species from Southern California.

— *Tarsonemus* in America.

Proc. Ent. Soc. Wash., iv, No. 3 (issued May 24, 1899), pp. 294-296, fig. 17.

A new species injurious to chrysanthemums.

— A new solpugid from California.

Proc. Ent. Soc. Wash., iv, No. 3 (issued May 24, 1899), pp. 314, 315.

A new species of *Cleobis*.

— New Myrmeleonidae.

Entomological News, x, No. 6, June, 1899, pp. 170-172.

Descriptions of three new species.

BARTSCH, PAUL. First record of the Turnstone, *Arenaria interpres* (Linn.), in Iowa (May 21, 1892).

Iowa Ornithologist, iv, No. 3, July, 1898, p. 3.

The paper records the capture of 2 specimens at Burlington, Iowa.

— Primitive nesting sites of the Cliff Swallow.

Osprey, III, No. 1, Sept., 1898, p. 6, 1 fig.

This paper mentions two colonies noted on the Oneota River in northern Iowa, and includes a figure showing their nesting site.

— An afternoon amongst old scenes.

Wilson Bull., No. 22, 1898, pp. 63-65.

This paper gives an account of the birds observed on an afternoon ramble in Henderson County, Ill.

— A piscivorous Yellow-leg.

Wilson Bull., No. 24, Jan., 1899, p. 8.

This paper records the Yellow-leg feeding upon Top minnows.

— *Xema sabinii* and *Chordeiles virginianus sennetti*: Two additions to the Iowa avifauna.

Auk, xvi, Jan., 1899, p. 86.

BARTSCH, PAUL—Continued.

Sabine's Gull and Sennett's Nighthawk are added to the list of Iowa birds. The record of the Nighthawk is based upon a specimen now in the National Museum collection.

— A primitive Swift colony.

Wilson Bull., No. 25, Mar., 1899, pp. 21, 22.

This paper deals with the Chimney Swifts, nesting in hollow cypress trees, at Lake Drummond, Dismal Swamp, Virginia.

BEAN, BARTON A. Notes on a collection of fishes from Mexico, with description of a new species of *Platyphacis*.

Proc. U. S. Nat. Mus., XXI, No. 1159, Nov. 21, 1898, pp. 539-542, 1 fig.

— Notes on the capture of rare fishes.

Proc. U. S. Nat. Mus., XXI, No. 1165, Dec. 20, 1898, pp. 639, 640.

— *Myoxocephalus mednii*, new species.

Bull. U. S. Nat. Mus., No. 47, Pt. II, 1898, pp. 1983, 1984.

A diagnosis of *Myoxocephalus mednii*, included in Jordan and Evermann's "Fishes of North and Middle America," published as Bulletin 47 of the National Museum.

— *Porocottus quadratus*, new species.

Bull. U. S. Nat. Mus., No. 47, Pt. II, 1898, p. 1998.

A diagnosis of *Porocottus quadratus*, included in Jordan and Evermann's "Fishes of North and Middle America," published as Bulletin 47 of the National Museum.

BEAN, TARLETON H., and BARTON A. Note on *Oryzotus acuticeps* (Gilbert) from Sitka and Kadiak, Alaska.

Proc. U. S. Nat. Mus., XXI, No. 1167, Dec. 20, 1898, pp. 655, 656.

BREWSTER, WILLIAM. An undescribed Clapper Rail from Georgia and East Florida.

Proc. New England Zool. Club, 1, June 9, 1899, pp. 49-51.

Rallus crepitans waynei is described as new. Based partly upon Museum material.

CASANOWICZ, I. M. Some customs of the Jews in Palestine.

American Hebrew, LXIV, pp. 641, 642.

(See also under Cyrus Adler.)

CHAPMAN, FRANK M. Kirtland's Warbler (*Dendroica kirtlandi*).

Auk, xv, No. 4, Oct., 1898, pp. 289-293, pl. iv.

An account of this rare bird is given, together with a list of the known specimens, and published records of the same. Based partly upon Museum material.

CHAPMAN, FRANK M.—Continued.

— The distribution and relationships of *Ammodramus maritimus* and its allies.

Auk, xvi, No. 1, Jan., 1899, pp. 1-12, pl. I.

A review of the forms of *Ammodramus maritimus*, giving the distinctive characters and geographical distribution of each. *Ammodramus maritimus fisheri* is described as new. Based partly upon Museum material.

CHESNUT, VICTOR KING. Thirty poisonous plants of the United States.

Farmers' Bull., U. S. Dept. Agric., No. 86, Jan. 19, 1899, pp. 1-32, figs. 1-24.

— Principal poisonous plants of the United States.

Bull. Div. Bot., U. S. Dept. Agric., No. 20, pp. 1-60, figs. 1-34.

CHITTENDEN, FRANK H. The Larger Apple-tree Borers.

Circ. Div. Ent., U. S. Dept. Agric. (second series), No. 32, July 1 (5), 1898, pp. 1-12, figs. 1-3.

A general consideration of *Saperda candida*, *S. cretata* and *Chrysobothris fenoreta*, with particular attention to remedial treatment. Three original illustrations are given.

— A new Squash Bug.

Canadian Entomologist, xxx, No. 9, Sept., 1898, pp. 239, 240.

A preliminary article on *Anasa armigera* Say.

— Insect injury to millet.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 17, Dec. 1, 1898, pp. 84-86.

Notes on injury to *Panicum miliaceum* and other species by *Chatoecnema denticulata*, *Monocrepidius beltus*, *Diabrotica 12-punctata*, *Lachnosterna* sp., and *Chlorops assimilis*.

— Insects injurious to beans and peas.

Yearbook U. S. Dept. Agric., 1898, pp. 233-260, figs. 66-82.

Popular economic accounts of 12 species of bean and pea-destroying Coleoptera, with notices of 15 other insects.

Author's extras of this paper were issued May 15, 1899.

— Twig pruners and allied species.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, Jan. 6, 1899, pp. 35-43, 4 figs.

A general popular account of *Elaphidion villosus*, with shorter notes on *E. incerne*, *E. subpubescens*, *E. mucronatum*, and 5 other species of the genus. Three of the figures are original.

CHITTENDEN, FRANK H.—Continued.

- A destructive borer enemy of birch trees with notes on related species.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, Jan. 6, 1899, pp. 44–51, 3 figs.

A general consideration of *Agritus anxius* and its injuries to birch at Buffalo, N. Y.

The portion of this article having reference to other forms of *Agritus* was excluded for lack of space, but the corresponding change was unfortunately not made in the title.

Author's extras were published January 12, 1899.

- A Leaf-tyer on grape and elderberry.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, Jan. 6, 1899, pp. 82, 83.

Notes on *Phlyctenia tertialis*.

- A Flea-beetle living on purslane.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, Jan. 6, 1899, pp. 83–85.

Biologic notes on *Disonychia caroliniana* with descriptions of the larva and pupa.

- Biologic note on *Conotrachelus elegans* Say.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, Jan. 6, 1899, pp. 94, 95.

- Recent injury by Bark-beetles: A correction.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, Jan. 6, 1899, p. 96.

Note on injury by *Dendroctonus* to coniferous forest trees in the Northern States.

- A Leaf-beetle injurious to cultivated sunflower.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, Jan. 6, 1899, p. 96.

Note on *Chrysomela* (*Zygogramma*) *exclamationis*.

- A new Sugar-beet beetle.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, Jan. 6, 1899.

Occurrence of *Monoxia puncticollis* on sugar beet at Hagerman, New Mexico, and on sea blight in the East.

- The Squash Ladybird; its literature and biology.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 11–20, figs. 1, 2.

A general consideration of *Epilachna borealis*.

- Life history of the common Squash Bug (*Anasa tristis* De G.).

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 20–28, figs. 3–5.

CHITTENDEN, FRANK H.—Continued.

- The Horned Squash Bug (*Anasa armigera* Say).

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 28–34, fig. 6.

- Some observations on the life history of the Squash-vine Borer (*Melittia satyriniformis* Hbn.).

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 34–40, figs. 7, 8.

- Notes on the Pickle Worm and Melon Caterpillar.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 41–44.

Notes on *Margarona nitidalis* and *M. hyalinata*.

- Leaf-footed plant-bugs which attack Cucurbits.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 44–48, figs. 9, 10.

Notes on *Leptoglossus oppositus* and *L. phyllopus*.

- Notes on the Striped Cucumber Beetle (*Diabrotica vittata* Fab.).

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 48–51, fig. 11.

Description of the egg and oviposition; notes on methods of control; note on *D. tri-vittata*.

- A new webworm enemy of cabbage and other cruciferous plants.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 51–57, fig. 12.

A general consideration of *Hellula undalis*, a recently discovered imported enemy of cruciferous crops in Georgia.

- Notes on the Garden Flea-hopper (*Halticus uhleri* Giard).

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 57–62, fig. 13.

A general account of this species.

- The Imbricated Snout-beetle (*Epicerus imbricatus* Say).

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 62–67, fig. 14.

- The Brown Fruit-chafer (*Euphoria inda* Linn.).

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 67–74, fig. 15.

CHITTENDEN, FRANK H.—Continued.

— Biologic notes on the May Beetle (*Lachnosterna arcuata* Smith).

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 74-80, figs. 16-18.

A somewhat general consideration of *Lachnosterna arcuata* and a note on insect enemies of white grubs in general.

— The Spinach Flea-beetle (*Disomya xanthomelana* Dalm.).

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 80-85, fig. 19.

— Biologic and other notes on the flea-beetles which attack solanaceous plants.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 85-90, fig. 20.

Notes on the North American species of *Eptitrix*.

— The Cherry Leaf-beetle (*Galerucella caricollis* Lec.).

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 90-93.

— Notes on the Plum and the Rose Leaf-beetles.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 93-95.

Notes on *Nodonota tristis* and *N. puncticollis* and a short note on *N. clypealis*.

— Notes on the Fruit-tree Bark-beetle and other borers affecting fruit-trees.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 19, April 12, 1899, pp. 96-99.

Notes on *Scolytus rugulosus*, *Chion cinctus*, *Amphicercus bicaudatus*, and *Oberca ocellata*.

— The Squash-vine Borer (*Melittia satyriniformis* Hbn.).

Circ. Div. Ent., U. S. Dept. Agric. (new series), No. 38, April 22, 1899, pp. 1-6, figs. 1, 2.

A compilation of the article on the same insect in Bulletin 19 (new series), pp. 34-40, with elaboration of remedial treatment.

— The Squash Bug (*Anasa tristis* Deg.).

Circ. Div. Ent., U. S. Dept. Agric. (second series), No. 39, May 11, 1899, pp. 1-5, figs. 1-3.

A similar adaptation of an article on this insect in Bulletin No. 19 (new series), pp. 20-28.

CLARK, HUBERT LYMAN. The feather-tracts of North American Grouse and Quail.

Proc. U. S. Nat. Mus., XXI, No. 1166, Jan. 1, 1899, pp. 641-653, pls. 47-49, figs. 1-4.

COOK, O. F. American Oniscoid Diplopoda of the order Merochetia.

Proc. U. S. Nat. Mus., XXI, No. 1154, Nov. 19, 1898, pp. 451-468, pls. 29-32.

— [Myriapoda.]

Report of Fur Seal Investigations 1896-1897, Part IV, 1898, Appendix I, pp. 350, 351.

Included in "Reports upon the insects, spiders, mites, and myriapods collected by Dr. L. Stejneger and Mr. G. E. Barrett-Hamilton on the Commander Islands," edited by W. H. Ashmead.

— African Diplopoda of the genus *Pachybolus*.

Proc. U. S. Nat. Mus., XXI, No. 1168, Mar. 17, 1899, pp. 657-666, pls. 50-52.

— The Diplopod family Striariidae.

Proc. U. S. Nat. Mus., XXI, No. 1169, March 30, 1899, pp. 667-676, pls. 53, 54.

— African Diplopoda of the family Gomphodesmidae.

Proc. U. S. Nat. Mus., XXI, No. 1170, Mar. 30, 1899, pp. 677-739, pls. 55-61.

COQUILLET, DANIEL W. On the Dip-terous family Scatophagidae.

Journ. N. Y. Ent. Soc., VI, No. 3, Sept., 1898, pp. 160-165.

Gives a synoptic table of the genera of this family occurring in this country, and describes 3 new genera and 7 new species.

— Additions to my synopsis of the Tachinidae.

Canadian Entomologist, XXX, No. 9, Sept., 1898, pp. 233-237.

Describes 9 new species, belonging to 6 different genera.

— Report on a collection of Japanese Diptera presented to the U. S. National Museum by the Imperial University of Tokyo.

Proc. U. S. Nat. Mus., XXI, No. 1146, Nov. 4, 1898, pp. 301-340.

— New species of Sapromyzidae.

Canadian Entomologist, XXX, No. 11, Nov., 1898, pp. 277-280.

Describes 14 new species belonging to 4 different genera.

— [Diptera and Siphonaptera.]

Report of Fur Seal Investigations 1896-1897, Part IV, 1898, Appendix I, pp. 341-346.

Included in "Reports upon the insects, spiders, mites, and myriapods collected by Dr. L. Stejneger and Mr. G. E. H. Barrett-Hamilton on the Commander Islands," edited by W. H. Ashmead.

A list of 29 species is given, with descriptions of 1 new genus and 8 new species.

COQUILLET, DANIEL W.—Continued.

— Description of a new *Psilopa*.

Canadian Entomologist, xxxi, No. 1, Jan., 1899, p. 8.

Describes *Psilopa petrolei* from California, the larva of which lives in earth saturated with crude petroleum.

— A Cecidomyiid injurious to seeds of sorghum.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, Jan. 7, 1899, pp. 81, 82.

Describes *Diplosis sorghicola*, with notes on the early stages of the larva, which infests the seeds of sorghum, causing them to shrivel up and die.

— A new Trypetid from Hawaii.

Entomological News, No. 5, May, 1899, p. 129, 130.

Describes *Dacus cucurbitæ*, the larva of which lives in green cucumbers.

COULTER, J. M., and ROSE, JOSEPH NELSON. *Hesperogenia*, a new genus of Umbelliferae from Mount Rainier.

Contrib. U. S. Nat. Herbarium, v, No. 4, Oct., 1899, p. 203.

COVILLE, FREDERICK VERNON, and ROSE, JOSEPH NELSON. List of plants collected by Dr. and Mrs. Leonhard Stejneger on the Commander Islands, 1895 and 1897.

Report of Fur Seal Investigations 1896-1897, Part IV, 1898, Appendix II, pp. 352-361.

CULIN, STEWART. Chess and playing cards.

Rep. Smithsonian Inst. (U. S. Nat. Mus.), 1896 (1899), pp. 665-942, pls. 1-50, figs. 1-226.

CURRIE, ROLLA P. New species of North American Myrmeleonidae. III.

Canadian Entomologist, xxx, No. 9, Sept., 1898, pp. 241-243.

Describes *Brachynemurus hubbardii*.

— New species of North American Myrmeleonidae. IV.

Canadian Entomologist, xxx, No. 11, Nov., 1898, pp. 273-276.

Describes *Brachynemurus brunneus*.

DALL, WILLIAM HEALEY. Note on the anatomy of *Resania* Gray and *Zenatia* Gray.

Proc. Malacological Soc., III, part 2, July, 1898, pp. 85, 86.

This is a note on the anatomy of 2 rare bivalves from New Zealand, which were obtained by the Museum from Mr. Suter, of

DALL, WILLIAM HEALEY—Continued.

Christchurch. Some interesting anatomical features are described in which these mollusks seem to differ from any hitherto known.

— A new species of *Ceres* from Mexico.

Nautilus, XII, No. 3, July, 1898, pp. 27, 28.

A new species of *Ceres* from Mexico, *Ceres nelsoni*, which is especially interesting for the reason that hitherto only two species of this remarkable genus have been known, and the present one, collected in Mexico by Mr. E. W. Nelson, is larger and finer than either of the earlier known species.

— On a new species of *Myllita*.

Nautilus, XII, No. 4, Aug., 1898, pp. 40, 41.

This paper discusses the nomenclature of the genus, enumerates the species which are already known, and describes *Myllita inæqualis*, a new species from South Australia.

— A new species of *Terebra* from Texas.

Nautilus, XII, No. 4, Aug., 1898, pp. 44, 45.

This note describes the first typical *Terebra* known from the tropical waters of eastern America. It was collected by Hon. J. D. Mitchell, of Victoria, Texas. The type, which has been named *Terebra texana*, is in the National Museum.

— A new *Polygyra* from New Mexico.

Nautilus, XII, No. 7, Nov., 1898, p. 75.

Polygyra minorhyssa, from the Sierra Blanca, Lincoln County, New Mexico.

— Description of a new *Ampullaria* from Florida.

Nautilus, XII, No. 7, Nov., 1898, pp. 75, 76.

This note describes *Ampullaria pinei*, collected on the Homosassa River, Florida, by Mr. George Pine.

— A table of the North American Tertiary horizons correlated with one another and with those of western Europe, with annotations.

18th Ann. Rep. U. S. Geol. Surv., part 2, 1898, pp. 325-348.

This paper gives a synopsis of the main divisions of the Tertiary, defining their limits, and shows in a table, so far as our present knowledge extends, the succession of these beds, and correlates those of the eastern, central, and western portions of the country in a manner to show the equivalent beds in the same horizontal line. This table includes the entire Tertiary series. A series of notes upon names used in the table is given, indicating the origin of the name, mentioning any question which has arisen in regard to the division of this or some other name, giving references to the literature in which each name was defined or fully described, and mentioning the chief synonyms.

DALL, WILLIAM HEALEY—Continued.

— On the proposed University of the United States and its possible relations to the scientific bureaus of the Government.

Am. Naturalist, XXIII, No. 386, Feb., 1899, pp. 97-107.

This essay discusses the practical methods by which the opportunities offered by the scientific bureaus of the Government could be utilized for the instruction of students, and points out the difficulties in the realization of any plan in which the presence of the students in those laboratories forms a part. Although this is a feature of most of the propositions for a National University, on the practicability of which the success of those projects depends absolutely, it has been almost universally ignored by those persons who have endeavored to promote the establishment of such a university.

— On a new species of *Drillia* from California.

Nautilus, XII, No. 11, Mar., 1899, p. 127.

A new species of *Drillia*, collected by Mr. and Mrs. T. S. Oldroyd, off San Pedro, Cal., is described under the name of *Drillia empyrosia*.

— A new *Pteronotus* from California.

Nautilus, XII, No. 12, Apr., 1899, pp. 138, 139.

This note describes *Pteronotus carpenteri*, obtained from several localities on the coast of California.

— How long a whale may carry a harpoon.

Nat. Geograph. Mag., x, No. 4, Apr., 1899, pp. 136, 137.

This paper gives some data in relation to a harpoon deposited in the National Museum by the National Geographic Society, and found in a whale taken in Bering Sea in August, 1890, which it appears must have been carried in the animal's body for thirty-six years.

— The Calaveras skull.

Proc. Acad. Nat. Sci., Phila., Apr., 1899, pp. 2-4.

This note places on record the observations of witnesses in regard to this skull, about which so much controversy has gathered and in regard to which, recently, some new expressions of incredulity have been published.

— Synopsis of the American species of the family Diplodontidae.

Journ. Conchology, IX, No. 8, Oct., 1899, pp. 244-246.

This synopsis exhibits the groups into which this family is divided, the genera already described, and their synonyms. Section *Felaniella*, based on *Felania usta* Gould, and section *Phycetiderma* Dall, based on *Diplodonta semi-*

DALL, WILLIAM HEALEY—Continued.

aspera Phil., are described as new; *Diplodonta verrilli* is proposed as a new name for *Diplodonta turgida* Verrill and Smith, not Conrad; *Diplodonta semirugosa* Dall is proposed as a new name for *Diplodonta semiaspera* of Carpenter, not of Philippi; *Diplodonta platensis* from Argentina is described as new.

— Synopsis of the recent and Tertiary Leptonacea of North America and the West Indies.

Proc. U. S. Nat. Mus., XXI, No. 1177, June 29, 1899, pp. 873-897, pls. 87, 88.

This paper gives the results of a revision of the groups belonging to the Leptonacea, a table of the revised classification and lists (A) of the species of the east coast of North America; (B) of the west coast of North America, and (C) of the Tertiary American species.

The genus *Galeomma* is divided into sections, of which two, *Amphilepida* and *Paralepida*, are new; *Spaniorinus* and *Scintillorhis* are new subgenera of *Solecardia* Conrad; *Vasconicella* is proposed as a new generic name for *Vasconia*, which is preoccupied. In the Leptonidae, *Epilepton* (subgenus of *Lepton*) is proposed for *Lepton clarkiae*; *Ceratobornia*, a section of *Bornia*, *Manickella* and *Kellia*, sections of *Kellia*, *Serridens* and *Dicranodesma*, subgenera of *Thecodonta*, and *Pythinella*, subgenus of *Mysella* angas, are new.

The following new species and varieties are described: *Sportella pilsbryi*, *S. californica*, *S. stearnsii*, *Anisodonta corbuloidea*, *Erycina linella*, *E. emmonsii*, *E. periscopiana*, *E. fernandina*, *E. compressa*, *Bornia barbadensis*, *B. retifera*, *Mysella tunidula*, var. *verrilli*, *Montacuta barbadensis*, *M. aleutica*, *M. pedronna*, *Montacuta floridana*, *M. minuscula*, *M. limpida*, *M. percompressa*.

The following new names are applied to species of which the names in use are preoccupied or erroneous: *Solecardia mörchii* for *S. eburnea* Mörch, not Conrad.

The new species are figured, the method in which *Pseudopythina* attaches itself to crustacea, and the animal of *Ceratobornia* are illustrated.

DILLER, J. S. Origin of Paleotrochis.

Am. Journ. Sci., VII, May, 1889, pp. 337-342.

The author shows that these supposed fossils are derived from an ancient eruptive rock. These bodies are of the nature of spherulites and are therefore not organic.

DYAR, HARRISON G. Notes on some Saw-fly larvae, especially the Xyelidae.

Canadian Entomologist, XXX, No. 7, July, 1898, pp. 173-176.

Describes 4 larvae.

— Concerning *Xanthorhoe glacialis* Hulst.

Canadian Entomologist, XXX, No. 8, Aug., 1898, p. 203.

DYAR, HARRISON G.—Continued.

- Six new or little-known larvæ of Pterophoridae.

Psyche, VIII, No. 268, Aug., 1898, pp. 249, 250.
One new species is described, *Pterophorus rhynchosia*.

- Life histories of New York Slug Caterpillars, XVI.

Journ. N. Y. Ent. Soc., VI, No. 3, Sept., 1898, pp. 151-158, pl. VIII, figs. 1-11.

- Life history of *Calybia slossoniæ*.

Journ. N. Y. Ent. Soc., VI, No. 3, Sept., 1898, pp. 158-160.

- Life history of *Pamphila ethlius*.

Entomological News, IX, No. 7, Sept., 1898, pp. 163-165.

- Note on the larva of *Melanomma aurinctarium* Grote.

Canadian Entomologist, XXX, No. 10, Oct., 1898, p. 257.

Description of larva.

- A new *Parasa*, with a preliminary table of the species of the genus.

Psyche, VIII, No. 270, Oct., 1898, pp. 273-276.

Describes *Parasa prasina*.

- *Inguromorpha slossonii* Hy. Edw.

Entomological News, IX, No. 9, Nov., 1898, pp. 213, 214.

- A new *Hypopta*.

Entomological News, IX, No. 9, Nov., 1898, p. 214.

Describes *Hypopta anna* from a specimen collected at Miami, Fla., by Mrs. A. T. Slosson.

- Notes on certain South American Cochlidiidae and allied families.

Journ. N. Y. Ent. Soc., VI, No. 4, Dec., 1898, pp. 231-239.

Contains descriptions of the following new genera: *Dulcerina*, *Epipinconia*, *Brachycodilla*, *Episibine*, *Protatima*, *Epiperola*, *Paleophobeton*, *Pseudoripsania*, and of one new species, *Euclea viridigrisca*.

- Life history of New York Slug Caterpillars. XVII.

Journ. N. Y. Ent. Soc., VI, No. 4, Dec., 1898, pp. 241-246, pl. XI, figs. 1-12.

- [Lepidoptera.]

Report of Fur Seal Investigations 1896-1897, Part IV, 1898, Appendix I, pp. 335, 336.

Included in "Reports upon the insects, spiders, mites, and myriapods collected by Dr. L. Stejneger and Mr. G. E. H. Barrett-Hamilton on the Commander Islands", edited by W. H. Ashmead. A list of 5 species.

DYAR, HARRISON G.—Continued.

- Life histories of North American Geometridæ. I.

Psyche, VIII, No. 273, Jan., 1899, pp. 310, 311.

Descriptive of *Aplodes mimosaria* Guenée.

- A suggestion for the Pterophoridae.

Entomologist's Record and Journal of Variation, XI, No. 2, Feb. 15, 1899, pp. 39, 40, pl. 1, figs. 1-6.

Points out the principal characters to be noted in describing the larvæ.

- Description of larva of *Ingura delineata* Guen.

Canadian Entomologist, XXXI, No. 2, Feb., 1899, pp. 27, 28.

Description of all stages.

- On the larvæ of North American Nolidae, with descriptions of new species.

Canadian Entomologist, XXXI, No. 3, Mar., 1899, pp. 61-64.

Three new species are described, viz: *Nola clethra*, *Meganola minor*, and *M. dentata*.

- Life histories of New York Slug Caterpillars. XVIII.

Journ. N. Y. Ent. Soc., VII, No. 1, Mar., 1899, pl. 1, figs. 1-10, pp. 61-68.

- Life history of *Diptera fallax* H.-S.

Journ. N. Y. Ent. Soc., VII, No. 1, Mar., 1899, p. 68.

- Description of the larva of *Calocampa curvimacla*.

Psyche, VIII, No. 275, Mar., 1899, pp. 336, 337.

- West African moths.

Canadian Entomologist, XXXI, No. 4, April, 1899, p. 88.

Corrective note of some previous descriptions.

- On the smallest Pyromorphid and its larva.

Entomological News, X, No. 4, April, 1899, pp. 99, 100.

Describes the Cuban genus *Setiodes* H.-S., and the new species, *S. bahamensis*, adult and larva.

- Spathulate Head Setæ on the larva of *Chamyris cerintha* Treits.

Journ. N. Y. Ent. Soc., VIII, No. 276, April, 1899, p. 349.

- Some structural points in Saw-fly larvæ.

Proc. Ent. Soc. Wash., IV, No. 3 (issued May 24, 1899), pp. 218-220.

DYAR, HARRISON G.—Continued.

— Note on an external feeding Hy-menopterous parasite.

Proc. Ent. Soc. Wash., IV, No. 3 (issued May 24, 1899), pp. 233, 234.

— A new Saw-fly.

Proc. Ent. Soc. Wash., IV, No. 3 (issued May 24, 1899), pp. 262, 263.

Describes larva and adult *Lophyrus pratti*.

— Identification of the eucleid larvæ figured in Glover's "Illustrations of North American Entomology."

Proc. Ent. Soc. Wash., IV, No. 3 (issued May 24, 1899), pp. 300-302.

— Descriptions of the larvæ of fifty North American Noctuidæ.

Proc. Ent. Soc. Wash., IV, No. 3 (issued May 24, 1899), pp. 315-332.

Contains also a synoptic table for the forms described in this paper.

— Larvæ of Xyelidæ.

Canadian Entomologist, XXXI, No. 5, May, 1899, p. 127.

Note in reply to F. W. Konow.

— A new Cossid from Texas.

Entomological News, X, No. 5, May, 1899, p. 129.

Describes *Inguromorpha arbeloides*.

— Notes on Alaskan Arctiidæ.

Entomological News, X, No. 5, May, 1899, pp. 130, 131.

Contains a description of a new species, *Hypophora subnubulosa*.

— A new Lithosian.

Psyche, VIII, No. 277, May, 1899, pp. 359, 360.

Describes *Ozodania schwarzi*, new genus and species.

— The phylogeny of the Lasiocampids.

Entomologist's Record and Journal of Variation, XI, No. 6, June 1, 1899, pp. 141, 142, pl. 1.

— *Spilosoma congrua* Walker.

Canadian Entomologist, XXXI, No. 6, June, 1899, pp. 155, 156.

Note in reply to Rev. T. W. Fyles.

DYAR, H. G. (See also under JOHN B. SMITH.)

EAKLE, ARTHUR S. Topaz crystals in the mineral collection of the U. S. National Museum.

Proc. U. S. Nat. Mus., XXI, No. 1148, Nov. 10, 1898, pp. 361-369, figs. 1-22.

EVERMANN, BARTON W. (See under DAVID S. JORDAN.)

GILBERT, CHARLES H. On the occurrence of *Caulolepis longidens* Gill, on the coast of California.

Proc. U. S. Nat. Mus., XXI, No. 1161, Nov. 21, 1898, pp. 565, 566.

GILL, THEODORE N. The determinants for the major classification of fish-like vertebrates.

Rep. Brit. Assoc. Adv. Sci., 1897 (1898), p. 696, 697.

Nine classes of vertebrates are recognized, of which five have been confounded under the designation of "fishes"—the Leptocardiæ, Marsipobranchs, Ostracophores, Selachians, and Teleostomes. "The gaps between the lower classes are very great. The least differences between the Selachians and Teleostomes are manifest in the Xenacanthini and Dipnoi of the Palæozoic; the least differences between the Teleostomes and Amphibians in the Crossopterygians and Stegocephals."

— On the derivation of the pectoral member in terrestrial vertebrates.

Rep. Brit. Assoc. Adv. Sci., 1897 (1898), p. 697.

The most important hint respecting the origin of the chiropterygium is furnished by *Polypterus*. "The chief objection to the derivation of the chiropterygium from the pectoral member of such a form as *Polypterus* is that at present no extinct representatives are known. Probably future research will reveal such, as the genus belongs to a very archaic type."

— Some questions of nomenclature.

Ann. Rep. Smithsonian Inst., 1896 (Nov. 19, 1898), pp. 457-483.

A republication, with corrections of former typographical errors, of the address as vice-president of section F (Zoology) at the Buffalo meeting of the American Association for the Advancement of Science, August, 1896. It also contains an additional note on Lang's "Methodus nova Testacea—distribuendi," 1722.

After an "introduction" (p. 457), the author treats of the "commencement of binomial nomenclature" (p. 459), "trivial names" (p. 461), "draconian laws" (p. 462), "misapplied names" (p. 465), "double names" or tautonyms (p. 468), "variants and similarity of names" (p. 469), "making of names" (p. 471), "typonyms" (p. 474), "choice of names simultaneously published" (p. 475), "major groups and their nomenclature" (p. 475), "family" (p. 478), "superfamily" (p. 481), "other groups" (p. 482), and "complaints of instability of nomenclature" (p. 482).

GILL, THEODORE N.—Continued.

— The tailless batrachians of Europe.

Science (new series), VIII, Dec. 30, 1898, pp. 932-938, with 13 figs.

A review of "The Tailless Batrachians of Europe, by G. A. Boulenger, F. R. S." The work is highly commended and the illustrations borrowed from it.

A comparison is instituted between the European and North American batrachians. Dissent is expressed from previous investigators respecting the affinities of *Scaphiopus*. The families Pelobatidae and Scaphiopidae of Cope are declared to be inseparable.

"Further, examination of the skeletons of *Pelodytes*, *Pelobates*, and *Scaphiopus* should convince a competent observer that the differences between *Pelobates* and *Pelodytes* are much less than those between *Pelobates* and *Scaphiopus*;" in fine, "if the family is to be divided, the two European genera should be combined and contrasted with the American." It is further urged that an arrangement of the phaneroglossate forms into three superfamilies of which the arciferous family of Discoglossids is the most generalized, may be more acceptable to some; the superfamilies are Discoglossoidae, Bufonoidae, and Ranoidae.

—The generic names *Pediocetes* and *Poocetes*.

Auk, XVI, Jan., 1899, pp. 20-23.

Pediocetes and *Poocetes* are formed on the model of *Ammocetes*, a misspelling of *Ammocetes* by Baird. The same author, however, substituted for them and first published *Pediocetes* and *Poocetes*, and those should be adopted. *Poocetes graminea affinis* is a new combination.

— Suggestions for a new history of North American birds.

Osprey, III, Feb., 1899, pp. 88-94.

The suggestions are arranged under the following headings: Our predecessors; deficiencies [of previous works]; a new work timely; desirability of generalized biographies; proposals for publication; classification to be adopted; avine orders; natural selection among birds; oscine families; subspecies; extra-limital species; synonymy; sequence of data; general; historical; who shall write?

— Concerning Dr. Gill's proposed history.

Osprey, III, Mar., 1899, p. 137.

A letter to the editor of the *Osprey*, inclosing letters to the writer, with comments.

— Relative value of the different groups of animals from the faunistic standpoint.

Proc. Ent. Soc. Wash., IV, May 24, 1899, p. 194.

Report of remarks at meeting of May 13, 1897.

GILL, THEODORE N.—Continued.

— Larval stage of the eel.

Science (new series), IX, June 9, 1899, p. 820.

It is deduced that "Inasmuch as (1) the sea-going eels do not mature their ova till the winter season, (2) the leptocephalus young are found from February to September, or later, and (3) the transitional form between the leptocephalus stage and the cylindrical stage has been found in January, it appears tolerably certain that the elvers which ascend the rivers in the early spring are the progeny of eels that descended therefrom *not later* than winter of the penultimate (and not last) season."

— The longevity of birds and other vertebrates.

Osprey, III, June, 1899, pp. 157-160.

Comments on Mr. J. H. Gurney's article "On the comparative ages to which birds live," with remarks on the conclusions of previous writers, and generalizations respecting relation of growth to duration of life in mammals, birds, and fishes.

— (Editor) Report, in part, of Samuel Mitchell, M. D., professor of natural history, etc., on the fishes of New York. Washington: Printed for the editor.

Svo, pp. i-x, 1-30.—Published Dec. 7, 1898.

The editor remarks: "One of the rarest of American contributions to ichthyology is a little work published in 1814—to be very precise, published 'January 1, 1814'—on the fishes of New York; in brief, the 'Report, in part, of Samuel L. Mitchell, M. D., professor of natural history, etc., on the fishes of New York.' The only copies of whose existence in the United States the editor was able to learn are three. It contains original and detailed descriptions of 49 species, with a simple catalogue of 21 more." Thirty-eight are described or designated as new and 12 were really so at the time. Four genera also are designated as new and 3 have been adopted by recent authors.

A small edition has been published with a historical and critical introduction and identification of the species, as well as a concordance of names with those by which the species are known at the present day.

GOODE, G. BROWN.¹ Report upon the condition and progress of the U. S. National Museum during the year ending June 30, 1896.

Rep. Smithsonian Inst. (U. S. Nat. Mus.), 1896 (1899), pp. 1-284, pls. 1-4.

GRINNELL, JOSEPH. Geographical races of *Harporyhnchus redivivus*.

Auk, xv, No. 3, July, 1898, pp. 236, 237.

¹ Died September 6, 1896.

GRINNELL, JOSEPH—Continued.

Harporyhynchus vellicivus paradensis is described as new. Based partly upon Museum material.

— The San Nicolas Rock Wren.

Auk, xv, No. 3, July, 1898, pp. 237-239.

Salpinctes obsoletus pulverinus is described as new. Based partly upon Museum material.

HAY, OLIVER P. On *Protostega*, the systematic position of *Dermochelys*, and the morphogeny of the Chelonian carapace and plastron.

Am. Naturalist, xxxii, Dec., 1898, pp. 929-948.

Observations on a young specimen of *Dermochelys* in the National Museum.

HAY, W. P. Description of a new species of subterranean isopod.

Proc. U. S. Nat. Mus., xxi, No. 1176, June 1, 1899, pp. 871, 872, pl. LXXXVI.

This species, *Haplophthalmus puteus*, was obtained from an old well in Irvington, Ind. It is related to *H. mengii* (Zaddach) and *H. danicus* Budde-Lund.

HENDERSON, L. F. Two new species of plants from the Northwestern States.

Contrib. U. S. Nat. Herbarium, v, No. 4, Oct., 1899, pp. 201, 202.

HILL, R. T., and VAUGHAN, T. WAYLAND. The Lower Cretaceous Gryphaeas of the Texas region.

Bull. U. S. Geol. Surv., No. 151, 1898, pp. 1-139, pls. 1-35.

This work treats in great detail the Texan Gryphaeas and the very intricate synonymy. The material is nearly all in the U. S. National Museum.

HOUGH, WALTER. Korean clan organization.

Am. Anthropologist (new series), i, No. 1, Jan., 1899, pp. 150-154.

An account of the interesting clan or family organization of Korea which has survived to the present day, paralleling the present governmental system. This paper grew out of the labeling of Korean specimens in the Museum by Mr. Kiu Beung Surh.

— The lamp of the Eskimo.

Rep. Smithsonian Inst. (U. S. Nat. Mus.), 1896 (1899), pp. 1025-1057, pls. 1-24, figs. 1-4.

A monograph of the lamps of the Eskimo area, showing distribution of forms, local modifications, effect of latitude, uses, and illuminants; also the bearing of the lamp on the social life, art, and religion of the Eskimo.

HOWARD, LELAND O. Remedial work against the Mexican Cotton-boll Weevil.

Circ. Div. Ent., U. S. Dept. Agric. (second series), No. 33, July 15, 1898, pp. 1-6.

An account of the latest and best measures to be used against *Anthonomus grandis*.

— House flies (*Musca domestica* et al.).

Circ. Div. Ent., U. S. Dept. Agric. (second series), No. 35, July 18, 1898, pp. 1-8, figs. 1-6.

An account of the habits and life histories and the remedies to be used against several dipterous insects found in houses.

— International relations disturbed by an insect.

Forum, July, 1898, pp. 569-573.

An account of international restrictions to prevent the spread of the San Jose scale, with a plea for scientific representation of the United States at foreign capitals.

— On some new parasitic insects of the family Encyrtinae.

Proc. U. S. Nat. Mus., xxi, No. 1142, Oct. 4, 1898, pp. 231-248.

Descriptions of ten new genera and thirty-four new species, together with a synoptic table of the species of the genus *Aphyus*.

— Two beneficial insects introduced from Europe.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 17, Dec. 1, 1898, pp. 13-16, figs. 1, 2.

Notes on *Scutellista cyanea* Mots., and *Habrolepis dalmatini* Westw.

— Notes on house flies and mosquitoes.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 17, Dec. 1, 1898, pp. 55, 55.

Author's abstract, treating especially of the use of permanganate of potash against mosquitoes, indicating its uselessness in spite of frequent recommendations.

— *Pulvinaria acericola* (W. & R.) and *P. innumerabilis* Rathv.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 17, Dec. 1, 1898, pp. 57, 58, 1 fig.

Giving evidence that these species, of which the first was considered a synonym of the second, are in reality distinct, and that the name *Pulvinaria acericola* (W. & R.) must hold.

— (Editor) Proceedings of the American Association for the Advancement of Science, forty-seventh meeting and fiftieth anniversary, held at Boston, 1898.

Salem, Dec. 18, 1898, pp. 1-658, 7 pls. and 18 figs.

HOWARD, LELAND O.—Continued.

— Report of the Entomologist for 1898.

Rep. Secy. Agric., 1898, pp. 17–25.

An executive report of the work of the Division of Entomology of the U. S. Department of Agriculture. Published also in separate form.

— The San José scale on dried fruit.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, 1898 (Jan. 6, 1899), pp. 7–13.

An account of a series of experiments made upon different varieties of fruit dried by different commercial methods. It was found that these methods invariably result in the death of the scale, and that therefore European restrictions on the importation of American dried fruit are uncalled for.

— The work of *Icerya purchasi* in Portugal, with an account of the introduction from America of *Novius cardinalis*.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, 1898 (Jan. 6, 1899), pp. 30–35.

An account of the introduction of *Icerya purchasi* into Portugal, with a statement of its damage and of the result of the sending *Novius cardinalis* from America, which at the time of writing appeared to promise the almost entire extermination of the *Icerya*.

— Cotton-field insects.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, 1898 (Jan. 6, 1899), pp. 85–89.

A list of insects collected in a cotton field at Victoria, Texas, by the Hon. J. D. Mitchell. The specimens were obtained by means of a trap lantern on a single night in October.

— General notes and notes from correspondence.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, 1898 (Jan. 6, 1899), pp. 89–101.

A number of unsigned notes.

— An insect breeding in crude petroleum.

Sci. Amer., LXXX, No. 5, Feb. 4, 1899, pp. 75, 76, 1 fig.

An account of *Psilopa petrolei* Coq., which breeds in crude petroleum pools in the vicinity of Los Angeles, California.

Reprinted in the *Pharmaceutical Era*, Mar. 2, 1899.

— The economic status of insects as a class.

Science, IX, No. 216 (new series), Feb. 17, 1899, pp. 233–247.

Address of the retiring president of the Biological Society of Washington, delivered Jan. 18, 1899.

Reprinted in the *Scientific American Supplement*, Nos. 1209, 1210, Mar., 1899.

HOWARD, LELAND O.—Continued.

— *Allorhina* as a fruit pest.

Entomological News, No. 3, Mar., 1899, p. 71.

— The odor of Coccidæ.

Canadian Entomologist, XXXI, No. 4, April, 1899, p. 96.

— The principal insects affecting the tobacco plant.

Yearbook U. S. Dept. Agric., 1898 (issued May 15, 1899), pp. 121–150, figs. 7–31.

An account of the life histories and habits of the principal tobacco insects of the United States, with data concerning the remedies used.

Author's extras of this paper were issued May 20, 1899.

— A dipterous parasite of *Lachnosterna*.

Proc. Ent. Soc. Wash., IV, No. 3, May 24, 1899, pp. 198, 199.

An account of undescribed dipterous eggs found upon the thorax of *Lachnosterna* in Greene County, N. Y.

— The Thomson-Mayr priority question settled.

Proc. Ent. Soc. Wash., IV, No. 3, May 24, 1899, pp. 207, 208.

Showing that the encyrtine genera of Gustav Mayr take priority over those of C. G. Thomson.

— Butterflies attracted to light at night.

Proc. Ent. Soc. Wash., IV, No. 3, May 24, 1899, pp. 333, 334.

An account of instances on record. *Pholisora catullus* is added to the list of species previously recorded.

— Notes on *Rasahus thoracicus*, *Xylocopa cubæcola*, and *Dichelonychia fulgida*.

Proc. Ent. Soc. Wash., IV, No. 3, May 24, 1899, p. 335.

— The extermination of the mosquito.

Sci. Am. Suppl., XLXII, No. 1222, June 3, 1899, p. 19593.

Exposes the so-called permanganate of potash remedy.

— Pests of the hop crop.

The Hop, its Culture, Care, Marketing, and Manufacture. By Herbert Myrick. Orange Judd Co., 1899, pp. 113–141, figs. 55–72.

An account of the habits and life histories of and remedies to be used against the insects which affect the hop plant in the United States.

Author's extras of this article were distributed June 21, 1899.

JORDAN, DAVID STARR, and EVERMANN, BARTON W. Smithsonian In-

JORDAN, DAVID STARR, and EVERMANN, BARTON W.—Continued.

stitution. | United States National Museum. | — | Bulletin | of the | United States National Museum. | No. 47. | — | The Fishes | of | North and Middle America: | A descriptive catalogue of the species of fish-like vertebrates found in | the waters of North America north of the Isthmus of Panama. | By | David Starr Jordan, Ph. D., | President of the Leland Stanford Junior University and of the | California Academy of Sciences, | and | Barton Warren Evermann, Ph. D., | Ichthyologist of the United States Fish Commission. | Part II. | Washington: | Government Printing Office. | 1898.

8vo., pp. I-XXX, 1241-2183.

— Smithsonian Institution. | United States National Museum. | — | Bulletin | of the | United States National Museum. | No. 47. | — | The Fishes | of | North and Middle America: | A descriptive catalogue of the species of fish-like vertebrates found in | the waters of North America north of the Isthmus of Panama. | By | David Starr Jordan, Ph. D., | President of the Leland Stanford Junior University and of the | California Academy of Sciences, | and | Barton Warren Evermann, Ph. D., | Ichthyologist of the United States Fish Commission. | Part III. | Washington: | Government Printing Office. | 1898.

8vo., pp. I-XXIV, 2184-3136.

KNOWLTON, FRANK HALL. In a coal swamp.

Plant World, III, Nov., 1898, pp. 21-23, 1 pl.

This paper contains a general account of the production of coal.

— The fossil plants of the Payette formation.

18th Ann. Rep. U. S. Geol. Surv., 1896-97 (1898), Part III, pp. 721-744, 4 pls.

In this paper, which is based upon material eventually to be transmitted to the U. S. National Museum, 32 forms are enumerated, of which 17 are described as new. They are from five localities in Boise County, Idaho, and are said to be of Upper Miocene age. The relationship of the flora to that of Bridge Creek and John Day Valley, Oregon, is pointed out.

KNOWLTON, FRANK HALL—Cont'd.

— A catalogue of the Cretaceous and Tertiary plants of North America.

Bull. U. S. Geol. Surv., No. 152, 1898, pp. 1-247.

This catalogue is arranged in alphabetical sequence. A bibliography, consisting of a list of the works and papers used in preparing the catalogue, is included.

LINELL, MARTIN L.¹ On the coleopterous insects of the Galapagos Islands.

Proc. U. S. Nat. Mus., XXI, Oct. 4, 1898, No. 1143, pp. 249-268.

Gives a list of the insects found on the Galapagos Islands and describes one genus and 14 species as new. Descriptions of two allied species from Brazil are included.

— Descriptions of some new species of North American heteromorous Coleoptera.

Proc. Ent. Soc. Wash., IV, No. 3 (issued May 24, 1899), pp. 180-185.

Describes 8 new species.

LINELL, MARTIN L., and SCHWARZ, EUGENE A. [Coleoptera.]

Report of Fur Seal Investigations 1896-1897,

Part IV, 1898, Appendix I, pp. 328-336.

Included in "Reports upon the insects, spiders, mites, and myriapods collected by Dr. L. Stejneger and Mr. G. E. H. Barrett-Hamilton on the Commander Islands," edited by W. H. Ashmead. Gives a list, with notes, of 48 Coleoptera.

LORD, EDWIN C. E. On the dikes in the vicinity of Portland, Me.

Am. Geologist, XXII, Dec., 1898, pp. 335, 336, 1 map.

Describes the petrographic nature of the rocks in the region noted. The work was done in the laboratory of the Division of Geology, and a type series of the rocks studied remains in the Museum.

— Petrographic report on rocks from the United States-Mexico boundary.

Proc. U. S. Nat. Mus., XXI, No. 1173, May 22, 1899, pp. 773-782, pl. 85.

Gives a description of the rocks collected by Dr. E. A. Mearns, while connected with the International Boundary Commission, and deposited by him in the National Museum.

LUCAS, FREDERIC AUGUSTUS. Contributions to Paleontology.

Am. Journ. Sci., VI, Nov., 1898 (article XXXIX), pp. 399, 400.

(1) A new crocodile from the Trias of southern Utah, to which the name *Heterodontosuchus ganei* is given. (2) A new species of *Dinictis* (*D. major*). The types are in the U. S. National Museum.

¹ Mr. Linell died May 3, 1897, and the papers here cited are posthumous.

LUCAS, FREDERIC AUGUSTUS—Cont'd.

— A new snake from the Eocene of Alabama.

Proc. U. S. Nat. Mus., XXI, No. 1164, Dec. 20, 1898, pp. 637, 638, pls. XLV, XLVI.

Describes a large snake found associated with remains of *Zenagodon* for which the name *Pterosphenus schucherti* is proposed.

— *Theragra* Lucas, a new genus.

Bull. U. S. Nat. Mus., No. 47, Part III, 1898, p. 2535.

Gives a diagnosis of the genus of which the Alaskan Pollack, *Theragra chalcogramma*, is the type. The description is included in Jordan and Evermann's "Fishes of North and Middle America," published as Bulletin 47 of the National Museum.

— The characters of *Bison occidentalis*, the Fossil Bison of Kansas and Alaska.

Kansas Univ. Quarterly, VIII, No. 1, Jan., 1899 (Series A), pp. 17, 18, pls. VIII, IX.

Describes this new species and contrasts it with *Bison antiquus*.

— The nomenclature of the hyoid in birds.

Science (new series), IX, No. 218, Mar. 3, 1899, pp. 223-234, 1 fig.

Calls attention to the discrepancies in naming the component parts of the hyoid and suggests the correct names for them.

— The Fossil Bison of North America.

Proc. U. S. Nat. Mus., XXI, No. 1172, May 13, 1899, pp. 755-771, pls. LXV-LXXXIV, figs. 1, 2.

Describes and figures the various species of North American fossil bison and gives synonymy.

The species recognized are *Bison alleni*, *antiquus*, *bison*, *crassicornis*, *ferox*, *latifrons*, and *occidentalis*. This paper is based largely upon material belonging to other institutions.

MCGREGOR, RICHARD C. Description of a new *Ammodramus* from Lower California.

Auk, xv, No. 3, July, 1898, pp. 265-267.

Ammodramus halophilus is here described. Based partly upon Museum material.

MARK, E. L. Reports on the dredging operations off the west coast of Central America to the Galapagos, to the west coast of Mexico, and in the Gulf of California, in charge of Alexander Agassiz, carried on by the U. S. Fish Commission steamer *Albatross* during 1891, Lieut. Commander Z. L. Tanner, U. S. N., commanding. XXIV.—Pre-

MARK, E. L.—Continued.

liminary report on *Branchiocerianthus urceolus*, a new type of actinian.

Bull. Mus. Comp. Zool. Harv. Coll., XXXII, No. 8, Aug., 1898, pp. 147-154, pls. 1-3.

In general appearance this form resembles *Cerianthus*, but differs from it in important points and may be the type of a new family. It exhibits a pronounced bilateral symmetry and an incomplete circle of branching gill-like organs.

The specimens were taken in the Gulf of Panama in 286 and 210 fathoms.

MARLATT, CHARLES L. House ants.

Circ. Div. Ent., U. S. Dept. Agric. (second series), No. 34, July, 1898, p. 4, 3 figs.

Gives the life habits and remedies for three common species.

— The true Clothes Moth.

Circ. Div. Ent., U. S. Dept. Agric. (second series), No. 36, Aug., 1898, pp. 1-2, 3 figs.

A full account of three species.

— Japanese Hymenoptera of the family Tenthredinidae.

Proc. U. S. Nat. Mus., XXI, No. 1157, Nov. 21, 1898, pp. 493-506.

Includes the description of 26 new species of sawflies, with a list of additional species based on material presented to the National Museum by Dr. K. Mitsukuri, of the Imperial University, Tokyo, Japan.

— Notes on insecticides.

Bull. Ent. Div., U. S. Dept. Agric. (new series), No. 17, Nov., 1898, pp. 94-98.

Presents the result of experimental work with kerosene, fish-oil soaps, and arsenicals. In the case of the latter particular attention is called to the superior value of arsenite of copper over paris green.

— Some new Nematids.

Canadian Entomologist, xxx, No. 12, Dec., 1898, pp. 302-304.

Describes the following new species: *Protania consors*, *P. borealis*, and *Pteronius carpini*; describes also the male of the two following species: *Pteronius quercus* and *Nematus chlorcus*.

— A new nomenclature of the broods of the Periodical Cicada.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, 1898, pp. 52-58.

Gives a review of the nomenclature adopted at different times for the Periodical Cicada, and points out the inappropriateness of the system in common use; suggests a renumbering of the broods, to show the relationship of the broods to each other, in both the seventeen and the thirteen-year race. The relationship sustained between the different broods

MARLATT, CHARLES L.—Continued.

of both races is indicated, and three new seventeen-year and three new thirteen-year broods are designated.

- A consideration of the validity of the old records bearing on the distribution of the broods of the Periodical Cicada, with particular reference to the occurrence of broods VI and XXIII in 1898.

Bull. Div. Ent., U. S. Dept. Agric. (new series), No. 18, 1898, pp. 59-78.

Points out the sources of error in the old records, describes the work undertaken in the case of broods XXIII and VI in 1898, and concludes with a list, by States and Counties, of the occurrence of these broods in the year named. The author also gives a list of the persons reporting on these broods, with an indication of the nature of the report received.

- An investigation of applied entomology in the Old World.

Proc. Ent. Soc. Wash., IV, No. 3 (issued May 24, 1899), pp. 265-291.

Summarizes the writer's experience in the course of several months' investigation of the practical work in entomology in various European States.

- Fitch's Cotton Scale Insect.

Entomological News, x, No. 5, May, 1899, p. 146.

Discusses the scale insect described by Dr. Fitch as *Aspidiotus gossypii*, and shows from examination of the original specimen received from China that it is not an *Aspidiotus* at all, but an *Aleurodes*. The literature of the subject is discussed.

- Some sources of error in recent work on Coccidæ.

Science (new series), x, June 16, 1899, p. 835.

Points out various characters in scale insects, particularly the Diaspinæ, which have mistakenly been made the basis of new species and varieties.

MASON, OTIS TUFTON. Aboriginal American zoötechny.

Am. Anthropologist (new series), I, No. 1, Jan., 1899, pp. 45-81, pls. 4.

A study of the aboriginal industries associated with the animal kingdom on the American continent before its discovery by the whites. In a word, aboriginal American zoötechny embraces every phase of Indian life growing out of the connection between man and the beasts of the Western Hemisphere in pre-Columbian times.

MEARNS, EDGAR A. Descriptions of two new birds from the Santa Barbara Islands, Southern California.

Auk, xv, No. 3, July, 1898, pp. 258-261.

Curpodacus clementis and *Lanius ludovicianus anthonyi* are described.

- Notes on the mammals of the Catskill Mountains, New York, with general remarks on the fauna and flora of the region.

Proc. U. S. Nat. Mus., XXI, No. 1147, Nov. 4, 1898, pp. 341-360, figs. 1-6.

MERRILL, GEORGE PERKINS. A trip across Lower California.

Osprey, III, Oct., 1898, pp. 20-25, pls. 1-5.

A popular review of an article on the "Geology and natural history of Lower California," published in the Annual Report of the U. S. National Museum for 1895.

- Some little-known American ornamental stones.

Am. Architect and Building News, LXII, Dec. 10, 1898.

A paper read before the thirty-second annual convention of the American Institute of Architects, Washington, October, 1898. The paper was also printed in abstract in other journals.

- Description of residual rocks and desert varnish. (Educational series of rocks.)

Bull. U. S. Geol. Surv., No. 150, 1898, pp. 376-385 and 389-391.

Describes, microscopically and chemically, residual sand from granite (District of Columbia), and from diabase (Medford, Mass.); residual clay from feldspathic rock (Hockessin, Del.), and from limestone (Virginia). The brown coating on quartzite pebbles, called "desert varnish," from the Tooele Valley, Utah, is also described.

- The physical, chemical, and economic properties of building stones.

Rep. Geol. Surv. of Maryland, II, Part II, 1898, pp. 39-123.

The article forms the introductory chapter to a general report on the "Building and decorative stones of Maryland, containing an account of their properties and distribution," by George P. Merrill and Edward B. Matthews.

- Marbles and granites.¹

Nature and Art Mag., I, No. 4, May, 1898, pp. 125-129.

A popular article for general readers.

¹Omitted from the bibliography of the last fiscal year.

MILLER, GERRIT S., Jr. List of bats collected by Dr. W. L. Abbott in Siam.

Proc. Acad. Nat. Sci. Phila., July 25, 1898, pp. 316-325.

Enumeration of 9 species from the province of Trong. *Cynopterus angulatus*, *Kerivoula minuta*, and *Emballonura peninsularis* are new to science.

— Descriptions of five new Phyllostome bats.

Proc. Acad. Nat. Sci. Phila., July 25, 1898, pp. 326-337, figs. 1-5.

Based in part on material belonging to the Institute of Jamaica and to Mr. Outram Bangs. *Chilonatalus*, subgen. nov.; *Reithronycteris*, gen. nov.; *Natalus brevimanus*, sp. nov.; *Micronycteris microtis*, sp. nov.; *Glossophaga longirostris*, sp. nov.; *Reithronycteris aphylla*, sp. nov., and *Micronycteris megalotis mexicanus*, subsp. nov., are described.

— A new chipmunk from Northeastern China.

Proc. Acad. Nat. Sci. Phila., Aug. 1, 1898, pp. 348-350.

Based in part on material belonging to the Academy of Natural Sciences, Philadelphia. *Eutamias senescens*, sp. nov., is described.

— Description of a new bat from Lower California.

Ann. and Mag. Nat. Hist. (7), II, Aug., 1898, pp. 124-125.

Based chiefly on material belonging to the British Museum. *Myotis peninsularis*, sp. nov., is described.

— Notes on the Arctic Red-backed Mice.

Proc. Acad. Nat. Sci. Phila., Oct. 11, 1898, pp. 358-367, figs. 1, 2.

Evotomys wosnessenskii (Polyakoff) and *E. alascensis*, sp. nov., are recognized as distinct from *E. rutilus*.

— Description of a new genus and species of Microtine rodent from Siberia.

Proc. Acad. Nat. Sci. Phila., Oct. 11, 1898, pp. 368-371, figs. 1-4.

Aschiomys lemminus, gen. et. sp. nov., is described.

— Notes on the Naked-tailed Armadillos.

Proc. Biol. Soc. Wash., XIII, Jan. 31, 1899, pp. 1-8, figs. 1, 2.

Based in part on material belonging to the Academy of Natural Sciences of Philadelphia, the American Museum of Natural History, and Mr. Outram Bangs.

The name *Tatoua* is substituted for *Xenurus*

MILLER, GERRIT S., Jr.—Continued.

(preoccupied); Gray's genus *Ziphila* is recognized as a subgenus, and *Tatoua centralis*, sp. nov., is described.

— Description of a new vole from Eastern Siberia.

Proc. Biol. Soc. Wash., XIII, Jan. 31, 1899, pp. 11, 12.

Microtus tschuktshorum, sp. nov., is described.

— A new vole from Hall Island, Bering Sea.

Proc. Biol. Soc. Wash., XIII, Jan. 31, 1899, pp. 13, 14.

Microtus abbreviatus, sp. nov., is described.

— Two new Glossophagine bats from the West Indies.

Proc. Biol. Soc. Wash., XIII, May 29, 1899, pp. 33-37.

Based in part on material belonging to the American Museum of Natural History. *Phyllonycteris planifrons*, sp. nov., and *P. bombifrons*, sp. nov., are described.

— A new polar hare from Labrador.

Proc. Biol. Soc. Wash., XIII, May 29, 1899, pp. 39, 40.

Based in part on material belonging to Mr. Outram Bangs. *Lepus labradorius*, sp. nov., is described.

— A new fossil bear from Ohio.

Proc. Biol. Soc. Wash., XIII, May 29, 1899, pp. 53-56.

Ursus procerus, sp. nov., is described.

— A new moose from Alaska.

Proc. Biol. Soc. Wash., XIII, May 29, 1899, pp. 57-59.

Alces gigas, sp. nov., is described.

MONTGOMERY, THOMAS H. The Gordiacea of certain American collections, with particular reference to the North American fauna.

Bull. Mus. Comp. Zool. Harv. Coll., XXXII, No. 3, April, 1898, pp. 23-59, pls. 1-15.

A historical review of previous researches on American species is followed by the systematic portion of the paper. Seventeen forms are described, among which are 1 new genus, 10 new species, and 1 new subspecies. In an appendix, additions to the bibliography are given.

MOORE, J. PERCY. The leeches of the U. S. National Museum.

Proc. U. S. Nat. Mus., XXI, No. 1160, Nov. 21, 1898, pp. 543-563, pl. XI.

The systematic portion of the paper is prefaced by a discussion of the annulation of the somite.

Twenty-nine species (6 of them new) are

MOORE, J. PERCY—Continued.

enumerated. They are referred to 15 genera, 1 of which is new. The material comes from different parts of the world.

MURDOCH, JOHN. A historical notice of Ross's Rosy Gull (*Rhodostethia rosea*).

Auk, XVI, No. 2, Apr., 1899, pp. 146-155.
An exhaustive history of the species.

NELSON, E. W. Descriptions of new birds from Mexico.

Auk, XVI, No. 1, Jan., 1899, p. 25.

The following species and subspecies are described as new: *Colinus virginianus maculatus*, *Callipepla gambeli fulvipes*, *Aphelocoma sieberi colinae*, *A. s. potosina*, *Pachyrhamphus major uropygialis*, *Melospiza adusta*, *Melospiza goldmani*, *Spizella socialis mexicana*, *Vireo noveboracensis micrus*, and *Geothlypis flaviceps*.

— Descriptions of new birds from northwestern Mexico.

Proc. Biol. Soc. Wash., XIII, May 29, 1899, pp. 25-31.

Twelve species and subspecies of birds are described as new, viz: *Amazona albifrons saltuensis*, *Anthus goldmani*, *Aphelocoma grisea*, *Pipilo fuscus intermedius*, *Cardinalis cardinalis affinis*, *C. c. sinuatus*, *Arremonops superciliosa sinuata*, *Basileuterus rufifrons caudatus*, *Thryothorus felix pallidus*, *Helodytes stridulus*, *Myadestes obscurus cinereus*, and *Catharus olivaceus*.

NEWBERRY, JOHN STRONG. The later extinct floras of North America. A posthumous work edited by Arthur Hollick.

Monograph U. S. Geol. Surv., XXXV, 1898, pp. 1-17, 1-295, pls. 1-68.

This is mainly a description of specimens originally illustrated and published without text, in 1876, under the title "Illustrations of Cretaceous and Tertiary plants of the Western Territories of the United States," a revised edition of which (with 43 additional plates) was published subsequently, but withheld from distribution.

NUTTING, CHARLES CLEVELAND. Hydroids from Alaska and Puget Sound.

Proc. U. S. Nat. Mus., XXI, No. 1171, Apr. 29, 1899, pp. 741-753, pls. LXII-LXIV.

A considerable proportion of the material upon which this paper is based was collected by the Young Naturalists' Society in connection with the University of Washington, which organized a dredging expedition in Puget Sound in the summer of 1895.

A table of the distribution of the 17 species in the collection previously described is followed by descriptions of 5 new species, and notes on 2 known species.

OBERHOLSER, HARRY C. Description of a new North American thrush.

Auk, xv, No. 4, Oct., 1898, pp. 303-306.

Hylocichla ustulata alma, a new subspecies, is described.

— A revision of the wrens of the genus *Thryomanes* Sclater.

Proc. U. S. Nat. Mus., XXI, No. 1153, Nov. 19, 1898, pp. 421-450.

— Description of a new *Hylocichla*.

Auk, XVI, No. 1, Jan., 1899, pp. 23-25.

Hylocichla ustulata adica is described as new.

— A synopsis of the Blue Honey-Creepers of Tropical America.

Auk, XVI, No. 1, Jan., 1899, pp. 31-35.

A list of the forms of Blue Honey-creepers is given, together with their synonymy and correct names.

Cyanerpes is proposed as a new term in place of *Arbclorhina*.

OSGOOD, WILFRED H. *Chama fasciata* and its subspecies.

Proc. Biol. Soc. Wash., XIII, May 29, 1899, pp. 41, 42.

The Wren-tits are found to belong to two forms, one of which is here named *Chama fasciata phæa*.

The form formerly described as *C. f. hen-shawi* is here shown to be true *fasciata*, or so near it as to be inseparable.

PALMER, WILLIAM. Our small eastern shrikes.

Auk, xv, No. 3, July, 1898, pp. 244-258.

A review of the small shrikes of eastern North America. *Lanius ludovicianus migrans* is described as a new subspecies. Based largely upon Museum material.

POLLARD, CHARLES LOUIS. Further observations on the eastern acaulescent violets.

Botan. Gazette (V), XXVI, No. 5, Nov., 1898, pp. 325-342, 1 fig.

A synopsis of the various species of this group, with a key and full bibliography. One new species, *Viola insignis*, is described and figured with a text cut, also a new variety of *V. primulaefolia* (var. *australis*). *V. communis* is proposed as a new name for the plant variously known as *V. obliqua* and *V. cucullata*, which are known to be distinct species.

RANKIN, W. M. The Northrop collection of Crustacea from the Bahamas.

Annals N. Y. Acad. Sci., XI, No. 12, Aug., 1898, pp. 225-254, pls. XXIX, XXX.

One new species, *Uca leptodactyla* (Guérin MS.), included by Mr. Rankin in his list, was

RANKIN, W. M.—Continued.

described by Miss M. J. Rathbun, and the type specimens are in the National Museum.

RATHBUN, MARY J. A contribution to a knowledge of the fresh-water crabs of America. The Pseudothelphusinae.

Proc. U. S. Nat. Mus., XXI, No. 1158, Nov. 21, 1898, pp. 507-537, text figs. 1-18.

The first part of this paper is devoted to a description of the subfamily, genera, and new species, with analytical keys. Four genera and 52 species are recognized, of which 17 species are new. The second part deals with the distribution of genera and species.

— The Brachyura collected by the U. S. Fish Commission steamer *Albatross* on the voyage from Norfolk, Va., to San Francisco, Cal., 1887-88.

Proc. U. S. Nat. Mus., XXI, No. 1162, Nov. 22, 1898, pp. 567-616, pls. XLI-XLIV.

The collections made on this cruise were obtained in the West Indies, on the coast of South America, and the west coast of Mexico.

The Brachyura number 151 species, of which 31 are new. The new forms are chiefly from the shores of Lower California. Nearly all of them are figured.

— Notes on the Crustacea of the Tres Marias Islands.

North Am. Fauna (U. S. Dept. Agric.), No. 14, Apr. 29, 1899, pp. 73-75.

These notes are part of a report on the natural history of the Tres Marias Islands, based on explorations made by E. W. Nelson and E. A. Goldman.

Four species of Crustacea were taken, viz: *Gecarcinus digueti* Bouvier, *Oecypode occidentalis* Stimpson, *Grapsus grapsus* (Linnaeus), and *Bithynis jamaicensis* (Herbst).

RICHARDSON, HARRIET. Key to the isopods of the Pacific coast of North America, with descriptions of 22 new species.

Proc. U. S. Nat. Mus., XXI, No. 1175, June 5, 1899, pp. 815-869, figs. 1-34.

The isopods of the Pacific coast of North America are distributed into 16 families, 44 genera, and 97 species. Keys are given to the families, genera, and species. Twenty-two new species are described and figured.

RICHMOND, CHARLES W. Description of a new species of *Gymnostinops*.

Auk, xv, No. 4, Oct., 1898, pp. 326, 327. *Gymnostinops cassini* is described.

— New name for the genus *Tetragonops*.

Auk, XVI, No. 1, Jan., 1898, p. 77.

Tetragonops is found to be preoccupied and *Pan* is proposed in its place.

RICHMOND, CHARLES W.—Continued.

— *Thalassidroma castro*, of Harcourt.

Auk, XVI, No. 2, Apr., 1899, pp. 177, 178.

A reproduction of the original description of this species.

— *Pelecanus occidentalis* versus *P. fuscus*.

Auk, XVI, No. 2, Apr., 1899, p. 178.

A note calling attention to the fact that the name *P. occidentalis* antedates *P. fuscus*.

— On the name *Xenocichla*.

Auk, XVI, Apr. 2, 1899, pp. 183, 184.

The name *Xenocichla* is shown to be preoccupied by *Bleda*, of Bonaparte.

— Four preoccupied names.

Auk, XVI, No. 2, Apr., 1899, pp. 186, 187.

The following names are shown to be preoccupied: *Amazona augusta*, *Pachyrhamphus similis*, *Blaz*, and *Bocagia*. They are renamed *Amazona imperialis*, *Pachyrhamphus salvini*, *Blacops*, and *Antichromus*, respectively.

— *Tyrannus magnirostris* d'Orb. (Renamed.)

Auk, xv, No. 4, Oct., 1899, p. 330.

Tyrannus magnirostris d'Orb., 1839, is found to be antedated by *T. magnirostris* Sw., 1831, and is accordingly given a new name, *T. cubensis*.

RIDGWAY, ROBERT. Descriptions of supposed new genera, species, and subspecies of American birds. I—Fringillidae.

Auk, xv, No. 3, July, 1898, pp. 223-230.

The author's edition of this paper was published May 13, 1898.

The following genera, etc., are described as new: *Melanospiza*, *Brachyspiza*, *Myospiza*, *Plagiospiza*, *Incapspiza*, *Rhynchospiza*, *Pselliophorus*, *Lysurus*, *Serinopsis*, *Heterospingus*, *Mitrospingus*, *Rhodothraupis*, *Hemithraupis*, *Stelgidostomus*, *Aimophila ruficeps sororia*, *Aimophila sartorii*, *Atlapetes pilcatus dilutus*, *Arremonops venezuelensis*, *Arremonops richmondi*, *Cyanocampa conercta cyanescens*, *Amphispiza bilineata deserticola*, *Amphispiza belli elementæ*.

— Description of supposed new genera, species, and subspecies of American birds. II—Fringillidae (continued).

Auk, xv, No. 4, Oct., 1898, pp. 319-324.

The following new forms are described: *Pinicola enucleator atascensis*, *P. e. montana*, *Astragalinus mexicanus jouyi*, *Calcarius lapponicus atascensis*, *C. l. coloratus*, *Junco montanus*, *Brachyspiza capensis insularis*, *Euthelia coryi*, *E. bryanti*, *Pyrhulagra affinis*, *P. dominicana*, *P. crissalis*, and *P. coryi*. *Brachyspiza capensis peruviana* (Lesson) is found to be the earliest name for the bird named *Zonotrichia capensis costaricensis* Allen, and *Guiraca caerulea lacula* (Lesson) for the species now known as *G. c. curhynchua* (Coues).

RIDGWAY, ROBERT—Continued.

The generic name *Passerina* is transferred from the painted buntings to the snowflakes, and *Cyanospiza* Baird is revived for the former.

— Descriptions of supposed new genera, species, and subspecies of American birds. III—Fringillidæ (continued).

Auk, xvi, No. 1, Jan., 1899, pp. 35-37.

The following forms are described as new: *Melospiza fasciata cooperii*, *M. f. pusillula*, *M. f. caurina*, *Passerella iliaca fuliginosa*, *Zonotrichia leucophrys nuttalli*, *Sicalis chapmani*, and *Spinus atteni*.

— Description of a new species of Hummingbird from Arizona.

Auk, xv, No. 4, Oct., 1898, pp. 325, 326.

Atthis morcomi is described as new.

— *Hemithraupis*—a correction.

Auk, xv, No. 4, Oct., 1898, 330, 331.

Hemithraupis is found to be preoccupied and is renamed *Sporothraupis*.

— On the genus *Astragalinus* Cabanis.

Auk, xvi, No. 1, Jan., 1899, pp. 79, 80.

Astragalinus is recognized as a genus distinct from *Spinus*. A list of the North American forms is added.

— On the generic name *Aimophila* versus *Peuca*.

Auk, xvi, No. 1, Jan., 1899, pp. 80, 81.

Aimophila is considered distinct from *Peuca*, and a list of the United States forms is given.

ROSE, JOSEPH NELSON. [*Bunchosia costaricensis* and *Bunchosia macrophylla*.]

Primitie Floræ Costaricensis, Instituto Físico-Geográfico Nacional, San José, Costa Rica, 2, fasc. 1, 1898, pp. 63, 64.

— Plants of the Tres Marias Islands.

North Am. Fauna (U. S. Dept. Agric.), No. 14, 1898, pp. 77-91.

— *Agave expatriata* and other Agaves.

Ann. Rep. Missouri Botan. Garden, II, June 3, 1899, 1-5.

— The genus *Agave*.

Cyclopedia North American Horticulture, I, 1899, pp. 33-36.

ROSE, J. N. (See also under J. M. Coulter and F. V. Coville.)

SAFFORD, JAMES, and SCHUCHERT, CHARLES. The Camden Chert of Tennessee and its Lower Oriskany fauna.

Am. Journ. Sci., vii, June, 1899, pp. 429-432.

Professor Safford describes the rocks and

SAFFORD, JAMES, and SCHUCHERT, CHARLES—Continued.

areal distribution, and Mr. Schuchert lists the fossils found by him in 1897 and shows their Lower Oriskany age. The fossils are in the U. S. National Museum.

SCHUCHERT, CHARLES. (See under JAMES SAFFORD and DAVID WHITE.)

SCHWARZ, EUGENE A. Martin Larsson Linell.

Proc. Ent. Soc. Wash., iv, No. 3 (issued May 24, 1899), pp. 117-180.

Gives a brief biography of Mr. Martin Larsson Linell and records the titles of 18 papers published by him.

— Note on the *Cedrela* Psyllids (genus *Freyguila* Aleman).

Proc. Ent. Soc. Wash., iv, No. 3 (issued May 24, 1899), pp. 195-197.

Gives a history of this Mexican genus, with a full diagnosis, and describes 2 new varieties from Venezuela and Trinidad.

— Descriptions of new species of Coleoptera.

Psyche, viii, No. 277, May, 1899 (Supplement), pp. 8-13.

An appendix to an article by H. G. Hubbard on the Insect fauna of the Giant Cactus. Describes 1 new genus and 7 new species of beetles from Arizona.

— Classified list of species observed by H. G. Hubbard on the Giant Cactus.

Psyche, viii, No. 277, May, 1899 (Supplement), pp. 13, 14.

Gives a list of Hymenoptera, Coleoptera, Lepidoptera, Diptera, Orthoptera, Neuroptera, Heteroptera, Acari, and Pseudoscorpionida found on the Giant Cactus.

(See also under Martin L. Linell.)

SMITH, HUGH M. On the occurrence of *Amphiuma*, the so-called Congo Snake, in Virginia.

Proc. U. S. Nat. Mus., xxi, No. 1150, Nov. 10, 1898, pp. 379, 380.

SMITH, JOHN B., and DYAR, HARRISON G. Contributions toward a monograph of the Lepidopterous family Noctuidæ of Boreal North America. A revision of the species of *Acronycta* (Ochsenheimer) and of certain allied genera.

Proc. U. S. Nat. Mus., xxi, No. 1140, Nov. 17, 1898, pp. 1-194, pls. 1-xxxii.

STARKS, EDWIN C. The osteology and relationships of the family Zeidae.

Proc. U. S. Nat. Mus., xxi, No. 1155, Nov. 21, 1898, pp. 469-476, pls. xxxiii-xxxviii.

STEARNS, R. E. C. Description of a species of *Actæon* from the Quaternary bluffs at Spanish Bight, San Diego, Cal.

Proc. U. S. Nat. Mus., XXI, No. 1145, Nov. 2, 1898, pp. 297-299, 1 fig.

A preliminary description of this species appeared in the *Nautilus*, XI, No. 1, Philadelphia, May, 1897.

Actæon traskii occurs in the above region both in a living and fossil state, together with *Actæon* (*Rictaxis*) *punctocelatus*, and a variety of the latter—var. *cormadoensis*.

— Notes on the *Cytherea* (*Tivela*) *crassatelloides* Conrad, with descriptions of many varieties.

Proc. U. S. Nat. Mus., XXI, No. 1149, Nov. 10, 1898, pp. 371-378, pls. XXIII-XXV.

In this paper the author gives the range of this species and a description. He divides the variations of color pattern into 6 groups and 16 different named varieties. The three plates illustrate the general characters of the shell variations in outline, and the anatomy.

— Preliminary description of a new variety of *Haliotis*.

Nautilus, XII, No. 9, Jan., 1899, pp. 106, 107.

Haliotis fulgens Phil., variety *wallatensis*, occurring on the coast of Mendocino County, Cal., is described.

— *Urosalpinx cinereus* Say, in San Francisco Bay.

Nautilus, XII, No. 10, Feb., 1899, p. 112.

The occurrence of the so-called oyster-drill of the Atlantic coast, heretofore detected on the western shore of San Francisco Bay, has later been found on the eastern side at a distance of several miles from the first-discovered locality.

— *Crepidula convexa* Say, variety *glauca* Say, in San Francisco Bay.

Nautilus, XIII, No. 1, May, 1899, p. 8.

The foregoing molluscan form is another incidental introduction from the Atlantic seaboard, as well as *Urosalpinx cinereus* previously mentioned. Both of these Eastern species have been introduced with the Eastern oyster, *Ostrea virginica*, by the oyster dealers of San Francisco.

— Natural history of the Tres Marias Islands of Mexico.

Nautilus, XIII, No. 2, June, 1899, pp. 19, 20.

The above paper refers to an article published in *North American Fauna*, No. 14 (Biological Survey, U. S. Department of Agriculture), in which the author, Mr. E. W. Nelson, states that himself and companion were the only naturalists who visited the islands sub-

sequent to the visits of Grayson and Farrer,

until May, 1897, whereas Mr. W. J. Fisher made an extensive collection in the group in 1876. The molluscan species collected by Fisher at that time are now a part of the national collection and are listed in the Proceedings of the U. S. National Museum, vol. XVII, No. 996, pp. 139-204. Eighty-nine species are enumerated.

STEJNEGER, LEONHARD. The birds of the Kuril Islands.

Proc. U. S. Nat. Mus., XXI, No. 1144, Oct. 4, 1898, pp. 269-296.

A complete list of the birds observed by the author, and others, in the Kuril Islands.

— Description of a new species of Spiny-tailed Iguana from Guatemala.

Proc. U. S. Nat. Mus., XXI, No. 1151, Nov. 10, 1898, pp. 381-383.

Ctenosaura palearis, new species (Type specimen No. 22703, U. S. N. M.).

— The | Asiatic Fur Seal Islands | and | Fur Seal Industry. | By | Leonhard Stejneger | of the U. S. National Museum. | — | With one hundred and thirteen plates and maps. | — | (Part IV of the Fur Seals and Fur Seal Islands of the North Pacific Ocean) | — | Washington | 1898.

Royal 8 vo., pp. 1-384, pls. 1-113.

The author's final report as member of the Fur Seal Investigation Commission.

— Report on the Russian Fur Seal Islands.

Seal and Salmon Fisheries and General Resources of Alaska, IV, 1898, pp. 613-751, 74 plates and 14 maps.

Essentially a reprint of "The Russian Fur-seal Islands" (1896), by the same author.

— [Review of] The birds of Indiana. By A. Butler.

Am. Naturalist, XXXIII, Jan., 1899, pp. 65-69.

— A curious malformation on a snake's head.

Am. Naturalist, XXXIII, March, 1899, pp. 251, 252, 2 figs.

The malformation consists chiefly in the absence of a frontal plate, and is supposed to be due to a wound. The specimen belongs to the Museum of the Cincinnati Natural History Society.

— Relationships of North American Grouse and Quail.

Am. Naturalist, XXXIII, March, 1899, pp. 259-263.

A review of "The Feather-tracts of North American Grouse and Quail," by H. L. Clark.

STEJNEGER, LEONHARD—Continued.

— Reptiles of the Tres Marias and Isabel Islands.

North. Am. Fauna (U. S. Dept. Agric.), No. 14, April 29, 1899, pp. 63-71.

The collection on which this paper is based was made by Mr. E. W. Nelson for the Biological Survey, U. S. Department of Agriculture, and is now in the National Museum.

— The land reptiles of the Hawaiian Islands.

Proc. U. S. Nat. Mus., XXI, No. 1174, June 5, 1899, pp. 783-813, figs. 1-13.

A list, with full synonymies and descriptions, of all the species occurring in the Archipelago.

One new species is described; *Hemiphyllodactylus leucostictus* (Type specimen 23500, U. S. N. M.). All the species are represented in the National Museum collection.

— Description of a new genus and species of Discoglossoid Toad from North America.

Proc. U. S. Nat. Mus., XXI, No. 1178, June 20, 1899, pp. 899-901, pl. LXXXIX, figs. 1-4.

Ascephus truei, new species and genus, from Humptulips, Washington, is described (Type specimen No. 25979 U. S. N. M.). This is the first member of the batrachian suborder Costata known with certainty to have been discovered in the Western Hemisphere.

— Evans's birds.

Am. Naturalist, XXXIII, June, 1899, pp. 523-526.

A review of volume IX of "The Cambridge Natural History—Birds," by A. H. Evans.

— Blind Cave Salamanders.

Popular Science, XXXIII, June, 1899, pp. 121, 122, with text figs.

A popular account of *Proteus anguineus*, *Typhlotriton sphecius*, and *Typhlomolge rathbuni*, with illustrations of the latter from photographs.

— On a collection of batrachians and reptiles from Formosa and adjacent islands.

Journ. Science College Mus. Univ. Tokyo (Japan), XII, part III, pp. 215-225.

The collection which was made for the Japanese Government was submitted to the author to be worked up. The first set of specimens belongs to the Science College Museum, Tokyo; the second has been presented to the National Museum. *Rana longicrus*, *Japalura nitsukurii*, *Emydopcephalus tjimae* are described as new species.

TEST, FREDERICK CLEVELAND. A contribution to the knowledge of the variations of the Tree Frog, *Hyla regilla*.

Proc. U. S. Nat. Mus., XXI, No. 1156, Nov. 19, 1898, pp. 477-492, pl. 39.

TRUE, FREDERICK W. On the nomenclature of the Whalebone Whales of the tenth edition of Linnaeus's "Systema Naturae."

Proc. U. S. Nat. Mus., XXI, No. 1163, Nov. 4, 1898, pp. 617-635.

— An account of the United States National Museum.

Rep. Smithsonian Inst. (U. S. Nat. Mus.), 1896 (1899), pp. 287-324.

UPHAM, E. P. (See under THOMAS WILSON.)

VAUGHAN, T. WAYLAND. (See under R. T. HILL.)

WALCOTT, CHARLES DOOLITTLE. Cambrian Brachiopoda: *Obolus* and *Lingulella*, with descriptions of new species.

Proc. U. S. Nat. Mus., XXI, No. 1152, Nov. 19, 1898, pp. 385-420, pls. 26-28.

In this paper the author describes 10 American species of *Obolus*, and 59 species and varieties of *Lingulella*.

— Fossil Medusae.

Monograph U. S. Geol. Surv., XXX, 1898, pp. 1-201, pls. 1-47.

In this extensive, detailed, and finely illustrated work by the Director of the U. S. Geological Survey, all the species of fossil medusae are described and figured. The chief localities for Paleozoic species are in America, and in Coosa Valley, Alabama, they are abundant. The material is now in the U. S. National Museum.

— Pre-Cambrian fossiliferous formations.

Bull. Geol. Soc. Am., x, April, 1899, pp. 199-244, pls. 22-28.

In this paper the writer brings together all that is known regarding the American fossiliferous formations beneath the Cambrian, and describes and figures the fossils, of which there are 9 species.

WARD, LESTER F. Descriptions of the species of *Cycadeoidea* or fossil cycadean trunks, thus far determined from the Lower Cretaceous rim of the Black Hills.

Proc. U. S. Nat. Mus., XXI, No. 1141, Oct. 29, 1898, pp. 195-229.

This paper is based on a study of 155 specimens, 25 of which belong to the National Museum. Twenty-one species are described, all of which, with one exception, are new to science.

WATSON, THOMAS L. Weathering of Diabase near Chatham, Va.

Am. Geologist, XII, Aug., 1898, pp. 85-101.

WATSON, THOMAS L.—Continued.

Gives results of studies of fresh and decomposed material along lines laid down by Dr. Merrill, in his work on "Rocks, rock-weathering, and soils."

The investigations were carried on in the National Museum laboratories, and the specimens described remain among the Museum collections.

WHITE, DAVID, and SCHUCHERT, CHARLES. Cretaceous series of the West Coast of Greenland.

Bull. Geol. Soc. Am., IX, June, 1898, pp. 343-368, pls. 24-26.

The writers were sent to North Greenland by this Museum in 1897. An account of their geological investigations is here published. The lists of fossil plants are based entirely on material collected by them.

The Cretaceous and Tertiary formations of Noursoak peninsula are described. Of sedimentary deposits the thickness is not less than 3,500 feet, capped by Tertiary basalts attaining a maximum thickness of 4,000 feet. The various localities and horizons for fossils are described.

WHITEAVES, J. F. On some additional or imperfectly understood fossils from the Hamilton formation of Ontario, with a revised list of the species therefrom.

Contributions to Canadian Palaeontology, Geological Survey of Canada, I, No. 7, Nov., 1898, pp. 361-436, pls. XLVIII-L.

Based partly on material collected in the vicinity of Thedford, Ontario, for the National Museum, by Charles Schuchert.

WILSON, THOMAS. Prehistoric art, or the origin of art as manifested in the works of prehistoric man.

Rep. Smithsonian Inst. (U. S. Nat. Mus.), 1896 (1899), pp. 325-664, pls. 1-74, figs. 1-325.

This paper deals with art in prehistoric times. It approaches the subject from the aesthetic rather than the utilitarian point of view, although the two are necessarily interrelated.

The introduction contains remarks on the theory of art.

The first and second chapters deal with all kinds of art in the Paleolithic and Neolithic periods, and with the differences in art between the two periods and the geometric ornaments employed in both.

The third chapter treats of prehistoric musical instruments, describing the gold and bronze horns of northern Europe. This portion of the work was prosecuted in collaboration with Mr. E. P. Upham, whose musical

WILSON, THOMAS—Continued.

knowledge made its successful accomplishment possible and to whom the credit of this chapter largely belongs.

— Art in prehistoric times.

Proc. Am. Assoc. Adv. Sci., XLVII, 1898, pp. 456-459.

A summary of the author's work on "Prehistoric Art."

This article was reprinted in *The American Archaeologist* (formerly *The Antiquarian*), II, Pt. 2, Nov., 1898, pp. 281-283.

— Classification of arrowpoints, spearheads, and knives.

Proc. Am. Assoc. Adv. Sci., XLVII, 1898, pp. 464-470.

Summary of the author's work on "Arrowpoints, spearheads, and knives of prehistoric times."

— Archaeological museums. Modes of lighting.—Effect of glass upon light.

Sci. Am. Suppl., No. 1203, New York, Jan. 21, 1899, p. 19288.

This paper was read before the mid-winter meeting of the American Association for the Advancement of Science, Dec., 1898, held at Columbia University, New York City.

Glass may affect the transmission of light by reflection, by refraction, or by absorption. The question discussed in this article is the amount or proportion of light lost in passing through glass of different kinds. Various mechanical appliances were used to determine loss: (1) a camera obscura, (2) comparative photographs, (3) photometer.

— (Translator and editor). Quaternary deposits at Abbeville, France, wherein Paleolithic implements were first discovered. By G. D'Ault Du Mesnil.

Am. Antiq. and Orient. Journ., XXI, No. 3, May and June, 1899, pp. 137-145.

Describes the deposits and shows the different strata in which appear the bones of fossil animals and artefacts of flint associated therewith.

WILSON, THOMAS, and UPHAM, E. P. Prehistoric musical instruments.

Proc. Am. Assoc. Adv. Sci., XLVII, 1898, pp. 459-464.

This article was reprinted in *The American Archaeologist* (formerly *The Antiquarian*), III, Part 1, Jan., 1899, pp. 9-14.

Summary of the third chapter of Mr. Wilson's work on "Prehistoric Art."

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APPENDIX V.

PAPERS PUBLISHED IN SEPARATE FORM DURING THE YEAR ENDING JUNE 30, 1899.

FROM THE REPORT FOR 1896.

- Report upon the condition and progress of the U. S. National Museum during the year ending June 30, 1896. By G. Brown Goode. pp. 1-284, pls. 1-4.
- An account of the United States National Museum. By Frederick W. True. pp. 287-324.
- Prehistoric art; or the origin of art as manifested in the works of prehistoric man. By Thomas Wilson. pp. 325-664, pls. 1-74, figs. 1-325.
- Chess and playing cards. By Stewart Culin. pp. 665-942, pls. 1-50, figs. 1-226.
- Biblical antiquities. By Cyrus Adler and I. M. Casanowicz. pp. 943-1023, pls. 1-46.
- The lamp of the Eskimo. By Walter Hough. pp. 1025-1057, pls. 1-24, figs. 1-4.

FROM VOLUME 21 OF THE PROCEEDINGS.

- No. 1140. Contributions toward a monograph of the Lepidopterous family Noctuidæ of Boreal North America. A revision of the species of *Acronycta* (Ochsenheimer) and of certain allied genera. By John B. Smith and Harrison G. Dyar. pp. 1-194, pls. 1-22.
- No. 1141. Descriptions of the species of Cycadeoidea, or fossil cycadean trunks, thus far determined from the Lower Cretaceous rim of the Black Hills. By Lester F. Ward. pp. 195-229.
- No. 1142. On some new parasitic insects of the subfamily Encyrtinae. By L. O. Howard. pp. 231-248.
- No. 1143. On the Coleopterous insects of Galapagos Islands. By Martin L. Linell. pp. 249-268.
- No. 1144. The birds of the Kuril Islands. By Leonhard Stejneger. pp. 269-296.
- No. 1145. Description of a species of *Actæon* from the Quaternary Bluffs at Spanish Bight, San Diego, Cal. By Robert E. C. Stearns. pp. 297-299.
- No. 1146. Report on a collection of Japanese Diptera, presented to the U. S. National Museum by the Imperial University of Tokyo. By D. W. Coquillett. pp. 301-340.
- No. 1147. Notes on the mammals of the Catskill Mountains, New York, with general remarks on the fauna and flora of the region. By Edgar A. Mearns. pp. 341-360, figs. 1-6.
- No. 1148. Topaz crystals in the mineral collection of the U. S. National Museum. By Arthur S. Eakle. pp. 361-369, figs. 1-22.
- No. 1149. Notes on *Cytherea* (*Tivela*) *crassatelloides* Conrad, with descriptions of many varieties. By Robert E. C. Stearns. pp. 371-378, pls. 23-25.
- No. 1150. On the occurrence of *Amphiuma*, the so-called Congo Snake, in Virginia. By Hugh M. Smith. pp. 379, 380.
- No. 1151. Description of a new species of Spiny-tailed Iguana from Guatemala. By Leonhard Stejneger. pp. 381-383.
- No. 1152. Cambrian Brachiopoda: *Obolus* and *Lingulella*, with descriptions of new species. By Charles D. Walcott. pp. 385-420, pls. 26-28.

- No. 1153. A revision of the wrens of the genus *Thryomanes* Selater. By Harry C. Oberholser. pp. 421-450.
- No. 1154. American Oniscoid Diplopoda of the order Merocheta. By O. F. Cook. pp. 451-468, pls. 29-32.
- No. 1155. The osteology and relationships of the family Zeidae. By Edwin Chapin Starks. pp. 469-476, pls. 33-38.
- No. 1156. A contribution to a knowledge of the variations of the Tree Frog, *Hyla regilla*. By Frederick Cleveland Test. pp. 477-492, pl. 39.
- No. 1157. Japanese Hymenoptera of the family Tenthredinidae. By C. L. Marlatt. pp. 493-506.
- No. 1158. A contribution to a knowledge of the fresh-water crabs of America—The Pseudothelphusinae. By Mary J. Rathbun. pp. 507-537, figs. 1-17.
- No. 1159. Notes on a collection of fishes from Mexico, with description of a new species of *Platyphacelus*. By Barton A. Bean. pp. 539-542, 1 fig.
- No. 1160. The leeches of the U. S. National Museum. By J. Percy Moore. pp. 543-563, pl. 40.
- No. 1161. On the occurrence of *Caulolepis longidens* Gill on the coast of California. By Charles Henry Gilbert. pp. 565, 566.
- No. 1162. The Brachyura collected by the U. S. Fish Commission steamer *Albatross* on the voyage from Norfolk, Va., to San Francisco, Cal., 1887-88. By Mary J. Rathbun. pp. 567-616, pls. 41-44.
- No. 1163. On the nomenclature of the Whalebone whales of the Tenth Edition of Linnæus's "Systema Naturæ." By Frederick W. True. pp. 617-635.
- No. 1164. A new snake from the Eocene of Alabama. By Frederic A. Lucas. pp. 637, 638, pls. 45, 46.
- No. 1165. Notes on the capture of rare fishes. By Barton A. Bean. pp. 639, 640.
- No. 1166. The feather-tracts of North American Grouse and Quail. By Hubert Lyman Clark. pp. 641-653, pls. 47-49, figs. 1-4.
- No. 1167. Notes on *Oxycoelus acuticeps* (Gilbert) from Sitka and Kadiak, Alaska. By Tarleton H. Bean and Barton A. Bean. pp. 655, 656.
- No. 1168. African Diplopoda of the genus *Pachybolus*. By O. F. Cook. pp. 667-676, pls. 50-52.
- No. 1169. The Diplopod family Striariidae. By O. F. Cook. pp. 667-676, pls. 53, 54.
- No. 1170. African Diplopoda of the family Gomphodesmidae. By O. F. Cook. pp. 677-739, pls. 55-61.
- No. 1171. Hydroida from Alaska and Puget Sound. By Charles Cleveland Nutting. pp. 741-753, pls. 62-64.
- No. 1172. The fossil Bison of North America. By Frederic A. Lucas. pp. 755-771, pls. 65-84, figs. 1, 2.
- No. 1173. Petrographic report on rocks from the United States-Mexico boundary. By Edwin C. E. Lord. pp. 773-782, pl. 85.
- No. 1174. The land reptiles of the Hawaiian Islands. By Leonhard Stejneger. pp. 783-813, figs. 1-13.
- No. 1175. Key to the isopods of the Pacific Coast of North America, with descriptions of 22 new species. By Harriet Richardson. pp. 815-869, figs. 1-34.
- No. 1176. Description of a new species of subterranean isopod. By W. P. Hay. pp. 871, 872, pl. 86.
- No. 1177. Synopsis of the recent and Tertiary Leptonacea of North America and the West Indies. By William H. Dall. pp. 873-897, pls. 87, 88.
- No. 1178. Description of a new genus and species of Discoglossoid Toad from North America. By Leonhard Stejneger. pp. 899-901, pl. 89.

PART II.

PAPERS DESCRIBING AND ILLUSTRATING COLLECTIONS IN THE U. S. NATIONAL MUSEUM.

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VIEW SHOWING WALL AND RAIL CASES AND INSTALLATION OF NONMETALLIC MINERALS ON GALLERY OF SOUTHWEST COURT OF U. S. NATIONAL MUSEUM. LOOKING WEST.



VIEW SHOWING RAIL CASE AND INSTALLATION OF NONMETALLIC MINERALS IN GALLERY OF SOUTHWEST COURT OF U. S. NATIONAL MUSEUM. LOOKING NORTH.

GUIDE TO THE STUDY OF THE COLLECTIONS IN THE SECTION OF APPLIED GEOLOGY.

BY

GEORGE P. MERRILL,

*Curator, Division of Physical and Chemical Geology,
and Head Curator of the Department.*



PREFATORY NOTE.

The accompanying handbook and guide is an outgrowth of the work of installing and labeling the collections of the economic section of the Division of Physical and Chemical Geology. The term nonmetallic, as used, includes those minerals which, as here exhibited, are utilized in other than metallic forms. The collections, comprising as now arranged, some 2,500 specimens, include therefore some materials which—like the iron oxides—may be utilized as ores of metals. As such they have already been considered in Bulletin No. 42, under the title *A Preliminary Descriptive Catalogue of the Systematic Collections in Economic Geology and Metallurgy*, by F. P. Dewey. The collection of building and ornamental stones which might perhaps be included herewith has been also the subject of a special handbook published in the Annual Report of the National Museum for 1886, and entitled *The Collection of Building and Ornamental Stones in the United States National Museum: A Handbook and Catalogue*. By George P. Merrill.

It is scarcely necessary to remark that in the preparation of this work the curator has been hampered by a great dearth of information on certain subjects and burdened with a superabundance on others. Certain materials, such as the coals, phosphates, limes, and cements, would each require a volume, and necessarily must be very imperfectly treated here. In such cases the curator has aimed to give as brief and concise an abstract as the requirements of a handbook would permit, and make up for the deficiencies in the bibliography. In other cases the subjects are treated as fully as the knowledge at hand will allow. In describing occurrences the aim has been to give in detail one or two fairly typical deposits, referring to others more briefly. Naturally the preference has been given to American materials. Statements as to prices and annual production are quite unsatisfactory and of very temporary value at best. But little space has therefore been devoted to this branch of the subject. Technical, chemical, and crystallographic points have been but lightly touched upon, such being already covered by existing literature. Only such statements as to hardness, color, etc., are given as it is thought may be of value in rough preliminary determinations.

The satisfactory installation and classification of collections of this nature are matters of no inconsiderable difficulty. As the materials

are utilized for industrial purposes, it might at first thought appear that they should be grouped according to the uses to which they are put, as is commonly done at expositions. Such a plan, however, involves a great amount of repetition, since many of the materials, as diatomaceous earths, the clays, steatite, etc., are used for a variety of purposes. On this account the method of installation, or grouping, adopted is somewhat loose, the materials being grouped (1) by kinds, and under kinds so far as possible (2) by uses. Further than this the character of the material has in many instances rendered it necessary to install those closely related and used, it may be, for quite similar purposes in cases of quite different type as is shown in the hydrocarbon series, the coals, asphalts, etc., being in the deep-wall cases while the petroleums, in bottles, are exhibited in the upright portion of the rail cases.

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GUIDE TO THE STUDY OF THE COLLECTIONS IN THE SECTION OF APPLIED GEOLOGY.

THE NONMETALLIC MINERALS.

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I. ELEMENTS.

1. CARBON.

The numerous compounds of which carbon forms the chief constituent are widely variable in their physical properties and origin. As occurring in nature few of its members possess a definite chemical composition such as would constitute a true mineral species, and they must for the most part be looked upon as indefinite admixtures in which carbon, hydrogen, and oxygen play the more important rôles. For present purposes the entire group may be best considered under the heads of (1) The Pure Carbon series; (2) The Coal series, and (3) The Bitumen series, the distinctions being based mainly on the gradually increasing amounts of volatile hydrocarbons, a change which is accompanied by a variation in physical condition from the hardest of known substances through plastic and liquid to gaseous forms. Here will be considered only the members of the pure carbon series, the others being discussed under the head of hydrocarbon compounds.

DIAMOND.—This mineral crystallizes in the isometric system, with a tendency toward octahedral forms, the crystals showing curved and striated surfaces. (Specimen No. 53558, U.S.N.M.) The hardness is great, 10 of Dana's scale; the specific gravity varies from 3.1 in the carbonados to 3.5 in good clear crystals. The luster is adamantine; the colors, white or colorless, through yellow, red, orange, green, brown to black. The transparent and highly refractive forms are of value as gems, and can best be discussed in works upon this subject. We have to do here rather with the rough, confused crystalline aggregates or rounded forms, translucent to opaque, which, though of no value as gems, are of the greatest utility in the arts. To such

forms the name *black diamond*, *bort*, and *carbonado* are applied. (Specimens Nos. 53668-53671, U.S.N.M.)

Origin and Occurrence.—The origin of the diamond has long been a matter of discussion. A small proportion of the diamonds of the world are found in alluvial deposits of gravel or sand. In the South African fields they occur in a so-called blue gravel, formed, according to Lewis, along the line of contact between an eruptive rock (peridotite) and highly carbonaceous shales. They were regarded by Lewis as originating through the crystallization of the carbon of the shales by the heat of the molten rock. De Launay states, however, that there is no necessary connection between the shales and the diamond, and shows with apparent conclusiveness that the latter occur often in a broken and fragmental condition, such as to indicate beyond doubt that they originated at greater depths and were brought upward as phenocrysts in the molten magma at the time of its intrusion. The primary origin of the diamonds he regards as through the crystallization, under great pressure, of the carbon contained in the basic magma in the form of metallic carbides.

The diamond-bearing rock as above noted is a peridotite often brecciated and more or less serpentinized (Specimen No. 62108, U.S.N.M.). The blue and green gravel formed by the decomposition of this rock is shown in Specimen No. 73188, U.S.N.M. With these are others of the associated, eruptive, and metamorphic rocks, as melaphyr (Specimen No. 73184, U.S.N.M.), quartzite (Specimen No. 73185, U.S.N.M.), shale (Specimen No. 73186, U.S.N.M.), and basalt (Specimen No. 73187, U.S.N.M.).

Whether or not a similar origin to that outlined above can be attributed to the Brazilian diamonds is as yet unproven. Their occurrence and association with detrital materials resulting from the breaking down of older rocks, with which they may or may not have been originally associated, renders the problem obscure and difficult of solution.

According to Kunz,¹ 95 per cent of all diamonds at present obtained come from the Kimberly Mines, Griqua Land, west South Africa; of these, some 47 per cent are bort. The remainder come from Brazil, India, and Borneo. A few have been found in North America, the Ural Mountains, and New South Wales, but these countries are not recognized as regular and constant sources of supply.

Uses.—The material, aside from its use as a gem, owes its chief value to its great hardness, and is used as an abrading and cutting medium in cutting diamonds and other gems, glass, and hard materials in general, such as can not be worked by softer and cheaper substances.

With the introduction of machinery into mining and quarrying there

¹ Gems and Precious Stones. New York, 1890.

has arisen a constant and growing demand for black diamonds, or bort, for the cutting edges of diamond drills, and to a less extent for teeth to diamond saws. (Specimens Nos. 53668 to 53670, U.S.N.M.)

According to a writer in the *Iron Age*¹ the crystallized diamond is not suitable for these purposes owing to its cleavage property. The best bort or "carbonado" comes, it is said, from Bahia, Brazil, where it is found as small, black pebbles in river gravels. The ordinary sizes used for drills weigh but from one-half to 1 carat, but in special cases pieces weighing from 4 to 6 carats are used. It is stated that the crowns of large drills, 10 inches in diameter, armed with the best grade of carbonado, are sometimes valued as high as \$10,000.

BIBLIOGRAPHY.

M. BABINET. The Diamond and other precious stones.

Report of the Smithsonian Institution, 1870, p. 333.

A DAUBRÉE. *Annales des Mines*, 7th ser., IX, 1876, p. 130.

Remarking on the occurrence of platinum associated with peridotites, he calls attention to the fact that Maskelyne had shown the diamonds of South Africa and Borneo to occur in a decomposed peridotite.

ORVILLE A. DERBY. Geology of the Diamantiferous Region of the Province of Paraná, Brazil.

American Journal of Science, XVIII, 1879, p. 310.

Geology of the Diamond.

American Journal of Science, XXIII, 1882, p. 97.

R. COHEN. Igneous origin of the Diamond.

Proceedings, Manchester Literary and Philosophical Society, 1884, p. 5.

H. CARVILL LEWIS. The Genesis of the Diamond.

Science, VIII, 1886, p. 345.

GARDNER F. WILLIAMS. The Diamond Mines of South Africa.

Transactions of the American Institute of Mining Engineers, XV, 1886, p. 392.

ORVILLE A. DERBY. The Genesis of the Diamond.

Science, IX, 1887, p. 57.

Discovery of Diamonds in a Meteoric Stone.

Nature, XXXVII, 1887, p. 110.

Diamond Mining in Ceylon.

Engineering and Mining Journal, XLIX, 1890, p. 678.

A. MERVYN SMITH. The Diamond Fields of India.

Engineering and Mining Journal, LIII, 1892, p. 454.

OLIVER WHIPPLE HUNTINGTON. Diamonds in Meteorites.

Science, XX, 1892, p. 15.

Diamonds in Meteoric Stones.

The American Geologist, XI, 1893, p. 282. (Abstract of paper by H. Moissan, *Comptes Rendus* 1893, pp. 116 and 228.)

HENRI MOISSAN. Study of the Diamantiferous Sands of Brazil.

Engineering and Mining Journal, LXII, 1896, p. 222.

HENRY CARVILL LEWIS. I. Papers and Notes on the Genesis and Matrix of the Diamond, edited by Prof. T. G. Bonney.

The Geological Magazine, IV, 1897, p. 366.

Sir WILLIAM CROOKES. Diamonds.

Nature, LV, 1897, p. 325.

¹ Volume XXXVI, December 24, 1885, p. 11.

L. DE LAUNAY. Les Diamants du Cap.
Paris, 1897.

ORVILLE A. DERBY. Brazilian Evidence on the Genesis of the Diamond.
The Journal of Geology, VI, 1898, p. 121.

H. W. FURMISS. Carbons in Brazil. U. S. Consular Reports, 1898, p. 604. See also
Engineering and Mining Journal, LXVI, 1898, p. 608.

M. J. KLINCKE. Gîtes Diamantifères de la République sud-Africaine.
Annales des Mines, XIV, 1898, p. 563.

GRAPHITE.—Graphite, plumbago, or black lead, as it is variously called, is a dark steel gray to black lustrous mineral with a black streak; hardness of but 1.2, and a specific gravity of from 2.25 to 2.27. The prevailing form of the mineral is scaly or broadly foliated (Specimen No. 51007, U. S. N. M.), with a bright luster, but it is sometimes quite massive (Specimen No. 61138, U. S. N. M.) and columnar (Specimen No. 59976, U. S. N. M.) or earthy, with a dull coal-like luster (Specimens Nos. 64795 and 63133, U. S. N. M.).

Its most characteristic features are its softness, greasy feeling, and property of soiling everything with which it comes in contact. Molybdenite, the sulphide of molybdenum, is the only mineral with which it is likely to become confounded. This last, however, though very similar in general appearance, gives a streak with a slight greenish tinge, and when fused with soda before the blowpipe yields a sulphur reaction. Chemically, graphite is nearly pure carbon. The name black lead is therefore erroneous and misleading, but has become too firmly established to be easily eradicated.

The analyses given below show the composition of some of the purest natural graphites.

Locality.	Carbon.	Ash.	Volatile matter.
Ceylon	98.817	0.280	0.90
Do.	99.792	.05	.158
Buckingham, Canada.....	97.626	1.78	.594
Do.	99.815	.076	.109

As mined the material is almost invariably contaminated by mechanically admixed impurities. Thus the Canadian material (Specimens Nos. 59977, 62153, U. S. N. M.) as mined yields from 22.38 to 30.51 per cent of graphite; the best Bavarian, 53.80 per cent (Specimen No. 52050, U. S. N. M.). The grade of ore that can be economically worked naturally depends upon the character of the impurities and the extent and accessibility of the deposit. It is said¹ that deposits at Ticonderoga, New York, have been worked in which there was but 6 per cent of graphite (Specimen No. 37825, U. S. N. M.).

Occurrence and origin.—Graphite occurs mainly in the older crystal-

¹ Engineering and Mining Journal, LXV, 1898, p. 256.

line metamorphic rocks, both siliceous and calcareous, sometimes in the form of disseminated scales, as in the crystalline limestone of Essex County, New York (Specimen No. 37825, U.S.N.M.), or in embedded masses, streaks, and lumps, often of such dimensions that single blocks of several hundred pounds weight are obtainable. (Specimen No. 59976, U.S.N.M.) It is also found in the form of veins.

The fact that the mineral is carbon, one of the constituents of animal and vegetable life, has led many authorities to regard it, like coal, as of vegetable origin. While this view is very plausible it can not, however, be regarded as in all cases proven.

That graphite may be formed independently of organic life is shown by its presence in cast iron, where it has crystalized out, on cooling, in the form of bright metallic scales. See Specimens Nos. 51298 and 51312 in the metallurgical series of the manufacture of iron.

Carbon is also found in meteorites which are plainly of igneous origin, and which have thus far yielded no certain traces of either plant or animal organisms. It is, however, a well-known fact that coal—itself of organic origin—has in some cases been converted into graphite through metamorphic agencies, and intermediate stages like the graphitic anthracite of Newport, Rhode Island, afford good illustrations of such transitions. (Specimen No. 59099, U.S.N.M.) Certain European authorities¹ have shown that amorphous carbonaceous particles in clay slates have been converted into graphite by the metamorphosing influence of intruded igneous rocks. Prof. J. S. Newberry described an occurrence of this nature in the coal fields of Sonora, Mexico.² He says:

All the western portion of this coal field seems to be much broken by trap dikes which have everywhere metamorphosed the coal and converted it into anthracite. At the locality examined the metamorphic action has been extreme, converting most of the coal into a brilliant but somewhat friable anthracite, containing 3 or 4 per cent of volatile matter. At an outcrop of one of the beds, however, the coal was found converted into graphite, which has a laminated structure, but is unctuous to the touch and marks paper like a lead pencil. The metamorphism is much more complete than at Newport (Rhode Island) [Specimen No. 59099, U.S.N.M.], furnishing the best example yet known to me of the conversion of a bed of coal into graphite.

In New York State, and in Canada, graphite occurs in Laurentian rocks, both in beds and in veins, a portion of the latter being apparently true fissure veins and others shrinkage cracks or segregation veins which traverse in countless numbers the containing rocks. It is said³ that in the Canadian regions (Specimens Nos. 51007, 59976, U.S.N.M.), the deposits occur generally in limestone or in their immediate vicinity, and that granular varieties of the rock often contain large crystalline

¹ Beck and Luzi, *Berichte der Deutschen Chemischen Gesellschaft*, 1891, p. 24.

² *School of Mines Quarterly*, VIII, 1887, p. 334.

³ See On the Graphite of the Laurentian of Canada, by J. W. Dawson, *Proceedings of the Geological Society of London*, XXV, 1870, p. 112, and an article on Graphite by Prof. J. F. Kemp in *The Mineral Industry*, II, 1893, p. 335.

plates of plumbago. At other times the mineral is so finely disseminated as to give a bluish-gray color to the limestone, and the distribution of the bands thus colored seems to mark the stratification of the rock. Further, the plumbago is not confined to the limestones; large crystalline scales of it are occasionally disseminated in pyroxene rock or pyralolite, and sometimes in quartzite and in feldspathic rocks, or even in magnetic oxide of iron. In addition to these bedded forms, there are also true veins in which graphite occurs associated with calcite, quartz, orthoclase, or pyroxene, and either in disseminated scales, in detached masses, or in bands or layers separated from each other and from the wall rock by feldspar, pyroxene, and quartz. Kemp describes¹ the graphite deposit near Ticonderoga, New York (Specimens Nos. 37825, 66759, U.S.N.M.), as in the form of a true fissure vein, cutting the lamination of the gneissic walls at nearly right angles. The wall rock is a garnetiferous gneiss, with an east and west strike, and the vein runs at the "big mine" north 12° west, and dips 55° west. The vein filling, he says, was evidently orthoclase (or microcline) with quartz and biotite and pockets of calcite. Besides graphite, it contained tourmaline, apatite, pyrite, and sphene.

Walcott² describes the graphite at the mines $\frac{1}{2}$ miles west of Hague, on Lake George, New York, as occurring in Algonkian rocks, and as probably of organic origin.

At the mines the alternating layers of graphite shale or schist form a bed varying from 3 to 13 feet in thickness. The outcrop may be traced for a mile or more. The garnetiferous sandstones form a strong ledge above and below the graphite bed. The appearance is that of a fossil coal bed, the alteration having changed the coal to graphite and the sandstone to indurated, garnetiferous, almost quartzitic sandstones. The character of the graphite bed is well shown in the accompanying plate, from a photograph taken by me in 1890. It is here a little over 9 feet in thickness and is formed of alternating layers of highly graphitic sandy shale and schist. [See Plate 3.]

According to J. Walther³ the Ceylonese graphite (Specimens Nos. 66857, 62073, U.S.N.M.) occurs in coarsely foliated or stalky masses in veins in gneiss which, where mined, is decomposed to the condition of laterite. The veins are regarded as true fissures, and vary from 12 to 22 cm. (about $4\frac{1}{4}$ to $8\frac{3}{4}$ inches) in width.

The graphite of Northern Moravia occurs in gray to black crystalline granular Archæan limestone interbedded with amphibolites and muscovite gneiss, the limestone itself being often serpentinous, in this respect apparently resembling the graphitic portions of the ophicalcites of Essex County, New York. (Specimen No. 70084, U.S.N.M.). The material is quite impure, showing on the average but 53 per cent of carbon and 44 per cent of ash, the latter being made up largely of

¹ Preliminary Report on the Geology of Essex County, Contributions from the Geological Department of Columbia College, 1893, pp. 452, 453.

² Bulletin of the Geological Society of America, X, 1898, p. 227.

³ Records of the Geological Survey of India, XXIV, 1891, p. 42.



VIEWS IN GRAPHITE MINE NEAR HAGUE, WARREN COUNTY, NEW YORK.
From photographs by Charles D. Walcott.

silica and iron oxide, with a little sulphur, magnesia, and alumina. This graphite is regarded as originating through the metamorphism of vegetable matter included in the original sediments, the agencies of metamorphism being both igneous intrusions and the heat and pressure incidental to the folding of the beds.¹

As to so much of the graphite as occurs in beds there seems, then, little doubt as to its origin from plant remains which may be imagined to have existed in the form of seaweeds or to have been derived from diffused bituminous matter. The origin of the vein material is not so evident, though it seems probable that it is due to the metamorphism of bituminous matter segregated into veins, like those of albertite in New Brunswick or of gilsonite, etc., in Utah. Kemp states that the Ticonderoga graphite must have reached the fissure as some volatile or liquid hydrocarbon, such as petroleum, and become metamorphosed in time to its present state. Walther believes the Ceylon material to have originated by the reduction of carburetted vapors. (See also under origin of diamonds, p. 166.)

The total quantity of carbon in the form of graphite in the Laurentian rocks of Canada has been estimated by Dawson as equal to that in any similar areas of the Carboniferous system of Pennsylvania.

Sources.—The chief sources of the graphite of commerce are Austria and Ceylon. Other sources of commercial importance are Germany, Italy, Siberia (Specimen No. 61138, U.S.N.M.), the United States, and Canada. The chief deposits of commercial value in the United States are at Ticonderoga, New York, where the graphite occurs in a granular quartz rock, or, according to J. F. Kemp, in "Elliptical Chimneys in Gneiss which are filled with Calcite and Graphite." An earthy, impure graphite, said to be suitable for foundry facings, is mined near Newport, Rhode Island (Specimen No. 53797, U.S.N.M.). About one hundred years ago the material was mined in Bucks County, Pennsylvania. Other American localities represented in the collections are Bloomingdale, New Jersey (Specimen No. 56272, U.S.N.M.); Clintonville, New York (Specimen No. 31597, U.S.N.M.); Hague, Warren County, New York (Specimen No. 63132, U.S.N.M.); Raleigh, Wake County, North Carolina (Specimen No. 63133, U.S.N.M.); Lehigh and Berks counties, Pennsylvania (Specimens Nos. 66952, 66953, U.S.N.M.); Salt Sulphur Springs, West Virginia (Specimen No. 63423, U.S.N.M.); St. Johns, Tooele County, Utah (Specimen No. 62721, U.S.N.M.).

Graphite is a very common mineral in the Laurentian rocks of Canada. The most important known localities are north of the Ottawa River, in the townships of Buckingham, Lochaber, and Grenville (Specimens Nos. 59976, 51007, U.S.N.M.). At Buckingham it is stated masses of graphite have been obtained weighing nearly 5,000 pounds.

¹Jahrbuch k. k. Geologische Reichsanstalt, 1897, XLVII, p. 21.

At Grenville the graphite occurs in a gangue consisting mainly of pyroxene, wollastonite, feldspar, and quartz, while the country rock is limestone. Blocks of graphite have been obtained weighing from 700 to 1,500 pounds.¹

Graphite is also found in Japan (Specimen No. 34359, U.S.N.M.), Australia (Specimen No. 62177, U.S.N.M.), New Zealand (Specimens Nos. 17796 and 64795, U.S.N.M.), Greenland (Specimen No. 65374, U.S.N.M.), Guatemala (Specimen No. 33990, U.S.N.M.), Germany, and in almost all the Austrian provinces, the most important and best known deposits being those of Kaiserberg at St. Michel, where there are five parallel beds occurring in a grayish black graphite schist, the beds varying from a few inches to 6 yards. The only workable deposit in Germany is stated to be at Passau in Bavaria. The material occurs in a feldspathic gneiss, seeming to take the place of the mica (Specimen No. 52050, U.S.N.M.). The beds have been worked chiefly by peasants for centuries, and the output used mainly for crucibles.²

Uses.—Graphite is used in the manufacture of “lead” pencils, lubricants, stove blacking, paints, refractory crucibles, and for foundry facings. In the manufacture of pencils only the purest and best varieties are used, and high grades only can be utilized for lubricants (Specimens Nos. 51608–51619, U.S.N.M.). For the other purposes mentioned impure materials can be made to answer. In the manufacture of the Dixon crucibles (Specimens Nos. 51598–51600, U.S.N.M.) a mixture of 50 per cent graphite, 33 per cent of clay, and 17 per cent of sand is used.

Preparation.—In nature graphite is usually associated with harder and heavier materials, which it is necessary to get rid of before the material is of value. In New York it is the custom to crush the rock in a battery of stamps, such as are used in gold mining, and then separate the graphite by washing, its lighter specific gravity permitting it to be floated off on water, while the heavy, injurious constituents are left behind. Mica, owing to its scaly form, can not be separated in this manner, and hence micaceous ores of the mineral are of little if any value.

An improvement in the manufacture of plumbago or graphite has been described in a recent patent specification. Graphite, crushed and passed through a sieve of from 120 to 150 meshes per inch, is stirred into a saturated solution of alum or aluminum sulphate at a temperature of 212° F.; steatite is then added, and more water, if required. After mixing, excess of water is evaporated until a consistency suited to grinding in a chilled steel or other mixer is obtained. More graphite may here be added; then, after thorough grinding, the material may be compressed into cakes for household use, or is ready for the manu-

¹ Descriptive Catalogue of Economic Minerals of Canada, 1876, p. 122.

² The Journal of the Iron and Steel Institute, 1890, p. 739.

facture of pencils or crucibles. The average formula of the mixture is: Graphite, 80 parts; steatite, soapstone, or talc, 14 parts; alum, 6 parts; but this varies with the purpose to which the material is to be applied. When several different kinds of graphite have to be employed, the richest in carbon is first mixed into the alum solution. By this process graphites previously regarded as incapable of being compacted are utilized, and are improved in polishing power. For pencils the material may be hard without being brittle, and black without being soft, while crucibles made from the treated graphite are at once harder, more durable, and lighter.¹

Prices.—The value of the mineral varies with its quality. In 1899 the crude lump was reported as worth \$8 a ton and the pulverized \$30.

The annual output as given² for the principal countries is as follows:

World's production of graphite.

Year.	Austria.	Canada.	Ceylon.	Germany.	India.	Italy.	United States.
	<i>Metric tons.</i>	<i>Metric tons.</i>	<i>Metric tons.</i>	<i>Metric tons.</i>	<i>Metric tons.</i>	<i>Metric tons.</i>	<i>Metric tons.</i>
1892.....	20,978	151	21,300	4,036	(a)	1,645	707
1893.....	23,807	Nil.	21,900	3,140	(a)	1,465	634
1894.....	24,121	63	10,718	3,133	1,623	1,575	349
1895.....	28,443	199	13,711	3,751	(a)	2,657	171
1896.....	35,972	126	10,463	5,248	(a)	3,148	184
1897.....	38,504	396	b 19,275	3,861	61	5,650	450
1898.....	33,062	1,107	b 78,509	4,593	22	6,435	824

a Not reported in the Government statistics.

b Exports.

BIBLIOGRAPHY.

J. W. DAWSON. On the Graphite of the Laurentian of Canada.

Quarterly Journal Geological Society of London, XXVI, 1870, p. 112.

M. BONNEFOY. Mémoire sur la Géologie et l'Exploitation des Gîtes de Graphite de la Bohême Méridionale.

Annales des Mines. 7th Ser., XV. 1879, p. 157.

JOHN S. NEWBERRY. The Origin of Graphite.

School of Mines Quarterly, VIII, 1887, p. 334.

Der Graphitbergbau auf Ceylon.

Berg- und Hüttenmännische Zeitung, XLVII, 1888, p. 322.

J. WALTHER. Ueber Graphitgänge in zersetztem Gneiss (Laterit) von Ceylon.

Zeitschrift der Deutschen Geologischen Gesellschaft, XLI, 1889, p. 359.

A. PALLAUSCH. Die Graphitbergbaue im südlichen Böhmen.

Berg- und Hüttenmännisches Jahrbuch, XXXVII, p. 95, 1889.

T. ANDRÉE. Graphite Mining in Austria and Bavaria. (Abstract.)

Journal of the Iron and Steel Institute, 1890, p. 738.

¹ Engineering and Mining Journal, LVIII, 1894, p. 440.

² The Mineral Industry, VI, 1897; VIII, 1899.

J. POSTLETHWAITE. The Borrowdale Plumbago; its Mode of Occurrence and Probable Origin.

Proceedings of the Geological Society of London, Session, 1889-1890, p. 124.
On the formation of Graphite in contact-metamorphism.

American Journal of Science, XLII, 1891, p. 514. Review of article in
Berichte der Deutschen chemischen Gesellschaft, XXIV, p. 1884, 1891.

W. LUZI. Zur Kenntniss des Graphitkohlenstoffes. (Berichte der Deutschen Chemischen Gesellschaft, XXIV, pp. 4085-4095. 1891.)

Neues Jahrbuch für Mineralogie, Geologie und Paleontologie. 1893. II, Part 2, p. 241. (Abstract.)

E. WEINSCHENK. Zur Kenntniss der Graphitlagerstätten. Chemisch-geologische Studien von Dr. Ernst Weinschenk.

1. Die Graphitlagerstätten des bayerischen Grenzgebirges. Habilitationsschrift zur Erlangung der *venia legendi* an der K. technischen Hochschule. München, 1897.

FRANZ KRETSCHMER. The Graphite Deposits of Northern Moravia.

Transactions of the North of England Institute of Mining and Mechanical Engineer, XLVII, 1898, p. 87.

2. SULPHUR.

Color of the mineral when pure yellow, sometimes brownish, reddish, or gray through impurities. Hardness, 1.5 to 2.5. Specific gravity, 2.05. Insoluble in water or acids. Luster resinous. Occurs native in beautiful crystals (Specimens Nos. 53115, 53116, and 60669, U.S.N.M.) or in massive (Specimens Nos. 16092, 60849, U.S.N.M.), stalactitic and spheriodal forms (Specimens Nos. 57137 and 60864, U.S.N.M.). Once seen the mineral is as a rule readily recognized, and all possible doubts are set at rest by its ready inflammability, burning with a faint bluish flame and giving the irritating odors of sulphurous anhydride. In nature often impure through the presence of clay and bituminous matters; sometimes contains traces of selenium or tellurium (Specimens Nos. 60856 and 60864, U.S.N.M.).

Origin and mode of occurrence.—Sulphur deposits of such extent as to be of economic importance occur as a product of volcanic activity, or result from the alteration of beds of gypsum. On a smaller scale, and of interest from a purely mineralogical standpoint, are the occurrences of sulphur through the alteration of pyrite and other metallic sulphides.

As a product of volcanic action sulphur is formed through the oxidation of hydrogen disulphide (H_2S), which, together with steam and other vapors, is a common exhalation from volcanic vents and solfataras. Such deposits on a small scale may be seen incrusting fumaroles in the Roaring Mountain (Specimen No. 72872, U.S.N.M.) or associated with the sinter deposits of the Mammoth Hot Springs in the Yellowstone Park (Specimen No. 72877, U.S.N.M.). It may also be produced through the mutual reaction of hydrogen disulphide (H_2S) on sulphuric anhydride (SO_3), the product being sulphur (S) and water (H_2O) as

before. To these types belong the sulphur deposits of Utah, California, Nevada, and Alaska in the United States, as well as those of Mexico, Japan, Iceland, and other volcanic regions. Sulphur is derived from the sulphate of lime (gypsum or anhydrite) through the reducing action of organic matter. The sulphate, through the loss of its oxygen, becomes converted into a sulphide, which, through the carbonic acid in the air and water, becomes finally reduced to hydrogen disulphide with the formation of calcium carbonate.

According to Fuchs and De Launay¹ there is formed at the same time with the hydrogen disulphide a polysulphide, which in its turn yields a precipitate of sulphur and carbonate of lime. The maximum amount of sulphur which would thus result from the decomposition of a given amount of gypsum is stated to be 24 per cent. This method of origin is illustrated in the celebrated deposit of Sicily, where we have the sulphur partially disseminated through and partly interbedded with a blue-gray limestone. (See Specimen No. 60932, U.S.N.M.). Beneath the sulphur beds as they now exist are found the older gypseous beds, which through decomposition have yielded the materials for the lime and sulphur beds now overlying.

With these Sicilian sulphurs occur a number of beautiful secondary minerals, as celestite (Specimens Nos. 60866, 60869, 60877, U.S.N.M.), calcite (Specimens Nos. 60854, 60865, 60871, U.S.N.M.), aragonite (Specimen No. 60859, U.S.N.M.), and selenite (Specimen No. 60857, U.S.N.M.).

Sulphur derived directly from metallic sulphides is of little economic interest. Kemp states² that masses of pyrite in the calciferous strata on Lake Champlain may yield crusts of sulphur an inch or so thick, and it is not uncommon to find small crystals of the mineral resulting from the alteration of galena, as described by George H. Williams³ at the Mountain View (Maryland) lead mine.

The minute quantities of sulphur found in marine muds are regarded by J. Y. Buchanan⁴ as due to the oxidation of metallic sulphides, which are themselves produced by the action of animal digestive secretions on preexisting sulphates, mainly of iron and manganese.

Localities.—The principal localities of sulphur known in the United States are, in alphabetical order: Alaska, California, Idaho, Louisiana, Nevada, Texas, Utah, and Wyoming. With the possible exception of those of Idaho and Texas, and that of Louisiana, these may all be traced to a solfataric origin. The Alaskan deposit,⁵ according to Dall, are best developed on the islands of Kadiak and Akutan.

¹Traité des Gîtes Minéraux et Métallifères, I, p. 259.

²The Mineral Industry, II, 1893, p. 585.

³Johns Hopkins University Circulars, X, 1891, p. 74.

⁴Proceedings of the Royal Society of Edinburgh, XVIII, 1890-91, p. 17.

⁵Alaska and its Resources, Boston, 1870.

California deposits have in times past been worked at Clear Lake, in Modoc County, in Colusa County, in Tehama County (Specimen No. 30118, U.S.N.M.), and in Napa County (Specimen No. 67697, U.S.N.M.). The Louisiana deposits lie in strata of Quaternary age, and are derived from gypsum. The following facts relative to this deposit are from Professor Kemp's paper, already alluded to:

Probably the richest and geographically the most accessible of the American localities is in southwestern Louisiana, 230 miles west of New Orleans and 12 miles from Lake Charles. The first hole which revealed this sulphur was sunk in search of petroleum, of which the presence of oil and tarry matter on the surface were regarded, quite justly, as an indication. While more or less of these bituminous substances were revealed by the drill, the great bed of sulphur is the main object of interest. A number of holes have since been put down with the results recorded below, and they leave no doubt that there is a very large body which awaits exploitation. The first explorations were made by the Louisiana Petroleum and Coal Oil Company. It was succeeded by the Calcasieu Sulphur and Mining Company. The Louisiana Sulphur Mining Company followed, and now the owners are the American Sulphur Company. The records of four holes are appended. Nos. 1 and 2 were the first sunk, and were about 150 feet apart. Nos. 2, 3, and 4 were put down in 1886. No. 3 is northwest of No. 1.

Records of several of the bore holes that have penetrated the sulphur bed.

Strata.	Original well No. 1.	Granet's Wells.			Van Slooten's well No. 5.	American Sulphur Company.		
		No. 2.	No. 3.	No. 4.		No. 6.	No. 7.	No. 8.
Clay, quicksand, and gravel	333	344	426	332	345	350	370	499
Soft rock	110	84	70	138	91	95	72	44
Sulphur bed, 70 to 80 per cent.	108	112	119	45	110	125	126	52
Gypsum and sulphur.	680	12	6	(a)	57	32	30	(a)
Depth of hole	1,231	552	621	525	603	602	598	596

a Stopped in sulphur.

Analyses from the large bed in holes No. 2 and No. 3 gave the following:

Depth.	Sulphur.	Depth.	Sulphur.
<i>Hole No. 2.</i>	<i>Per cent.</i>	<i>Hole No. 3.</i>	<i>Per cent.</i>
428 feet.....	62	503 feet	70
441 feet.....	70	533 feet	60
459 feet.....	80	549 feet	81
466 feet.....	83	552 feet	91
486 feet.....	90	604 feet	98
— feet.....	80		
— feet.....	75		
— feet.....	80		
540 feet.....	68		

The difficulties in development lie in the quicksands and gravel, which are wet and soft, and in the soft rock (hole 1), which yields sulphurous waters under a head, at the surface, of about 15 feet.

The Nevada deposits occupy the craters of extinct hot springs near Humboldt House. These craters are described by Russell¹ as situated on the open desert, above the surface of which they rise to a height of from 20 to 50 feet.

Nearly all of the cones are weathered and broken down, and are all extinct, the water now rising to the surface for miles around. The outer surface of the cones is composed of calcareous tufa and siliceous sinter, forming irregular imbricated sheets that slope away at a low angle from the orifice at the top. The interiors of these structures are filled with crystalline gypsum, that in at least two instances is impregnated with sulphur. One of the cones has been opened by a cut from the side in such a manner as to expose a good section of the material filling the interior, and a few tons of the sulphur and gypsum removed. The percentage of sulphur is small, and the economic importance of the deposit, as shown by the excavation already made, will not warrant the further expenditure of capital. The cone that has been opened is surrounded on all sides by a large deposit of calcareous and siliceous material, thus forming a low dome or crater, with a base many times as great in diameter as the height of the deposit. These cones correspond in all their essential features with the structures that surround hot springs that are still active in various parts of the Great Basin, thus leaving no question as to their origin. They are situated within the basin of Lake Lahontan, and must have been formed and become extinct since the old lake evaporated away.

Sulphur is reported as occurring in the chemically formed deposits that surrounded Steamboat Springs, situated midway between Carson and Reno, Nevada. The conditions at these springs must be very similar to those that existed near Humboldt House at the time the cones containing the sulphur were formed. Sulphur is also said to occur in the Sweetwater Mountains, situated on the boundary between California and Nevada, in latitude $38^{\circ} 30'$. The extent and geological relations of these deposits are unknown.

Another illustration of sulphur deposits of the volcanic type is that furnished by the Rabbit-Hole Sulphur Mines (Specimen No. 16092, U.S.N.M.). These are located in northwestern Nevada, on the eastern border of the Black Rock Desert, and derive their name from the Rabbit-Hole Springs, a few miles to the southward. The hills bordering the Black Rock Desert on the east are mainly of rhyolite, with a narrow band of volcanic tufa along the immediate edge of the desert. These beds of tufa are stratified and evidently water-lain, and are identical with tufa deposits that occur over an immense area in Oregon and Nevada. At the sulphur mines the tufas contain angular fragments of volcanic rock, and have been cemented by opal and other siliceous infiltrations since their deposition, so that they now form brittle siliceous rocks, with pebbles and fragments of older rocks scattered through the mass.

¹Transactions of the New York Academy of Sciences, I, 1881-1882, p. 172.

In many places these porous tufas and breccias are richly charged with sulphur, which fills all the interstices of the rock and sometimes lines large cavities with layers of crystals 5 or 6 feet in thickness. In the Rabbit-Hole District sulphur has been found in paying quantities for a distance of several miles along the border of the desert, but the distribution is irregular and uncertain, and is always superficial, so far as can be judged by the present openings. The sulphur has undoubtedly been derived from a deeply seated source, from which it has been expelled by heat, and escaping upward along the lines of faulting has been deposited in the cooler and higher rocks in which it is now found, though whether the deposition took place by direct sublimation or through the decomposition of hydrogen disulphide can not now be told with certainty. Judging from the siliceous material that cements the tufas, it is evident that the porous rocks in which the sulphur is now found were penetrated by heated waters bearing silica in solution previous to the deposition of the sulphur. The mines occur in a narrow north-and-south belt along a line of ancient faulting which is one of the great structural features of the region. The association of faults with sulphur-bearing strata of tufa is here essentially the same as at the Cove Creek Mines, yet to be noted. At the Rabbit-Hole Mines, however, no very recent movement of the ancient fault could be determined. This absence of a recent fault-scarp, together with the fact that the mines are now cold and do not give off exhalations of gas or vapor, shows that the solfataric action at this locality has long been extinct, though at the Cove Creek Mines, mentioned below, the deposition is still in progress.

According to A. F. Du Faur¹ this Cove Creek (Utah) deposit is in Beaver County, near Millard County line. It was first discovered in 1869, but owing to lack of railroad communications remained undeveloped until 1883. The region is one of comparatively recent volcanic activity. The sulphur occurs impregnating limestone and slate to such a degree that very pure pieces as large as one foot in diameter are obtainable. It also occurs impregnating a decomposed andesite (Specimen No. 14921, U.S.N.M.). The Cove Creek mines are situated about 2 miles southeast of Cove Creek fort and to the east of the Beaver road in a small basin near the foot of the Sulphur Mountains, surrounded by low hills, with a narrow ravine opening in the west-northwest direction into the plain. The basin is about 6,000 feet above the level of the sea, while the Sulphur Mountains to the east rise about 2,000 feet higher. The hills surrounding the basin consist mainly of andesite, partly also of a very light white trachyte.

As far as explored, the sulphur bed extends at least 1,800 feet by 1,000 feet, and the quantity of sulphur contained therein was estimated

¹Transactions of the American Institute of Mining Engineers, XVI, 1888, p. 33.

by Professor vom Rath, at a time when the bed was not as fully exposed as it now is, to be at least 1,300,000 tons.

A curved cut has been made through the sulphur bed near the western end, exposing a vertical wall 34 feet high of rich yellow sulphur. The sulphur extends up to the surface over part of the basin, but is mostly covered with sand or rather decomposed andesite. The surface of the deposit is wavy, giving the impression of an agitated mass gradually cooled. The sulphur is partly mixed with sand or gypsum. Most of it is yellow color, while some of it is dark gray, and is called "black sulphur." The deposits of pure sulphur partly resemble the so-called "virgin rock," which is formed as a product of distillation in the sulphur-flower chambers, particularly when distillation goes on too rapidly. Some also resemble the delicate crystals formed on the walls of such chambers; others are like the crystals formed in slowly cooled masses of sulphur. Gases escape in many places in the cut and in the prospect holes, together with water holding salts in solution. At some points also a considerably elevated temperature is observed.

Of the foreign localities of sulphur, the most noted at present are those of Sicily and Japan. The first-named deposits are described as occurring in Miocene strata involving, from below up, sandy marls with beds of salt, limey marls and lignite, gypsum and limestone impregnated with sulphur, black shales, and micaceous sands.

Overlying all these is a white, marly Pleocene limestone, while below the Miocene is the Eocene nummulitic limestone. The sulphur is found in veinlets and sometimes in larger masses, which ramify through the cellular limestone, as shown in fig. 1 and Specimens Nos. 60932, 60862, 60852, U.S.N.M.

The yield in sulphur varies from 8 to 25 per cent, rarely running as high as 40 per cent. Below 8 per cent the rock can not be worked. More or less petroleum and bitumen are found in the mines. Barite and celestite sometimes accompany the sulphur.

The mining regions are in the southern central portion of the island. Girgenti and Larcara are the chief centers. The mines are distributed over an area 160 to 170 kilometers (about 100 miles) from east to west, and 85 to 90 kilometers (55 miles) from north to south. They occur in groups around centers, partly because the sulphur-bearing stratum

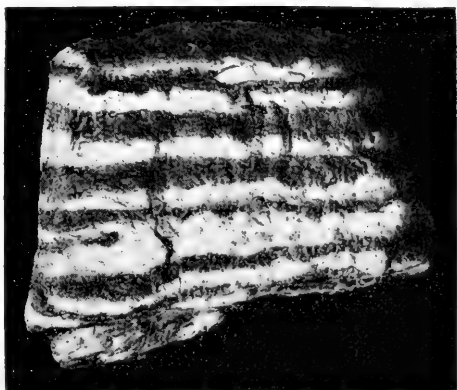


Fig. 1.
BLOCK OF LIMESTONE WITH ALTERNATING BANDS OF
SULPHUR.
Sicily, Italy.
Specimen No. 60932, U.S.N.M.

is not continuous, and partly because the sulphur indications are concealed by later deposits. The region, moreover, is much faulted.

According to Professor Kemp, the common methods of mining are of the crudest description. In most cases the deposits are reached by steep slopes or circular stairways ("scala"), with wide steps, up which boys laboriously bring the crude rock in baskets or sacks. No mine maps are made, and no precautions taken to work beds on a systematic scale. Timbering or any supports for the roof are not generally thought of. A feeling of distrust prevails between the owners of the land and the operators, and between the latter and the miners.

These objectionable features arise partly from the irregular nature and uncertainty of the deposits, partly from excessive subdivision of ownership and ill-adapted property laws, and partly from the local prejudices against innovations. Even in one case where an American and an Englishman in partnership secured the right to work a mine, and set about installing suitable hoisting machinery, they were hampered by a lawsuit with the owner because of this innovation, and had a long legal contention to establish their undoubted rights. It is a striking fact that in the new developments in Japan, on a remote island and against great natural difficulties, the most modern methods and management prevail, while in Sicily, in the center of the oldest civilization, these are to a great extent of the crudest.

The Japanese sulphur deposits are all of volcanic origin, and the Abosanobori mine (Specimen No. 61941, U.S.N.M.), in Kushiro village, Kawakami-gori, Kushiro Province, Hokkaido, may be taken as fairly typical. The mine is on a conical-shaped mountain of augite andesite which, on its northern side is open, and looks down upon a plain covered with lava and shut in by the walls of the old crater on the other sides. Sulphur is found in different parts of these walls in massive heaps and sulphur fumes still issue nearly everywhere about the mines. The ore as taken from the mines carries from 35 per cent to 90 per cent of sulphur, which is extracted by steam refining works at Hyocha, some 35 miles north of the mine.¹

Other Japanese localities represented in the collection are the Aroya mines, at Onikobe village, Rikuzen Province (Specimen No. 61945, U.S.N.M.), refined sulphur from the Mitsui Production Company at Tokio (Specimen No. 61944, U.S.N.M.), and the active volcano of Iwo-San, in Yezo (Specimen No. 72801, U.S.N.M.).

In addition to these localities may be mentioned the following, in alphabetical order: Austria, Celebes, Egypt, France, Greece, Hawaii, Iceland, Italy, Mexico (Specimens Nos. 57136 and 57137 from Popocatepetl), New South Wales, New Zealand, Peru, Russia, Spain, and the West Indies (Specimen No. 33309, U.S.N.M.).

¹The Mining Industry of Japan, by Wada Tsunashiro, 1893.

Extraction and preparation.—Sulphur rarely occurs in nature in any quantity sufficiently pure for commercial purposes. In freeing it from its impurities three methods are employed: (1) Melting, (2) distillation, and (3) solution. In the first the ore is simply dry washed at a low temperature or treated with superheated steam until the sulphur melts and runs off. Specimen No. 60861 shows the rock after being subjected to this treatment. The first process is extremely wasteful; the second much more economical in the end, but demanding a more expensive plant. A process of fusion in a calcium chloride solution has come into use of late years, and bids fair to yield better results than either of the above. In the distillation process the ore is heated in iron retorts until the sulphur distills off and is condensed in chambers prepared for it. Specimen No. 60860 shows the rock after removal of the sulphur by this process. The product is mostly in the form of "flower of sulphur." The method is expensive, but the resultant sulphur very pure. In the third process mentioned the ore is treated with carbon disulphide, which dissolves out the sulphur and from which it is recovered by evaporation. This method, while giving good results, is expensive and somewhat dangerous, owing to the explosive nature of the gases formed.¹

Uses.—Sulphur is used mainly for making of sulphuric acid—though small amounts are utilized in the manufacture of matches—for medicinal purposes, and in the making of gunpowder, fireworks, insecticides, for vulcanizing india rubber, etc. In the manufacture of sulphuric acid the sulphur is burned to sulphurous anhydride (SO_2) on a grate and then conducted with a slight excess of air into large lead-lined chambers and mixed with steam and nitrous fumes, where the SO_2 is oxidized to the condition of SO_3 (sulphuric anhydride) and takes up water from the steam forming H_2SO_4 (sulphuric acid). Ordinary roll sulphur is quoted in the current price lists at from $1\frac{1}{2}$ to $2\frac{1}{2}$ cents per pound. (See also under iron pyrites, p. 190.)

BIBLIOGRAPHY.

- R. PUMPELLE.—Sulphur in Japan.
Geological Researches in China, Mongolia, and Japan. Smithsonian Contributions, XV, 1867, p. 11.
- I. C. RUSSELL.—Sulphur Deposits of Utah and Nevada.
Transactions of the New York Academy of Science, I, 1882, p. 168.
- A. FABER DU FAUR.—The Sulphur Deposits of Southern Utah.
Transactions of the American Institute Mining Engineers, XVI, 1887, p. 33.
The Sulphur Mines of Sicily.
Engineering and Mining Journal, XLVI, 1888, p. 174.
- V. LAMANTIA. Sulphur Mines of Sicily.
U. S. Consular Report No. 108, 1889, pp. 146–155.

¹ The Mineral Industry, II, 1893, p. 600.

3. ARSENIC.

This substance occurs native in the form of a brittle, tin-white metal, with a specific gravity of 5.6 to 5.7 and a hardness equal to 3.5 of the scale. On exposure it becomes dull black on the immediate surface. It is found, as a rule, in veins in the older crystalline rocks associated with antimony and ores of gold and silver. Some of the more celebrated localities for the mineral, as given by Dana, are the silver mines of Freiberg (Specimens Nos. 60924 and 67730, U.S.N.M.), Annaberg, Marienberg, and Schneeberg in Saxony; Joachimsthal in Bohemia; Andreasberg in the Harz; Kapnik and Orawitz in Hungary; Kongsberg in Norway; Zmeov in Siberia; St. Maria aux Mines, Alsace; Mount Corna dei Darden, Italy; Chañarcillo, Chili; San Augustin, Hidalgo, Mexico, and New Zealand. In the United States it has been found at Haverhill, New Hampshire; Greenwood, Maine; near Leadville, Colorado; and on Watson Creek, Frozen River in British Columbia.

The arsenic of commerce is, however, rarely obtained from the native mineral, but is prepared by the ignition of arsenical pyrites (FeAs_2) or arsenical iron pyrites ($\text{FeS}_2, \text{FeAs}_2$). The white arsenic of commerce (arsenious acid, As_2O_3), though occurring sometimes native as arsenolite in the form of botryoidal and stalactitic crusts of a white or yellowish color, is, as a rule, obtained as a by-product in the metallurgical operations of extracting certain metals, particularly cobalt and nickel, from their ores. Such ores as niccolite, a nickel arsenide (NiAs), gersdorffite (NiAsS), Rammelsbergite (NiAs_2), Smaltite (CoAs_2), Skutterudite (CoAs_3), Proustite (Ag_3AsS_3), and other arsenides and sulpharsenides on roasting give up their arsenic in the form of fumes, which are condensed in chambers prepared for this purpose.

Uses.—Arsenic is utilized in the form of arsenious acid (As_2O_3) in dyeing, calico printing, in the manufacture of various pigments, in arsenical soaps, in the preparation of other salts of arsenic, and as a preservative in museums, particularly for the skins of animals and birds.

4. ALLEMONTITE.

Allemontite, or arsenical antimony of the formula SbAs_3 , =arsenic 65.2; antimony 34.8, occurs somewhat sparsely at Allemont in France, Pribram, Bohemia, and other European localities associated with sphalerite, antimony, etc. (Specimen No. 67728, U.S.N.M.). So far as the writer has information the mineral has not as yet been found in sufficient quantity to be of economic value.

II. SULPHIDES AND ARSENIDES.

1. REALGAR.

This is a monosulphide of arsenic, AsS , = sulphur 29.9 per cent; arsenic, 70.1 per cent; hardness, 1.5 to 2; specific gravity, 3.55; color, aurora red or orange yellow, streak the same.

2. ORPIMENT; AURIPIGMENT.

A trisulphide of arsenic, of the formula As_2S_3 , = sulphur 39 per cent, arsenic, 61; hardness, 1.5; specific gravity, 3.4 to 3.5. Color, lemon yellow. This mineral occurs usually associated with realgar at the localities mentioned below.

Occurrences.—Realgar and orpiment are very beautiful, though not abundant minerals which occur associated with ores of silver and lead in various European mining regions and also those of Japan (Specimen No. 11864, U.S.N.M.), Hungary (Specimen No. 66813, U.S.N.M.), Bohemia, Transylvania, and Saxony. They have been reported in the United States in beds of sandy clay beneath lava in Iron County, Utah, and form the so-called "Arsenical gold ore" of the Golden Gate Mine, Mercur, Tooele County, this same State (Specimen No. 53363, U.S.N.M.); also in San Bernardino County, California; Douglas County, Oregon (Specimen No. 62101, U.S.N.M.), and in minute quantities in the geyser waters of the Yellowstone National Park.

The realgar and orpiment of the Coyote mining district, Iron County, Utah, occur in a compact, sandy clay, occupying a horizontal seam or layer about 2 inches thick, not distinctly separated from the clay, but lying in its midst in lenticular and nodular masses. The bulk of the layer consists of realgar in divergent, bladed crystals, closely and confusedly aggregated, sometimes forming groups of brilliant crystal-line facets in small cavities toward the center of the mass. The orpiment is closely associated with the realgar in the form of small and delicately fibrous crystalline rosettes, and small spherical aggregations made up of fine radial crystals, and also in bright yellow, amorphous crusts in and around the mass of the realgar. Fine parallel seams of gypsum occur both above and below the layer, and the strata of arenaceous clays above for 30 feet or more are charged with soluble salts which exude and effloresce upon the surface of the bank, forming hard crusts. The whole appearance and association of the minerals indicates that they have been formed by aqueous infiltration since the deposition of the beds.¹

Orpiment is said² to occur at Tajowa, near Neusohl, Hungary, as nodular masses and isolated crystals in clay or calcareous marl.

¹ W. P. Blake, American Journal of Science, XXI, 1881, p. 219.

² H. A. Miers, Mineralogical Magazine, July, 1892, p. 24.

Uses.—Realgar is used mainly in pyrotechny, yielding a very brilliant white light when mixed with saltpeter and ignited. It is now artificially prepared by fusing together sulphur and arsenious acid.¹ Orpiment is used in dyeing and in preparation of a paste for removing hair from skins. According to the British consular reports there were exported from Baghdan, in 1897, some 55,600 pounds of the mineral for use as a pigment. As with realgar, the mineral is now largely prepared artificially. The name "orpiment" is stated by Dana to be a corruption of *auripigment*, golden paint, in allusion to the color.

BIBLIOGRAPHY.

- W. P. BLAKE. Occurrence of Realgar and Orpiment in Utah Territory.
American Journal of Science, XXI, 1881, p. 219.
- H. B. FULTON. Arsenic in Spanish Pyrites, and its elimination in the local treatment for production of copper precipitate.
Journal of the Society of Chemical Industry, V, 1886, p. 296.
- Production of Arsenic in Cornwall and Devon.
Engineering and Mining Journal, LII, 1891, p. 96.
- WILLIAM THOMAS. Arsenic.
The Mineral Industry, II, 1893, p. 25.

3. COBALT MINERALS.

Several minerals contain cobalt as one of their essential constituents in sufficient quantity to make them of value as ores. In other cases the cobalt exists in too small quantities to pay for working for this substance alone, and it is obtained as a by-product during the process of extraction of other metals, notably of nickel. The common cobalt-bearing minerals, together with their chemical composition, mode of occurrence, and other characteristics are given below:

COBALTITE.—Cobaltine, or cobalt glance. (Specimens Nos. 60922, 34266, U.S.N.M.) This is a sulpharsenide of cobalt of the formula Co AsS , = Sulphur 19.3 per cent; arsenic, 45.2 per cent; cobalt, 35.5 per cent; hardness 5.5, and specific gravity 6 to 6.3. The luster is metallic and color silver white to reddish. When in crystals, commonly in cubes or pyritohedrons. Analysis of a massive variety from I, Siegen, Westphalia; II, Skutterud, Norway, and III and IV, Daskhessian, in the government of Elizavetpol, Caucasus, as given by various authorities, yielded results as below:

Constituents.	I.	II.	III.	IV.
Arsenic	45.31	43.46	35.97	31.73
Sulphur	19.35	20.08	.....	.....
Cobalt	33.71	33.10	17.90	17.55
Iron	1.63	3.23	1.44	9.85
Nickel .....	.....	.....	0.22	0.26
Undetermined .....	.....	.....	44.26	40.71

¹Wagner's Chemical Technology, p. 87.

In Saxony the mineral (Specimens Nos. 60922 and 67736, U.S.N.M.) occurs in lodes in gneiss and in which heavy spar (baryte) forms the characteristic gangue. It is associated with other metallic sulphides, notably those of lead and copper. At Skutterud and Snarum, Norway, the cobaltiferous fahlbands, according to Phillips¹—

Occur in crystalline rocks varying in character between gneiss and mica schists, but from the presence of hornblende they sometimes pass into hornblende schists; among the accessory minerals are garnet, tourmaline, and graphite. These schists, of which the strike is north and south, and which have an almost perpendicular dip, contain fahlbands very similar in character to those of Kongsberg. They differ from those of that locality, however, inasmuch as while here the fahlbands are often sufficiently impregnated with ore to pay for working, those of Kongsberg, although to some extent containing disseminated sulphides, are only of importance as zones of enrichment for ores occurring in veins. The ore zones usually follow the strike and dip of the surrounding rocks, and vary in breadth from $2\frac{1}{2}$ to 6 fathoms. The distribution of the ores is by no means equal, since richer and poorer layers have received special names and are easily recognized. The Erzbander, or ore bands, are distinguished from the Reicherzbander, or rich ore bands, while the bands of unproductive rock are known as Felsbander. The predominant rock of the fahlbands is a quartzose granular mica schist, which gradually passes into quartzite, ordinary mica schist, or gneiss. The ores worked are cobalt glance, arsenical, and ordinary pyrites containing cobalt, skutterudite, magnetic iron pyrites, copper pyrites, molybdenite, and galena. It is remarkable that in these mines nickel ores do not accompany the ores of cobalt in any appreciable quantity. The principal fahlband is known to extend for a distance of about 6 miles, and is bounded on the east by a mass of diorite which protrudes into the fahlband, while extending from the diorite are small dikes or branches traversing it in a zigzag course. It is also intersected by dikes of coarse-grained granite which contain no ore, but which penetrate the diorite.

The Skutterud mine in 1879 produced 7,700 tons of cobalt ore, which yielded 108 tons of cobalt schlich (concentrates), containing from 10 to 11 per cent of cobalt, and worth about £11,000.

At Daeshkessan the ore occurs under a sheet of diabase, the cobaltite being in the wall rock of this sheet, and which carries also garnets and copper pyrites. In 1887, 1,216 kilograms of the mineral were extracted; in 1888, 928 kilograms, and in 1889, 12,960 kilograms, besides some 3,000 kilograms of cobaltiferous matter obtained in treating the cobaltiferous copper ores.²

SMALTITE.—(Specimen No. 66757, U.S.N.M.) This is essentially a cobalt diarsenide of the formula CoAs_2 , = arsenic, 71.8 per cent; cobalt, 28.2 per cent; hardness, 5.5 to 6; specific gravity, 6.4 to 6.6. Color, white to steel gray. Through the assumption of nickel the mineral passes by gradations into chloanthite.

¹Ore Deposits, by J. A. Phillips, p. 389. ²Annales des Mines, II, 1892, p. 503.

Analyses of samples from (I) Schneeberg, Saxony, and (II) Gunnison County, Colorado, as given by Dana, yielded results as below:

Constituents.	I.	II.
Arsenic.....	71.53	63.82
Sulphur.....	1.38	1.55
Cobalt.....	18.07	11.59
Iron.....	7.31	15.99
Nickel.....	1.02	Trace.
Copper.....	0.01	0.16

The mineral occurs like cobaltite in veins associated with other metallic arsenides and sulphides.

SKUTTERUDITE is the name given to a cobaltic arsenide of the formula CoAs_3 , = arsenic, 79.3; cobalt, 20.7. It is of a tin-white color, varying to lead-gray, has a hardness of 6, and specific gravity of 6.72 to 6.86. It occurs associated with cobaltite, titanite, and hornblende in a vein in gneiss at Skutterud, Norway. The name *safflorite* is given to a cobalt diarsenide closely resembling smaltite but differing in being orthorhombic, rather than isometric in crystallization. The composition as given by Dana is quite variable, running from 61 per cent to 70 per cent arsenic, and 10 to 23 per cent cobalt, with 4 to 18 per cent of iron and smaller amounts of sulphur, copper, nickel, and bismuth. It is found associated with smaltite in various localities.

GLAUCODOT is a sulpharsenide of cobalt and iron of the formula $(\text{Co}, \text{Fe}) \text{AsS}$, = sulphur, 19.4 per cent; arsenic, 45.5 per cent; cobalt, 23.8 per cent; iron, 11.3 per cent. Color, grayish; hardness, 5; specific gravity, 5.9 to 6. Actual analysis of a Chilean variety yielded (according to Dana) As 43.2, S 20.21, Co 24.77, Fe 11.90. It is therefore essentially a ferriferous cobaltite, that is, a cobaltite in which a part of the cobalt has been replaced by iron. The mineral is found at Huasco, Chile, associated with cobaltite in a chloritic schist. The name *allosclerite* is given to a variety of glaucodot containing bismuth and answering to the formula $\text{Co}(\text{As}, \text{Bi})\text{S}$. The composition as given is somewhat variable. Arsenic, 28 to 33 per cent; bismuth, 23 to 32 per cent; sulphur, 16 to 18 per cent; cobalt, 20 to 24 per cent; iron, 2.7 to 3.8 per cent. It is reported only from Orawitza, Hungary.

LINNÆITE (Specimens Nos. 56159, 65309, U.S.N.M.) is a sulphide of cobalt with the formula Co_3S_4 , = sulphur, 42.1 per cent; cobalt, 57.9 per cent; a part of its cobalt is commonly replaced by nickel, giving rise to its variety *siegenite*. The mineral is brittle, of a pale steel-gray color, tarnishing red. Hardness, 5.5 and specific gravity 4.8 to 5. When crystallized it is commonly in octahedrons. The following analyses of a nickel-bearing variety (*siegenite*) are quoted from Dana:

Constituents.	S.	CO.	Ni.	Fe.	Cu.
Müsen, Prussia	41.00	43.86	.....	5.31	4.10
Mineral Hill, Maryland.....	39.70	25.69	29.56	1.96	2.23
Mine La Motte, Missouri	41.54	21.34	30.53	3.37	Trace.

The mineral occurs in gneiss in Sweden; with barite and siderite at Müsen; in limestone with galena and dolomite at Mine La Motte, Missouri, and with sulphides of iron and copper in chloritic schists in Maryland.

SYCHNODYMITE has the formula $(\text{Co}, \text{Cu})_4 \text{S}_5$, and yields sulphur, 40.64 per cent; copper, 18.98 per cent; cobalt, 35.79 per cent; nickel, 3.66 per cent; iron, 0.93 per cent. It is of a steel-gray color, metallic luster, and has a specific gravity of 4.75.

ERYTHRITE OR COBALT BLOOM (Specimens Nos. 17698, 51909, 56463, 53096, and 67759, U.S.N.M.) is the name given to a hydrous cobalt arsenate of the formula $\text{Co}_3\text{As}_2\text{O}_8 + 8\text{H}_2\text{O}$, = arsenic pentoxide, 38.4 per cent; cobalt protoxide, 37.5 per cent, and water, 24.1 per cent. It occurs in globular and reniform shapes and earthy masses of a crimson to peach-red color associated with the arsenides and sulphar-senides mentioned above and from which it is derived by a process of oxidation. In Churchill County, Nevada, it occurs as a decomposition product of a cobalt bearing niccolite. It is also found at the Kelsey mine, Compton, in Los Angeles County, California; associated with cobaltite at Tambillo and at Huasco, Chile, and under similar conditions in various parts of Europe.

ASBOLITE, or earthy cobalt (Specimen No. 60993, U.S.N.M.), is a black and earthy ore of manganese (wad) which sometimes carries as high as 30 per cent of cobaltic oxide. It takes its name from the Greek *ασβολαινω*, to soil like soot. ROSELITE is an arsenate of lime, magnesia and cobalt with the formula $(\text{Ca}, \text{Co}, \text{Mg})_3\text{As}_2\text{O}_8, 2\text{H}_2\text{O}$, = arsenic pentoxide, 51.4 per cent; lime, 28.1 per cent; cobalt protoxide, 12.5 per cent; water, 8 per cent. It is of a light to dark rose-red color, hardness 3.5; specific gravity 3.5 to 3.6, and vitreous luster. SPHEROCOBALTITE is a cobalt protocarbonate of the formula CoCO_3 , = carbon dioxide, 37.1 per cent; cobalt protoxide, 62.9 per cent. It is also of a rose-red color, varying to velvet black. Hardness 4, and specific gravity 4.02 to 4.13. It occurs but sparingly, associated with roselite at Schneeberg in Saxony. REMINGTONITE is a hydrous carbonate the exact composition of which has not been ascertained. COBALTOMENITE is a supposed selenide of cobalt. BIEBERITE, or cobalt vitriol, is a sulphate of the formula $\text{CoSO}_4 + 7\text{H}_2\text{O}$. The color is flesh to rose red. It is soluble in water, has an astringent taste, and occurs in secondary stalactitic form. PATERAITE is a possible molybdate of cobalt.

Aside from the possible sources mentioned above, cobalt occurs

very constantly associated with the ores of nickel (niccolite, millerite, chloanthite, etc.), and is obtained as a by-product in smelting. Considerable quantities have thus from time to time been obtained from the Gap mines of Pennsylvania, Mine La Motte, Missouri, and Lovelock, Nevada. (Specimen No. 61324, U.S.N.M.) The nickel mines of New Caledonia are perhaps the most productive. The ore here (a silicate), carries some 3 per cent of cobalt protoxide. (Specimen No. 61027, U.S.N.M.)

A vein of cobalt ore near Gothic, Gunnison County, Colorado, is described as lying in granite, the gangue material being mainly calcite, throughout which was disseminated the ore in the form of smaltite. With it were associated erythrite, a small amount of iron pyrites, and native silver. An analysis of this ore yielded as below:

Cobalt	11.59	Bismuth	1.13
Iron	11.99	Copper	0.16
Arsenic	63.82	Nickel	Trace.
Silica	2.60	Silver	Trace.
Lead	2.05		
Sulphur	1.55		94.89

A cobalt ore, consisting of a mixture of glaucodot and erythrite, occurring near Carcoar Railway Station, New South Wales, has the composition given below:

Constituents.	I.	II.
Moisture .....	.120	2.180
Metallic arsenic	51.810	29.010
Metallic cobalt	10.447	13.830
Metallic nickel .....	.590	.390
Metallic iron	11.860	15.78
Alumina		Trace.
Metallic manganese	Nil.	Nil.
Metallic calcium	Nil.	.71
Magnesium	1.480	.22
Gold	Trace.	
Silver	Trace.	
Sulphur	1.520	11.24
Gangue (insoluble in acids)	22.078	26.31
	99.905	99.67
Specific gravity	5.43	

According to the Annual Report, Department of Mines, for 1888, this ore occurs concentrated in irregular hollows and bunches, often intimately mixed with diorite in a line of fissure between an intrusive diorite and slate, the fissure running for some distance following the line of junction between the two rocks, and being presumably formed at the time of the extrusion of the diorite.

Other cobalt ores, carrying from 13 to 15 per cent of cobalt oxide, occur near Nina.¹

Uses.—Cobalt is produced and sold in the form of oxide and used mainly as a coloring constituent in glass and earthen wares. Only some 200 tons are produced annually the world over. The market value of the material is variable, but averages about \$2 a pound.

BIBLIOGRAPHY.

Fuchs et De Launay, *Traité des Gites Minéraux*, II, pp. 75–91.

4. ARSENOPYRITE; MISPICKEL; OR ARSENICAL PYRITES.

Composition.—Somewhat variable. Essentially a sulpharsenide of iron of the formula FeAsS , or $\text{FeS}_2, \text{FeAs}_2$, =arsenic, 46 per cent; sulphur, 19.7 per cent, and iron, 34.3 per cent. The name *danaite* is given to a cobaltiferous variety. The specific gravity of the mineral varies from 5.9 to 6.2. Hardness, 5.5 to 6. Colors, silver white to steel gray, streak dark gray to black; luster, metallic. Brittle.

Occurrence.—The mineral occurs principally in crystalline rocks, and is a common associate of ores of silver, gold, tin, and lead. It is at times highly auriferous, forming a valuable ore of gold, as in New South Wales and more rarely in California and Alaska. It is found in nearly all the States bordering along the Appalachian Mountain system, but in no instance is regularly mined excepting incidentally in the process of working other metals. Concerning its occurrence abroad Dana states that it is “abundant at Freiberg and Munzig, where it occurs in veins (Specimens Nos. 62803, 66809, 66810, 73104, U.S.N.M.); at Reichenstein in Silesia in serpentine; at Auerbach in Baden; in beds at Breitenbrunn and Raschau, Andreasberg and Joachimsthal; at Tunaberg in Sweden; at Skutterud in Norway; at Wheal Mawdlin and Unanimity, Cornwall, and at the Tamar mines in Devonshire, England (Specimens Nos. 67456, 67457, U.S.N.M.) and in Bolivia.

Uses.—The only use of the mineral is as an ore of arsenic.

5. LÖLLINGITE; LEUCOPYRITE.

The prismatic arsenical pyrites, or *leucopyrite*, is essentially a diarsenide of iron, with the formula FeAs_2 , though usually contaminated with a little sulphur and not infrequently cobalt, bismuth, or antimony. It has a specific gravity of 7 to 7.4, hardness of 5 to 5.5, metallic luster and silver-white to steel-gray color.

The mineral has been found at Edenville, New York (Specimen No. 67744, U.S.N.M.); Roxbury, Connecticut, and other places in the United States and associated with other arsenides and sulpharsenides in the gold and silver mines of Europe.

¹Complete analyses of these are given in Catalogue of the New South Wales Exhibit, World's Columbian Exposition, Chicago, 1893, p. 330.

6. PYRITES.

Two forms of the disulphide of iron are common in nature. The first, known simply as pyrite or iron pyrites, occurs in sharply defined cubes and their crystallographic modifications (Specimen No. 51740, U.S.N.M.), or in granular masses of a brassy-yellow color (Specimen No. 62152, U.S.N.M.).

The second, identical in composition, crystallizes in the orthorhombic system (Specimens Nos. 17124, 55206, and 73613, U.S.N.M.), but is more common in concretionary (Specimen No. 62976, U.S.N.M.), botryoidal (Specimen No. 30772, U.S.N.M.), and stalactitic (Specimens Nos. 62800 and 67761, U.S.N.M.) forms, which are of a dull grayish-yellow color. This form is known as the gray iron pyrites. Both forms have the chemical composition, FeS_2 , = iron 46.6 per cent and sulphur 53.4 per cent.

The ore as mined is, however, never chemically pure, but contains admixtures of other metallic sulphides, besides, at times, considerable quantities of the precious metals. The following analyses¹ of materials from well-known sources will serve to show the general variation:

Constituents.	I.	II.	III.	IV.	V.	VI.	VII.
Sulphur	48.0	48.0	48.02	40.00	47.76	46.40	45.60
Iron	43.0	44.0	42.01	35.0	43.99	39.00	38.52
Copper	1.6	1.6		4.00	3.69	1.50	
Zinc	1.5	1.5			0.24		6.00
Silica	5.0	3.7	7.60	20.00	1.99	9.25	8.70
Alumina						3.75	
Arsenic	Trace.			Trace.	0.83	0.10	Trace.
Silver and gold				Trace.	Trace.		
Lead					0.10		0.64

I. Milan, Coos County, New Hampshire; II. Rowe, Massachusetts; III. Louisa County, Virginia; IV. Sherbrooke, Canada; V. Rio Tinto, Spain; VI. near Lyons, France; VII. Westphalia, Germany.

Pyrite is sufficiently hard to scratch glass, and this, together with its color, crystalline form, and irregular fracture, is sufficient for its ready determination in most cases. Once known, it is thereafter readily recognized. Owing to its yellow color, the mineral has by ignorant persons been mistaken not infrequently for gold—which, however, it does not at all resemble—and has hence earned the not very flattering but quite appropriate name of “fool’s gold.” In certain cases, however, it carries the precious metals, and in many regions is sufficiently rich in gold to form a valuable ore.

Mode of occurrence.—Pyrite is one of the most widely disseminated of minerals, both geologically and geographically, occurring in rocks of all kinds and of all ages the world over. It is found in the form of

¹ Mineral Resources of the United States, 1883–1884, p. 877.

disseminated grains throughout the mass of a rock, or along the line of contact between basic eruptives and sedimentaries; as irregular and sporadic and concretionary masses in sedimentary rocks and modern sands and gravels; in the form of true fissure veins, and as interbedded, often lenticular masses, sometimes of immense size, lying conformably with the stratification (or foliation) of the inclosing rock. On the immediate surface the mineral is in most cases considerably altered by oxidation and hydration, forming the caps of gossan or limonite.

The origin of the mineral in the older crystalline rocks, as that of the rocks themselves, is not infrequently somewhat obscure. In sedimentary rocks it is undoubtedly due to the precipitation of the included ferruginous matter by sulphureted and deoxidizing solutions from decomposing animal and vegetable matter.

Some of the pyritiferous deposits, as those of Louisa County, Virginia (Specimens Nos. 54239, 54241, and 54242, U.S.N.M.), and Huelva, Spain, are of enormous proportions. The first named is described¹ as over 2 miles in length, and to have been exploited to upwards of 600 feet in depth and in width, from foot to hanging rock, as high as 60 feet of pure ore (see large Specimen No. 54242, U.S.N.M.). The average width of the two worked beds is upward of 18 feet. The rocks inclosing the deposits consist principally of talcose and hydromica slates. At Rio Tinto the ore is described² as occurring in immense masses several thousand feet in length and from 300 to 800 feet in width, extending in depth to an unknown distance. The ore (Specimen No. 11427, U.S.N.M.) is very clean and massive, containing besides sulphur and iron only some 2 to 4 per cent of copper and traces of silver and gold. The material is mined wholly from open cuts and to a depth of some 400 feet. The country rock is described as of Silurian and Devonian schists near contact with diorites.

Uses.—With the exception of the small amount utilized in the preparation of vermilion paints and the still smaller amount used for jewelry, almost the sole value of the mineral is for the manufacture of sulphuric acid and the sulphate of iron, known as green vitriol or copperas. In the process of making sulphuric acid the ore is roasted or burnt in specially designed ovens and furnaces until the mineral is decomposed, the sulphur fumes being caught and condensed in chambers prepared for the purpose. By the Glover and Gay-Lussac method from 280 to 290 parts of sulphuric acid of a density of 66° Baumé may be obtained for each 100 parts of sulphur in the ore or about 2,565 pounds of acid to 1 ton (2,000 pounds) of average ore.

In the manufacture of copperas the ore is broken into small pieces and thrown into piles over which water is allowed to drip slowly. A

¹Origin of the Iron Pyrites Deposits in Louisa County, Virginia, by F. L. Nason, Engineering and Mining Journal, LVII, 1894, p. 414.

²A Visit to the Pyrite Mines of Spain, Eng. and Min. Jour., LVI, 1893, p. 498.

natural oxidation takes place, whereby the sulphide is transformed into a hydrated sulphate. The latter being soluble runs off in solution in the water, which must be collected and evaporated in order to obtain the salt. Thus prepared the sulphate is used in dyeing, in the manufacture of writing ink, as a preservative for wood, and as a disinfectant. It has also been used in the manufacture of certain brands of fertilizers. The method of manufacture as formerly carried on at Strafford, Vermont, is given below:

The process consists in first raising the ore from the bed, which is principally done with the help of gunpowder. The blocks of ore are then broken up into small pieces, to facilitate the decomposition, by suffering the oxygen contained in water and the atmosphere to come more directly in contact with the material composing the ore. Large heaps of these pieces, called leaches, are made upon a tight plank bottom or upon a sloping ledge of solid rock, where the liquor or lye that subsequently runs from them may be saved.

In dry weather a small stream of water is made to flow upon and penetrate these leaches in order to produce a spontaneous combustion, which in warm weather commences in a few days, and if properly managed will continue several weeks. When combustion is taking place great care is requisite in order to have the work go on successfully, for if too much water is suffered to penetrate the leach or heap the decomposition is checked by the reduction of temperature and the lye or liquor issuing from it is too weak to be valuable, and if there is not water enough put on the leach the decomposition is also arrested by the absence of the oxygen found in the water, which is necessary to convert the sulphurous acid into the sulphuric, that sulphate of iron or copperas may be produced.

The liquor that runs from the leaches is collected in reservoirs, from which it can be taken at pleasure. Below the reservoirs upon the hillside buildings are erected, called evaporators, to which liquor is conducted in troughs from the reservoirs in small streams that are divided and subdivided by means of perforated troughs, brush, etc. Several tiers of brush are arranged in the building, through which the liquor is made to pass to facilitate the process of evaporation. In dry, windy weather the evaporation is oftentimes so rapid that the brush and other substances with which the liquor comes in contact during the latter part of its journey often have an incrustation of copperas formed upon them; but upon the return of rainy weather the humid atmosphere checks the evaporation, and the crust of copperas is dissolved and passes with the liquor into reservoirs prepared to receive it.

The liquor, which is now very strongly impregnated with copperas, is conducted into leaden boilers, where heat is applied and the liquor reduced to a strength indicated by the acidimeter to be right for the production of copperas. The liquor is then placed in vats of lead or of brick and water cement, called crystallizers, and after remaining from eight to ten days a crust of copperas is formed upon the bottom and sides of the vats, composed of nicely formed crystals. The water remaining in the crystallizers is then pumped back into the boilers, the crust of copperas removed, and, after being sufficiently drained, it is packed in casks ready for market.¹ [See also under Alum shale and vitriol stone, p. 421.]

The analyses given below show (1) the composition of fresh pyrite from the Coal Measures of Mercer County, Pennsylvania, and (2) and (3) that of two varieties of paint produced from it by calcination.²

¹ *Geology of Vermont*, II, 1861, p. 830.

² Report M. M. Second Report of Progress in the Laboratory of the Survey at Harrisburg, Second Geological Survey of Pennsylvania, 1879, p. 374.

Constituents.	1.	2.	3.
Bisulphide of iron.....	96.161	0.415	0.405
Bisulphide of copper.....	Trace.		
Sesquioxide of iron.....		66.143	77.143
Alumina.....	.653	.697	.543
Protoxide of iron.....		6.300	5.142
Lime.....	.450	.160	.160
Magnesia.....	.140	.100	.100
Silica.....	.680	3.880	3.980
Sulphuric acid.....		13.110	7.334
Water and carbonaceous matter.....		9.195	5.194
Undetermined.....	1.916		
Total.....	100,000	100,000	100,000

Pyrite on decomposing in the presence of moisture in the ground sometimes gives rise to an acid sulphate of iron. This may attack aluminous minerals when such are present, giving rise thus to solutions of sulphate of iron and alumina, which come to the surface as "alum springs," or, if no alumina is present, merely as iron or chalybeate springs, which are of more or less medicinal value. The presence of such sulphates in a soil is readily detected by the well-known astringent taste of green vitriol and alum, even where the quantity is not sufficient to appear as a distinct efflorescence. Impregnation of these salts in soils are by ignorant persons sometimes assumed to be of great medicinal value, and the writer has in mind a case in one of the Southern States, in which the aqueous leachings of such a soil were regularly bottled and sold as a specific for nearly all the ills to which the flesh is heir, though prescribed especially for flux, wounds, and ulcers. (See also under Alum, p. 416.)

BIBLIOGRAPHY.

- W. H. ADAMS. The Pyrites Deposits of Louisa County, Virginia.
Transactions of the American Institute of Mining Engineers, XII, 1883, p. 527.
- WILLIAM MARTYN. Pyrites.
Mineral Resources of the United States, 1883-84, p. 877.
- J. H. COLLINS. The Great Spanish Pyrites Deposits.
Engineering and Mining Journal, XL, 1885, p. 79.
- E. D. PETERS. A Visit to the Pyrites Mines of Spain.
Engineering and Mining Journal, LVI, 1893, p. 498.
- FRANK L. NASON. Origin of the Iron Pyrites Deposits in Louisa County, Virginia.
Engineering and Mining Journal, LVII, 1894, p. 414.
- M. DRILLON. The Pyrites Mines of Sain-Bel.
Minutes of Proceedings of the Institute of Civil Engineers, CXIX, 1894-95, p. 470.

7. MOLYBDENITE.

A disulphide of molybdenum having the formula MoS_2 , = sulphur 40 per cent, molybdenum 60 per cent.

This mineral, like graphite, occurs, as a rule, in small, black, shining scales, sometimes hexagonal in outline and with a bright metallic luster. It is soft enough to be readily impressed with the thumb nail, and leaves a bluish-gray trace on paper. On porcelain it leaves a lead gray, slightly greenish streak. This faint greenish tinge, together with its property of giving a sulphur reaction when fused with soda, furnish a ready means of distinguishing it from graphite, which it so closely resembles. Through alteration it sometimes passes over into molybdate or molybdic ocher, a straw-yellow to white ocherous mineral of the formula MoO_3 , = oxygen 33.3 per cent, molybdenum 66.7 per cent.

Occurrence.—The mineral has a wide distribution, occurring in embedded masses and disseminated scales in granite (Specimen No. 62169, U.S.N.M.), gneiss, syenite, crystalline schists, quartz (Specimen No. 60995, U.S.N.M.), and granular limestone. It is found in Norway, Sweden, Russia, Saxony, Bohemia, Austria, France, Peru, Brazil, England, and Scotland, throughout the Appalachian region in the United States and Canada (Specimen No. 53046, U.S.N.M.), and in various parts of the Rocky and Sierra Nevada mountains. In Okanogan County, Washington, the mineral occurs in beautiful large flakes in an auriferous quartz vein traversing slates. (Specimen No. 53126, U.S.N.M.)

On Quetachoo-Manicouagan Bay, on the north side of the Gulf of St. Lawrence, the mineral is reported¹ as occurring disseminated in a bed of quartz 6 inches thick, in the form of nodules from 1 to 3 inches in diameter and in flakes which are sometimes 12 inches broad by $\frac{1}{4}$ inch in thickness.

Molybdenite is also found in the form of finely disseminated scales or small bunches among the iron ores of the Hude mine at Stanhope, New Jersey, sometimes constituting as high as 2 per cent of the ore.

Molybdenum is also a constituent of the mineral wulfenite, or molybdate of lead.

Uses.—The principal use to which molybdenite has as yet been put is in the preparation of molybdates for the chemical laboratory. It is stated that a fine blue pigment can be prepared from it, which it has been proposed to use as a substitute for indigo in dyeing silk, cotton, and linen. The metal molybdenum is produced but rarely and only as a curiosity, and has a purely fictitious value. Up to the present time there has been no constant demand for the mineral nor regular source of supply.

¹ Geology of Canada, 1863, p. 754.

III. HALIDES.

1. HALITE; SODIUM CHLORIDE; OR COMMON SALT.

Composition Na Cl , =sodium 60.6 per cent; chlorine 39.4 per cent. The natural substance is nearly always more or less impure, as noted later. Hardness, 2.5; specific gravity, 2.1 to 2.6 per cent. Colorless or white when pure, but often yellowish or red or purplish by the presence of metallic oxides and organic matter. Readily soluble in cold water, and has a saline taste. Crystallizes in the isometric system,

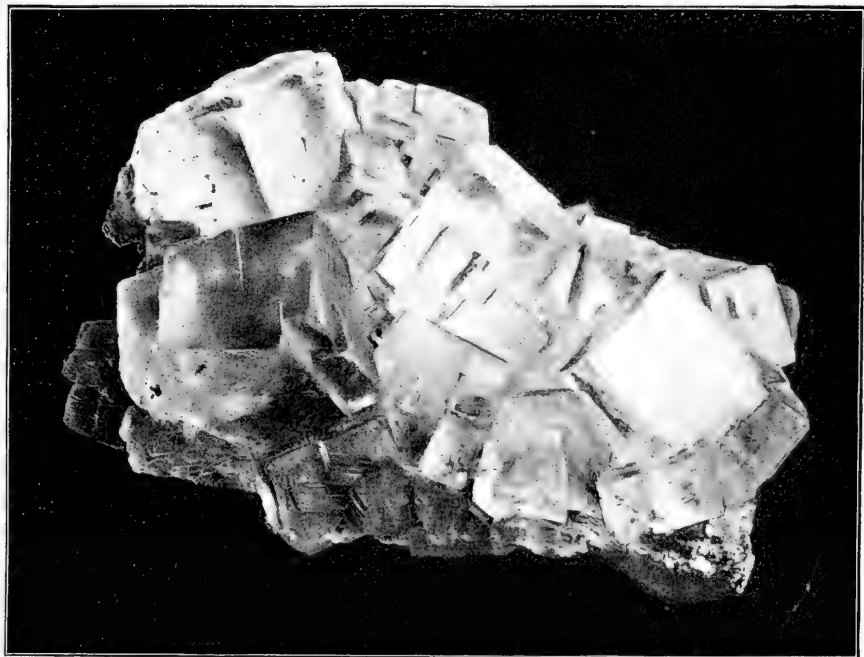


Fig. 2.

CLUSTER OF HALITE CRYSTALS.

Stassfurt, Germany.

Specimen No. 40222, U.S.N.M.

usually in cubes (fig. 2, Specimen No. 40222, U.S.N.M.), but sometimes in octahedrons, the faces of the crystals (particularly when prepared artificially) being often cavernous or hopper shaped. Sometimes occurs in fibrous forms, which it has been suggested are pseudomorphous after fibrous gypsum (Specimen No. 64733, U.S.N.M.). Often found in the form of massive, crystalline granular aggregates commonly known as rock salt (Specimens Nos. 67558, 64736, 62946, U.S.N.M.).

Sylvite, the chloride of potassium, sometimes occurs associated with halite, where it has formed under similar conditions. From halite

it can be distinguished by its crystalline form, that of a combination of cube and octahedron (Specimen No. 40223, U.S.N.M. See fig. 4, p. 203), and more biting taste. Owing to its ready solubility it is rarely found in a state of nature. Bischofite, the chloride of magnesium (Specimen No. 62428, U.S.N.M.) is still more soluble and practically unknown except in crystals artificially produced.

Origin and occurrences.—Sodium in the form of chloride, to which is commonly given the simple name of salt, is one of the most widely disseminated of natural substances, and not infrequently occurs in large masses interstratified with other rocks of the earth's crust in such a manner as to constitute a true rock mass.

The geological history of these beds of rock salt is as follows:

No terrestrial waters are absolutely pure, but all hold in solution more or less mineral matter which has been taken up from the rocks and soils with which they have come in contact. The nature of these impurities depends on the nature of the formations permeated and their relative solubility. Numerous analyses of river waters have shown that the substances mentioned below, though sometimes existing as mere traces, are almost invariably present; these are sodium, potassium, magnesium, silicon, aluminum, and iron, which exist mostly in the form of carbonates, oxides, sulphates, and chlorides.

When a stream bearing these substances in solution flows into a lake with no outlet, as the Great Salt Lake or the Dead Sea, the water is returned to the atmosphere by evaporation, while the impurities remain. In this way the water gradually becomes charged more and more heavily with mineral matter, until the point of saturation is reached and further concentration is impossible without precipitation. When such precipitation of mineral matters takes place, it is in the inverse order of their solubilities; that is, those substances which are least soluble will, under like conditions of temperature, be first precipitated. Hence a water containing the ingredients before mentioned on being subjected to complete evaporation would deposit its load in the following order: (1) Carbonates of lime and magnesia in the form of limestones, marls, and dolomites; (2) sulphate of lime in the form of anhydrite and gypsum; (3) chloride of sodium, or common salt; and these followed in regular order by the sulphates of magnesia and soda (Epsom salt and Glauber's salt) and the chlorides of potassium and magnesium. These last are, however, so readily deliquescent that they are rarely found crystallized out in a state of nature as above noted.

It rarely happens, however, that nature's processes are sufficiently regular and uninterrupted to allow a complete precipitation of the pure salts as above outlined. During periods of flood suspended silt may be poured into the inclosed basin to finally settle, forming thus alternating beds of saliferous clay or marl.

Such having been the method of formation, it is scarcely necessary

to state that salt beds are not confined to strata of any one geological horizon, but are to be found wherever suitable circumstances have existed for their formation and preservation. The beds of New York State and of Canada and a part of those of Michigan lie among rocks of the Upper Silurian Age. They are regarded by Professor Newberry as the deposits of a great salt lake that formerly occupied central and western New York, northern Pennsylvania, northeastern Ohio, and southern Ontario, and which he assumes to have been as large as Lake Huron, or possibly Lake Superior. A part of the Michigan beds, on the other hand, were laid down near the base of the Carboniferous series, as were also those of the Ohio Valley, and presumably those of Virginia, while those of Petite Anse, Louisiana, are of Cretaceous, or possibly Tertiary Age. The beds of the Western States and Territories are likewise of recent origin, many of them being still in process of formation.

The English beds at Cheshire, the source of the so-called "Liverpool" salt, are of Triassic Age, as are also those of Vic and Dieuze in France, Wurtemberg in Germany, and Salzburg in Austria, while those of Wieliczka in Austrian Poland, and of Parajd in Transylvania are Tertiary.

Salt is now manufactured from brines or mined as rock salt in fifteen States of the American Union. These, in the order of their apparent importance, are Michigan, New York, Kansas, California, Louisiana, Illinois, Utah, Ohio, West Virginia, Nevada, Pennsylvania, Virginia, Kentucky, Texas, and Wyoming. At one time Massachusetts was an important producer of salt from sea waters. The industry has, however, been gradually languishing and may ere now be wholly extinct. In California salt is obtained largely from sea water, but also from salt lakes and salines. In Michigan, Ohio, the Virginias, Pennsylvania, and Kentucky salt is obtained from brines obtained from springs or by sinking wells into the salt-bearing strata, while in New York, Kansas, Louisiana, and the remaining States it is obtained both from brines and by mining as rock salt.

Of the foreign sources of rock salt the following districts are the most important: (1) The Carpathian Mountains, (2) the Austrian and Bavarian Alps, (3) western Germany, (4) the Vosges, (5) Jura, (6) Spain, (7) the Pyrenees and the Celtiberian Mountains, and (8) Great Britain, while sea salt is an important product of Turks Island in the Bahamas, of the island of Sicily, and of Cadiz, Spain.

We have space here for details concerning but a few of these beds, preference naturally being given to those of the United States.

The beds of New York State, of Ontario, northern Pennsylvania, northeastern Ohio, and eastern Michigan all belong to the same geologic group—are the product of similar agencies. They have been penetrated in many places by wells, and from the results obtained we

are enabled to form some idea of their extent and thickness. Below is given a summary of results obtained in boring one of these wells to a depth of 1,517 feet at Goderich, Canada. Beginning at the top, the rocks were passed through in the following order:

	Ft.	In.
I. Clay, gravel, marls, limestone, dolomite, and gypsum variously interstratified.....	997	0
II. First bed of rock salt.....	30	11
III. Dolomite with marls.....	32	1
IV. Second bed of rock salt.....	25	4
V. Dolomite.....	6	10
VI. Third bed of rock salt.....	34	10
VII. Marl, dolomite, and anhydrite.....	80	7
VIII. Fourth bed of rock salt.....	15	5
IX. Dolomite and anhydrite.....	7	0
X. Fifth bed of rock salt.....	13	6
XI. Marl and anhydrite.....	135	6
XII. Sixth bed of rock salt.....	6	0
XIII. Marl, dolomite and anhydrite.....	132	0
Total thickness of formations passed through.....	1,517	feet.
Total thickness of beds of salt.....	126	feet.

The above section shows that the ancient sea or lagoon underwent at least six successive periods of desiccation, and especial attention is called to the remarkable regularity of the deposits. On the oldest sea bottom (XIII) the carbonates and sulphates of lime and magnesia were deposited first, being least soluble. Then followed the salt, and this order is repeated invariably. The other constituents mentioned as occurring in the waters of lakes and seas are not sufficiently abundant to show in the section, or owing to their ready solubility they have been in large part removed since the beds were laid down. Chemical tests, however, reveal their presence.

Although salt was manufactured from the brine of springs, near Onondaga Lake, in New York, as early as 1788, and has been regularly manufactured from the brine of wells since 1798, it was not until subsequent to the discovery of extensive beds of rock salt in the Wyoming Valley, while boring for petroleum, that the mining of the material in this form became an established industry. In June, 1878, a bed of rock salt 70 feet in thickness was found in the valley above mentioned, at a depth of 1,270 feet. Subsequently other borings in Wyoming, Genesee, and Livingston counties disclosed beds at varying depths. In 1885 the first shaft was sunk at Pifford by the Retsof Mining Company, the salt bed being found at a depth of 1,018 feet. Three other shafts have since been sunk, the first about a mile west of the Retsof, the second about 2 miles south of Leroy, and the third at Livonia, in Livingston County. The salt when taken from the bed is stated to be of a gray color, due to the presence of clay, which renders solution and recrystallization necessary when designed for culinary purposes. The thickness of the salt beds and their depth are somewhat variable. The following figures are quoted from

Dr. Engelhardt's report.¹ At Morrisville, in Madison County, it is 12 feet thick and at a depth of 1,259 feet; at Tully, in Onondaga County, it varies from 25 to 318 feet, at depths of from 974 to 1,465 feet. The seven beds found at Ithaca have a total thickness of 248 feet, the uppermost lying at a depth of 2,244 feet. In the Genesee Valley the beds vary in depth from 750 to 2,100 feet and in thickness from 40 to 93 feet. In the Wyoming Valley the depth varies from 610 to 2,370 feet below the surface and in thickness from 12 to 85 feet.²

Michigan.—The salt-producing areas of this State are, so far as now known, limited to the counties of Iosco, Bay, Midland, Gratiot, Saginaw, Huron, St. Clair, Manistee, and Mason, the beds of the Saginaw Valley lying in the so-called Napoleon sandstone, at the base of the Carboniferous. Professor Winchell has estimated this formation to cover an area of some 17,000 square miles within the State limits. The beds of the St. Clair Valley, on the other hand, are in Upper Silurian strata, being presumably continuous with those of Canada. The manufacture of salt from brines procured from these beds began in the Saginaw Valley in 1860 and has since extended to the other regions mentioned. According to F. E. Engelhardt the rock salt deposits in the Upper Silurian beds, with a thickness of 115 feet, were reached at Marine City, in St. Clair County, at a depth of 1,633 feet; at St. Clair, St. Clair County, at a depth of 1,635 feet and with a thickness of 35 feet. At Caseville, in Huron County, the beds lie at a depth of 1,164 feet, and at Bay City, Saginaw Bay, at 2,085 feet, the salt beds being 115 feet in thickness. At Manistee the bed is 34 feet thick, lying 2,000 feet below the surface, while at Muskegon, in the Mason well, it was 50 feet thick at a depth of 2,200 feet. Although of so recent development, Michigan is rapidly becoming one of the leading salt-producing regions of the world, the estimated manufacturing capacity being now upward of 5,000,000 barrels annually. The total product of all the years since 1868 is given as 60,614,464 barrels of 280 pounds each.

In Kansas the rock salt occurs in beds regarded as of Permian age, and has been reached by means of shafts in several counties in the southern and central part of the State. The following is a section of a shaft sunk at Kingman in 1888-89:

	Feet.
"Red-beds," red arenaceous, limestones, ferruginous clays, and clay shales	
with thin streaks of gray shales and bands of gypsum as satin spar.....	450
Gray or bluish "slate," with 2 feet of limestone at 500 feet.....	140
Red clay shale.....	4
Gray "slate," with occasional streaks of limestone, 2 to 8 inches thick, and some salt partings and satin spar with ferruginous stain.....	78

¹The Mineral Industry, its Statistics and Trade for 1892, by R. P. Rothwell.

²For a very complete historical and geological account of these salt beds and the method of manufacture, see Bulletin No. 11, of the New York State Museum, 1893, by F. J. H. Merrill.

	Feet.
First rock salt, pure white	2
Shale and "slate," bluish, with vertical and other seams of salt, from 1 to 3 inches thick	26
Rock salt	4
Shales, with salt	11
Rock salt	7
Shale	3
Rock salt	3
Salt and shale, alternate thin seams	62
Rock salt	11
Shale	1 $\frac{1}{2}$
Rock salt	5
Shales and limestone	8
Rock salt, bottom of it not reached	5
Total	820

Borings and shafts have also proven the existence of beds of salt in other parts of the State, as at Kanopolis, Lyons, Caldwell, Rago, Pratt, and Wilson. According to Dr. Robert Hays¹ it is safe to assume that beds of rock salt from 50 to 150 feet in thickness underlie fully half the area from the south line of the State to north of the Smoky River, an area from 20 to 50 miles in width. Although the mining of rock salt began in this region only in 1888, the annual output has already reached over 1,000,000 barrels.

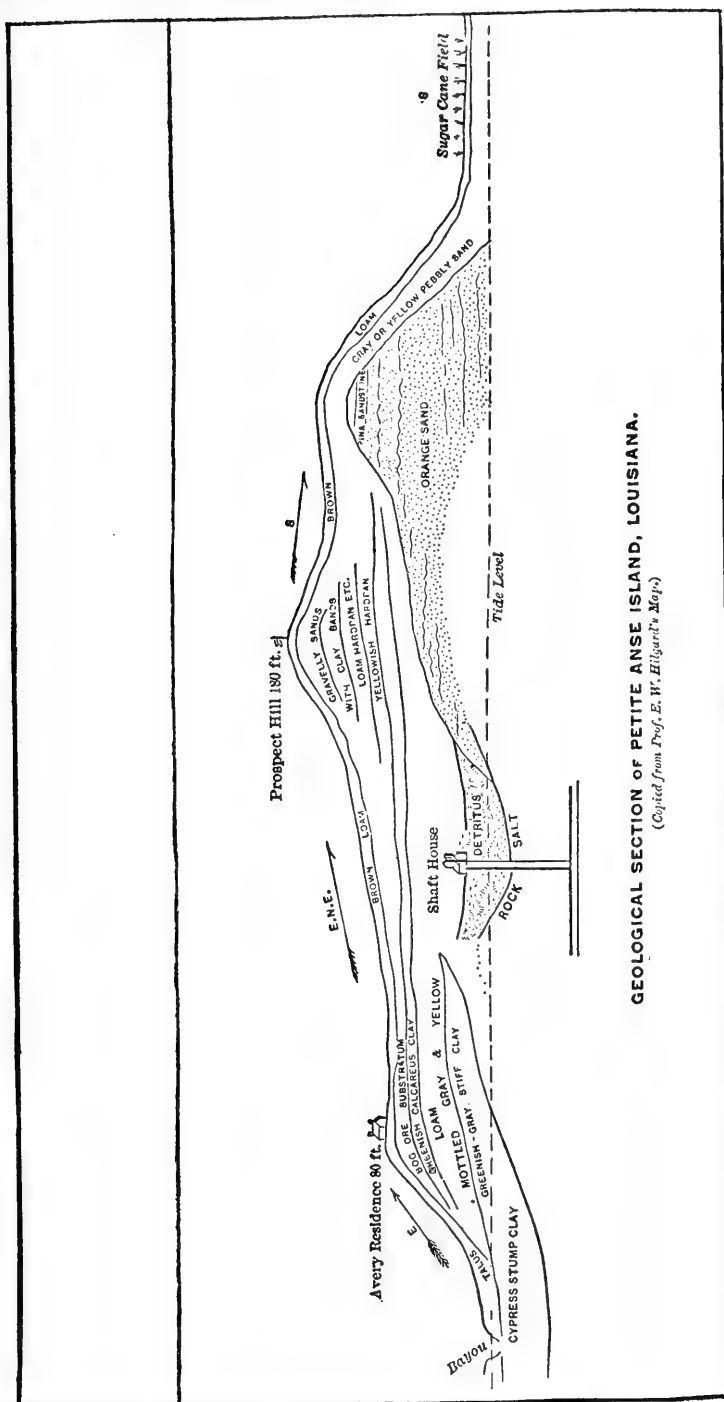
Louisiana.—Salt in this State is derived from Petite Anse, a small island rising from the marshes on the southern coast and connected with the mainland by a causeway some 2 miles in length. According to E. W. Hilgard² the deposit is probably of Cretaceous age, and is presumably but a comparatively small residual mass of beds once extending over a much larger area, but now lost through erosion. (See fig. 3.) Exploration has shown the area occupied by the beds to be some 150 acres, but the full thickness, though known to be upward of 165 feet, has never been fully determined.

Salt in Kentucky is obtained from the brine of springs and wells in Carboniferous limestone. In Meade County brine accompanies the natural gas, the latter in some cases being utilized as fuel for its evaporation. Springs in Webster County furnished salt for Indians long anterior to the occupancy of the county by whites, and fragments of their clay kettles and other utensils used in the work of evaporation are still occasionally found.

Texas.—The occurrences of salt are numerous and widespread. Along the coast are many lagoons and salt lakes, from which considerable quantities are taken annually. "Besides the lakes along the shores many others occur through western Texas, reaching to the New Mexico

¹ Geological and Mineral Resources of Kansas, 1893, p. 44.

² Smithsonian Contributions to Knowledge, XXIII. On the Geology of Lower Louisiana and the Salt Deposit on Petite Anse Island.



GEOLOGICAL SECTION OF PETITE ANSE ISLAND, LOUISIANA.
(Copied from Prof. E. W. Hilgart's Map)

Fig. 3.

line, while northeast of these, in the Permian region, the constant recurrence of such names as Salt Fork, Salt Creek, etc., tell of the prevalence of similar conditions." In addition to the brines there are extensive beds of rock salt. That which is at present best developed is located in the vicinity of Colorado City, in Mitchell County. The bed of salt was found at a depth of 850 feet, with a thickness of 140 feet. In eastern Texas there are many low pieces of ground called salines, where salt has been manufactured by evaporation of the brines obtained from shallow wells. At the "Grand Saline," in Van Zandt County, a bed of rock salt over 300 feet in thickness was found at a depth of 225 feet.

In England the salt occurs at Cheshire in two beds interstratified with marls and clays. The upper, with a thickness varying from 80 to 90 feet, lies at a depth of some 120 feet below the surface, and the second at a depth of 226 feet has a thickness varying between 96 and 117 feet. The accompanying general sections are from Davies' *Earthy and Other Economic Minerals*.

Detailed section of strata sunk through at Wilton, near Northwich, to the lower bed of salt.

	Ft.	In.
1. Calcareous marl	15	0
2. Indurated red clay	4	6
3. Indurated blue clay and marl	7	0
4. Argillaceous marl	1	0
5. Indurated blue clay	1	0
6. Red clay with sulphate of lime in irregular branches	4	0
7. Indurated red clay with grains of sulphate of lime interspersed	4	0
8. Indurated brown clay with sulphate of lime crystallized in irregular masses and in large proportions	12	0
9. Indurated blue clay with laminae of sulphate of lime	4	6
10. Argillaceous marl	4	0
11. Indurated brown clay laminated with sulphate of lime	3	0
12. Indurated blue clay laminated with sulphate of lime	3	0
13. Indurated red and blue clay	12	0
14. Indurated brown clay with sand and sulphate of lime irregularly interspersed through it. The fresh water, at the rate of 360 gallons a minute, forced its way through this stratum	13	0
15. Argillaceous marl	5	0
16. Indurated blue clay with sand and grains of sulphate of lime	3	9
17. Indurated brown clay as next above	15	0
18. Blue clay as strata next above	1	6
19. Brown clay as strata next above	7	0
20. The top bed of rock salt	75	0
21. Layers of indurated clay with veins of rock salt running through them	31	6
22. Lower bed of rock salt	115	0
Total	341	9

At Wieliczka, in Austrian Poland, the salt occurs in massive beds stated to extend over an area some 20 by 500 miles, with a maximum thickness of 1,200 feet. At Parajd, in Transylvania, beds belonging

to the same geological horizon are estimated to contain upward of 10,000,000,000,000 cubic feet of salt.

One of the most remarkable deposits of the world, remarkable for its extent as well as for the variety of its products, is that of Stassfurt, in Prussian Saxony. On account of its unique character, as

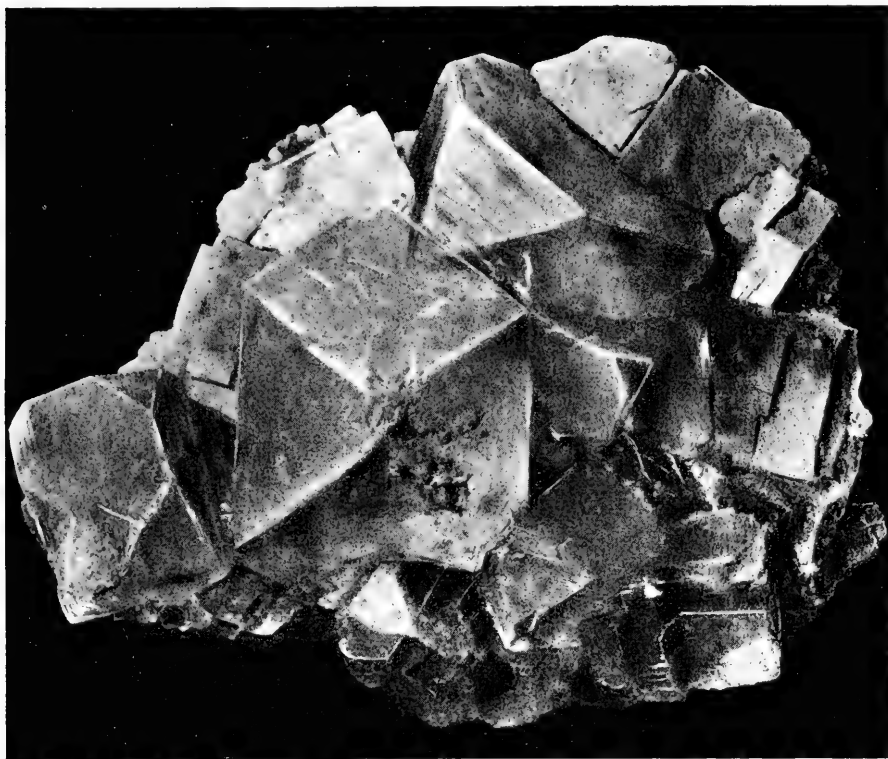


Fig. 4.
CLUSTER OF SYLVITE CRYSTALS,
Stassfurt, Germany.
Specimen No. 40223, U.S.N.M.

well as its commercial importance, being to-day the chief source of natural potash salts of the world, a little space may well be given here to a detailed description.¹

Stassfurt is a small town of some 12,000 inhabitants, about 25 miles southwest of the city and fortress of Magdeburg, in Prussia. It lies in a plain, and the river Bode, which takes its rise in the Harz Mountains, flows through it. The history of the salt industry in Stassfurt is a very old one, and dates back as far as the year 806. Previous to the year 1839 the salt was produced from brine pumped from wells sunk about 200 feet into the rock. The brine, in the course of time, became so weak,

¹ Journal of the Society of Chemical Industry, II, 1883, pp. 146, 147.

as regards the common salt it contained, that it was impossible to carry on the manufacture from this source without loss. In 1839 the Prussian Government, who were the owners of these saline springs, commenced boring with the object of discovering the whereabouts of the bed of rock salt from which the brine had been obtained, and in the year 1843, seven years after the commencement of the borings, the top of the rock salt was reached at a depth of 256 metres. The boring was continued through another 325 metres into the rock salt without reaching the bottom of the layer. At this total depth of 581 metres the boring was suspended. On analysing the brine obtained from the bore-hole, it was found to consist, in 100 parts by weight, of—

Sulphate of calcium	4.01
Chloride of potassium	2.24
Chloride of magnesium.....	19.43
Chloride of sodium	5.61

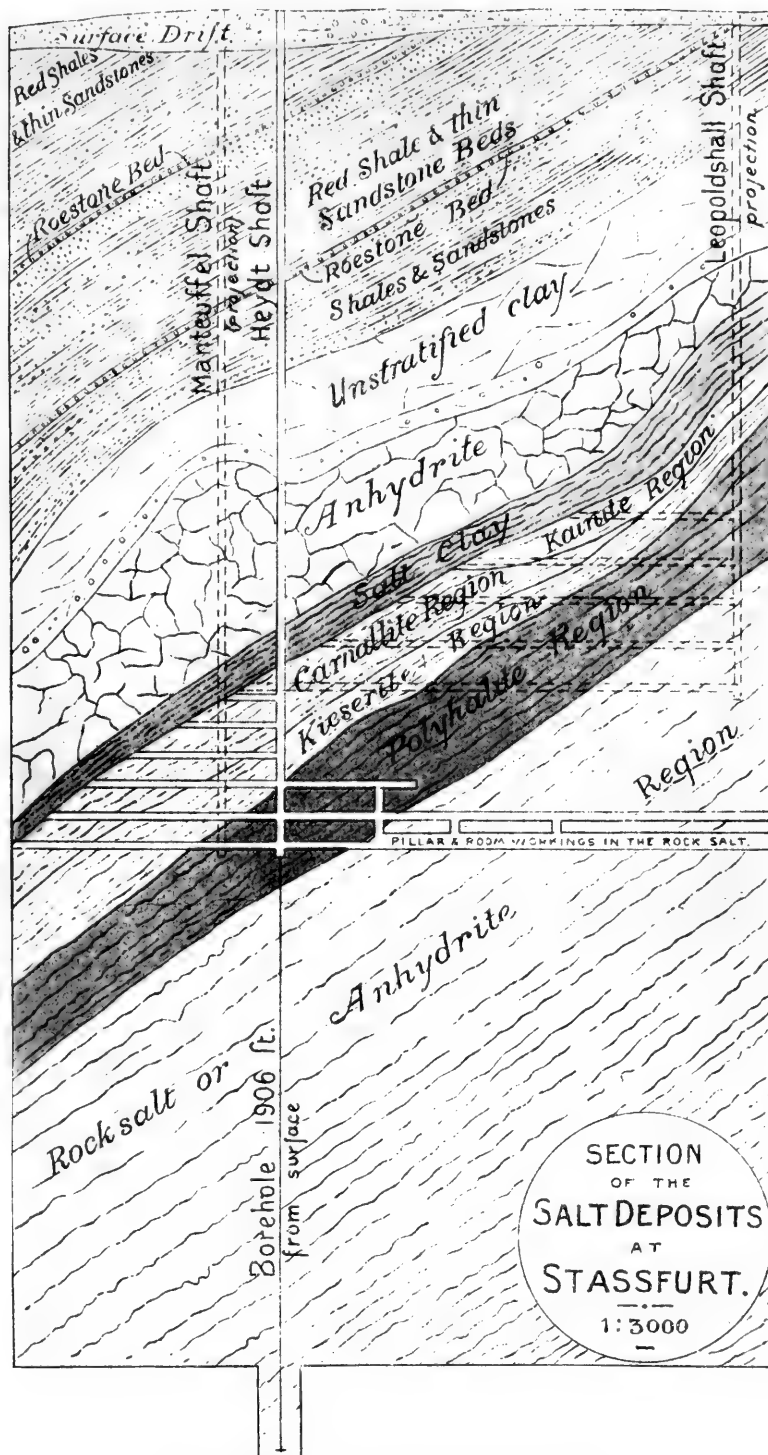
A result not only unexpected but disappointing, since the presence of chloride of magnesium in such quantities dispelled for the time all hopes of striking on the pure rock salt. The Government, however, guided by the opinions expressed by Dr. Karsten and Professor Marchand, namely, that the presence of chloride of magnesium in such quantities was probably due to a deposit lying above the rock salt, determined to further investigate the matter, and in the year 1852 the first shaft was commenced, which after five years had penetrated, at a depth of 330 metres, into a bed of rock salt, passing on its way, at a depth of 256 metres, a bed of potash and magnesia salts of a thickness of 25 metres.

On referring to the section of the mines [Plate 4], it will be seen that the lowest deposit of all consists of rock salt. The bore-hole was driven 381 metres into it without reaching the bottom of the layer. Its depth is therefore unknown. The black lines drawn across the rock salt deposit represent thin layers of sulphate of calcium 7 millimetres thick, and almost equidistant. The lines at the top of the rock salt represent thin layers of the trisulphate of potash, magnesia, and lime as the mineral Polyhallite [Specimen No. 67754, U.S.N.M.]. The deposit lying immediately on the bed of rock salt consists chiefly of sulphate of magnesia as the mineral Kieserite [Specimen No. 62417, U.S.N.M.]. Still farther toward the surface the deposit consists of the double chloride of potassium and magnesium, known as the mineral Carnallite, [Specimens Nos. 40225, 62416, U.S.N.M.] mixed with sulphate of magnesia and rock salt. The deposit to the right, on the rise of the strata, consists of the double sulphate of potash and magnesia combined with one equivalent of chloride of magnesium, and intermingled with common salt to the extent of 40 per cent. This double sulphate is known as the mineral Kainite [Specimen No. 64735, U.S.N.M.] and is a secondary formation, resulting from the action of a limited quantity of water on a mixture of sulphate of magnesia and the double chloride of potassium and magnesium, as contained in the uppermost deposit previously spoken of.

The upper bed of the rock salt, resting on a thick bank of Anhydrite [Specimen No. 64740, U.S.N.M.], is also a later formation. Almost imperceptible layers of Polyhallite are present in this deposit and at greater intervals than in the lower and older deposit. It has therefore probably originated from the action of water on the older deposit. This upper bed of rock salt varies in thickness from 40 to 90 metres, and its extent is comparatively limited. It is worked in preference to the older deposit, where both exist in the same mine, it being of much purer quality, averaging about 98 per cent in the mines of the New Stassfurt Mining Company and in the Royal Prussian mines.

Sixteen different minerals have as yet been discovered in the Stassfurt deposits. They may be divided into primary and secondary formations. Those of primary formation are rock salt, Anhydrite [Specimen No. 64740, U.S.N.M.], Polyhallite (K_2SO_4 , $MgSO_4$, $2CaSO_4$, $2H_2O$) [Specimen No. 67754, U.S.N.M.], Kieserite ($MgSO_4$,

Prussian Shafts.



SECTION OF THE SALT DEPOSITS AT STASSFURT.

From the Transactions of the Edinburgh Geological Society, V, 1884, p. 111.

H_2O) [Specimen No. 62417, U.S.N.M.], Carnallite ($KCl, MgCl_2, 6H_2O$) [Specimen No. 40225, U.S.N.M.], Boracite ($2(Mg_2B_2O_7), MgCl_2$) [Specimen No. 64742, U.S.N.M.], and Douglasite ($2KCl, FeCl_2, 2H_2O$). Those of secondary formation, resulting from the decomposition of the primary minerals are, nine in number, namely: Kainite ($K_2SO_4, MgSO_4, MgCl_2, 6H_2O$); Sylvite (KCl) [Specimen No. 62419, U.S.N.M.]; Tachydrite ($CaCl_2, 2MgCl_2, 12H_2O$) [Specimen No. 40220, U.S.N.M.]; Bischofite ($MgCl_2, 6H_2O$) [Specimen No. 62428, U.S.N.M.]; Krugite ($K_2SO_4, MgSO_4, 4CaSO_4, 2H_2O$) [Specimen No. 62426, U.S.N.M.]; Reichardtite ($MgSO_4, 7H_2O$); Glauberite ($CaSO_4, Na_2SO_4$) [Specimen No. 40229, U.S.N.M.]; Schönite ($K_2SO_4, MgSO_4, 6H_2O$) [Specimen No. 62418, U.S.N.M.], and Astrakanite ($MgSO_4, 4H_2O$) [Specimen No. 64738, U.S.N.M.]. Only four of these minerals have any commercial value, namely: Carnallite, Kainite, Kieserite, and rock salt. The yield of boracite, which is found in nests in the carnallite region of the mine, is too insignificant to be classed among those just mentioned.

The mine may be divided chemically into four regions: (1) The rock salt, (2) the Kieserite, (3) the Carnallite, (4) the Kainite region.

The rock salt region has almost the same composition throughout. Its character is crystalline, though in this region well-defined crystals are never met with. In other parts of the mine, especially in the Carnallite region, it is found crystallised in the form of the cube [Specimen No. 40222, U.S.N.M.] and the octahedron, sometimes coloured different shades of red and blue [Specimen No. 64731, U.S.N.M.]. Specimens have also been found of varied structure, laminated, granular, and fibrous [Specimen No. 64733, U.S.N.M.].

The deposit lying on the top of the rock constitutes the so-called Kieserite region. The thickness of this deposit is about 56 metres, and its average composition as follows:

	Per cent.
Kieserite	17
Rock salt	66
Carnallite	13
Tachydrite	3
Anhydrite	2
	<hr/> 100

In the pure state Kieserite is amorphous and translucent, possessing a specific gravity of 2.517. It contains 87.1 per cent sulphate of magnesia and 12.9 per cent water, corresponding to the formula $MgSO_4, H_2O$. Exposed to the air it becomes opaque from the absorption of moisture, and is converted into Epsom salts; 100 parts of water dissolve 40.9 parts of this mineral at $18^\circ C$. The solution, however, takes place very slowly at this temperature.

This deposit has not been worked to any great extent. Its composition is interesting as showing the gradual decrease of the proportion of common salt and the commencement of the separation of the more soluble salts.

Each of the two divisions of the mine just described contains only one mineral of importance. The third division, called the Carnallite region, contains a variety of minerals, and to this deposit Stassfurt owes its world-wide fame. The average thickness of this deposit is about 25 metres, and its composition is as follows:

	Per cent.
Carnallite	60
Kieserite	16
Rock salt	20
Tachydrite	4

besides small quantities of magnesium bromide. These minerals are deposited in the order given above, in successive layers, varying in thickness from $\frac{1}{10}$ to 1 metre, the different colours of these minerals giving the deposit a remarkable appearance.

The predominating mineral in this region is Carnallite [Specimen No. 40225, U.S.N.M.], a double chloride of potassium and magnesium, containing 26.76 per cent chloride of potassium, 34.50 per cent chloride of magnesium, and 38.74 per cent water, corresponding to the formula $KCl, MgCl_2, 6H_2O$. In the pure state it is colorless and transparent, and possesses a specific gravity of 1.618. It is very hygroscopic, and is easily soluble in water, 100 parts of which dissolve 64.5 parts of the mineral. It may be artificially formed from a solution of chloride of potassium, containing not less than 26 per cent of chloride of magnesium. The deposit which figures to the right of the Carnallite region is, as before mentioned, a secondary formation, and consists principally of the mineral Kainite [Specimen No. 64735, U.S.N.M.]. This deposit, though limited as compared to the other salt deposits, is yet of vast extent. The average composition of this deposit is:

Sulphate of potash	23.0
Sulphate of magnesia	15.6
Chloride of magnesium	13.0
Chloride of sodium	34.8
Water	13.6
	<hr/>
	100.0

In the pure state it is colorless and almost transparent, and possesses a specific gravity of 2.13; 100 parts of water dissolve 79.5 parts of it. Cold water does not decompose it, but from its saturated hot solution the double sulphate of potash and magnesia separates, and chloride of magnesium remains in solution.

Methods of mining and manufacture.—In the manufacture of salt three principal methods are employed. The first, if, indeed, it can be called manufacture, consists in mining the dry salt from an open quarry, as in the Rio Virgen and Barcelona deposits, or by means of subterranean galleries, the methods employed at Petite Anse and in Galicia.

At Petite Anse the method of mining and preparation, as given by Mr. R. A. Pomeroy,¹ is as follows:

Mining is done by means of galleries on two levels. There are 16 to 25 feet of earth above the salt deposit. The contour of the latter conforms nearly with that of the surface. The working shaft is 168 feet deep. The depth to the first level or floor is 90 feet; to the second, 70 feet farther. The remaining 8 feet are used for a dump. The galleries of the first level were run, on an average, 40 feet in width and 25 feet and upwards in height, leaving supporting pillars 40 feet in diameter.

The galleries of the second level are run 80 feet in width and 45 feet in height, leaving supporting pillars 60 feet in diameter. The lower pillars are so left that the weight of the upper ones rests upon them in part, if not wholly, with a thickness of at least 25 feet of salt rock between.

Galleries aggregating nearly 1 mile in length have been run on the upper level and some 700 feet on the lower.

In running a gallery the first work is the "undercutting" on the level of the floor, of sufficient height to enable the miners to work

¹Transactions of the American Institute Mining Engineers, XVII, 1888-89, pp. 111.

with ease. The salt is then blasted down from the overhanging body. The yearly output is about 50,000 tons.

The salt as it comes from the mine is dumped into corrugated cast-iron rolls, which crush it. Next it goes into revolving screens, which take out the coarser lumps for "crushed salt" and let the fine stuff pass to the buhrstones. These grind the salt, and from them it goes to the pneumatic separators, which take out the dust and separate the market salt into various grades. Taking the dust out is essential to the production of a salt that will not harden, since the fine particles of dust deliquesce readily and on drying cement the coarse particles together. The drill used in the mine is what is known as the "Russian auger." It is turned by hand and forced by a screw of 12 threads per inch. The holes take cartridges $1\frac{1}{2}$ inches diameter. Two men will bore 75 feet of hole each working-day of eight hours. Three-quarters of a pound of 18 per cent dynamite is used to the ton of salt mined.

On the Colorado Desert the salt occurs in the form of a crust a foot or more in thickness, resting on a lake of shallow brine. This crust, which is covered with a thin layer of dust and sand blown over it from the surrounding desert, is cut away longitudinally, much as ice is cut in the North. When loosened, the block, falling into the water beneath, is cleaned of its impurities, and is then thrown out on a platform to dry, after which it is ground and packed for market. In many parts of the arid West the salt is obtained merely by shoveling up the impure material deposited by the evaporation of salt lakes and marshes during seasons of drought. In this way is obtained a large share of the material used in chloridizing ores.

In the preparation of salt from sea water, solar evaporation alone is relied upon nearly altogether. This method, like the next to be mentioned, depends for its efficiency upon the fact already noted—that sea water holds in solution besides salt various other ingredients, which, owing to their varying degrees of solubility, are deposited at different stages of the concentration. In Barnstable County, Massachusetts, it was as follows: A series of wooden vats or tanks, with nearly vertical sides and about a foot in depth, is made from planks. These are set upon posts at different levels above the ground, and so arranged that the brine can be drawn from one to another by means of pipes. Into the first and highest of these tanks, known as the "long water room," the water is pumped directly from the bay or artificial pond by means of windmills, and there allowed to stand for a period of about ten days, or until all the sediment it may carry is deposited. Thence it is run through pipes to the second tank, or "short water room," where it remains exposed to evaporation for two or three days longer, when it is drawn off into the third vat, or "pickle room," where it stands until concentration has gone so far that the lime is deposited and a thin pellicle of salt begins to form on

the surface. It is then run into the fourth and last vat, where the final evaporation takes place and the salt itself crystallizes out. Care must be exercised, however, lest the evaporation proceed too far, in which case sulphate of soda (Glauber's salt) and other injurious substances will also be deposited, and the quality of the sodium chloride thereby be greatly deteriorated.

As to the capabilities of works constructed as above, it may be said that during a dry season vats covering an area of 3,000 square feet would evaporate about 32,500 gallons of water, thus producing some 100 bushels of salt and 400 pounds of Glauber's salt. The moist climate of the Atlantic States, however, necessitates the roofing of the vats in such a manner that they can be protected or exposed as desired, thereby greatly increasing the cost of the plant. Sundry parts of the Pacific coast, on the other hand, owing to their almost entire freedom from rains during a large part of the year, are peculiarly adapted for the manufacture by solar evaporation. Hence, while the works on the Atlantic coast have nearly all been discontinued, there has been a corresponding growth in the West, and particularly in the region about San Francisco Bay.

The methods of procedure in the California works do not differ materially from that already given, excepting that no roofs are required over the vats, which are therefore made much larger. One of the principal establishments in Alameda County may be described as follows: The works are situated upon a low marsh, naturally covered by high tides. This has been divided, by means of piles driven into the mud and by earth embankments, into a series of seven vats or reservoirs, all but the last of which are upon the natural surface of the ground—that is, without wooden or other artificial bottoms. The entire area inclosed in the seven vats is about 600 acres, necessitating some 15 miles of levees. The season of manufacture lasts from May to October. At the beginning of the spring tides, which rise some 12 to 15 inches above the marsh level, the fifteen gates of reservoir No. 1, comprising some 300 acres, are opened and the waters of the bay allowed to flow in. In this great artificial salt lake the water is allowed to stand until all the mud and filth has become precipitated, which usually requires some two weeks. Then, by means of pumps driven by wind-mills, the water is driven from reservoir to reservoir as concentration continues, till finally the salt crystallizes out in No. 7, and the bittern is pumped back into the bay. The annual product of the works above described is about 2,000 tons.

A somewhat similar process is pursued in the manufacture of salt from inland lakes as the Great Salt Lake, Utah. The following account of the method here employed is by Dr. J. E. Talmage:

The Inland Salt Company's gardens are situated near Garfield Beach, the most popular pleasure resort on the lake. In the method employed the water is pumped

from the lake into ponds prepared for its reception and situated above the level of the lake surface. The mother liquors flow off—are returned to the lake, in fact—when the evaporation has reached the proper stage. From the establishment of the works until 1883 the lake was close to the ponds; but, owing to the unusually high rate of evaporation attending the dry seasons of the immediate past, the water has receded, so that at present it has to be conveyed over 2,500 feet to the evaporating receptacles. This is effected by the aid of two centrifugal pumps, raising together 14,000 gallons of water per minute. The pumps throw the water to a height of 14 feet into a flume, through which it flows to the ponds. These are nine in number, and are arranged in series. In the first pond the mechanically suspended matters are left as sediment or scum, and the water passes into the second in a clear condition. The ponds cover upward of a thousand acres, and the drain channels leading from them aggregate 9 miles in length. The pumping continues through May, June, and July. A fair idea of the rate of evaporation in the thirsty atmosphere of the Great Basin may be gained from contemplating the fact that to supply the volume of water disappearing from the ponds by evaporation requires the action of the pumps ten hours daily in June and July. This is equal to the carrying away of 8,400,000 gallons per day from the surface of the ponds.

The "salt harvest" begins in August, soon after the cessation of pumping, and continues till all is gathered, frequently extending into the spring months of the succeeding year. An average season yields a layer of salt 7 inches deep, which amount would be deposited from 49 inches of lake water. The density at which salt begins to deposit, as observed at the ponds and confirmed by laboratory experiments, is 1.2121, and that of the escaping mother liquors is 1.2345. The yield of salt is at the rate of 150 tons per inch depth per acre. The crop is gathered on horse cars, which run on movable tracks into the ponds. At the works the operations are simple and effective. A link-belt conveyor carries the coarse salt to the crusher; thence to the dryer, after which a sifting process is employed by which the salt is separated into table salt and dairy salt.¹ [See Specimens Nos. 53630–53634, U.S.N.M.]

Owing to the depth below the surface of the salt beds in Ohio, Michigan, and other inland States, the material is never mined as in the cases first mentioned, but is pumped to the surface as a brine and there evaporated by artificial heat. In the Warsaw Valley region the beds lie from 800 to 2,500 feet below the surface, and are reached by wells. These are bored from 5½ to 8 inches in diameter and are cased with iron pipes down to the salt. Inside the first pipe is then introduced a second, 2 inches in diameter, with perforations for a few feet at its lower end, and which extends nearly if not quite to the bottom. Fresh water is then allowed to run from the surface down between the two pipes. This dissolves the salt, and forms a strong brine which, being heavier, sinks to the bottom of the well and is pumped up through the smaller or inner tube. At Syracuse the wells are not sunk into the salt bed itself, but into an ancient gravel deposit which is saturated with the brine. Here the introduction of water from the surface is done away with. In those cases, not at all uncommon, where the brine flows naturally to the surface in the form of a spring, pumping is of course dispensed with.

The methods of evaporation vary somewhat in detail. In New

¹Science, XIV, 1889, p. 445.

York the brine is run in a continuous stream in large pans some 130 feet long by 20 feet wide and 18 inches deep. As it evaporates the salt is deposited on the bottom and, by means of long-handled scrapers, is drawn on the sloping sides of the pan. Here it is allowed to drain, and is afterwards taken to the storage bins for packing or grinding.¹ Salt thus produced, it should be noticed, is never so coarse as the so-called rock salt, or that which has formed by natural evaporation. In Michigan the brine from the wells is first stored in cisterns, whence it is drawn off into large shallow pans, known technically as "settlers," where it is heated by means of steam pipes to a temperature of 175°, until the point of saturation is reached. It is then drawn into a second series of pans, called "grainers," where it is heated to a temperature of 185°, until crystallization takes place.

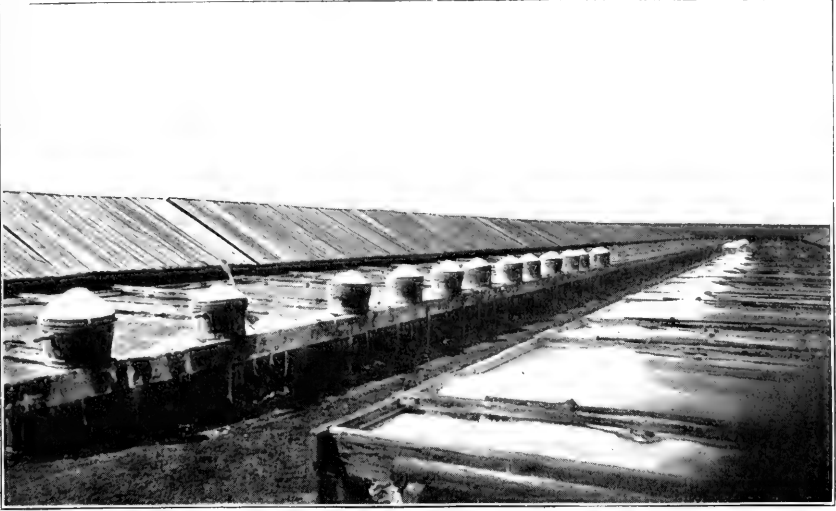
The strength of brines, and therefore the quantity of water that must be evaporated to produce a given quantity of salt, varies greatly in different localities. At Syracuse the brine contains 15.35 per cent of salt; at the Saginaw Valley, 17.91 per cent; at Saltville, Virginia, 25.97 per cent; while Salt Lake contains 11.86 per cent, and the waters of San Francisco Bay but 2.37 cent. The amount of impurities depends on the care exercised in process of manufacture, rapid boiling giving less satisfactory results than slower methods. The Syracuse salt has been found to contain 98.52 per cent sodium chloride; California Bay salt 98.43 per cent and 99.44 per cent; and Petite Anse 99.88 per cent. The impurities in these cases are nearly altogether chlorides and sulphates of lime and magnesia.

The Cheshire (England) salt beds are worked both by mining as rock salt and by pumping the brine. Formerly both upper and lower beds were mined, but flooding and falling in of the roofs caused the work to be discontinued on the upper beds. That now mined as rock salt comes wholly from the lower bed, and being impure is used mainly for agricultural purposes.

At Wieliczka the salt is likewise mined from galleries resembling in a general way those of a coal mine. These, according to Brehm,² begin at a depth of about 95 meters, forming several levels connected by stairways, the lowermost gallery being at a depth of 312 meters, or some 50 meters below sea level. These galleries have a total length of some 680 kilometers. They are connected with one another by means of "onze puits," of which seven are utilized for hoisting purposes. The work goes on continually night and day the year through. The salt is cut out in the form of blocks, leaving huge chambers, the roof being sustained by means of large columns of salt left standing. The

¹For details, see Salt and Gypsum Industries of New York, by Dr. F. J. H. Merrill, Bulletin No. 11, New York State Museum, 1893.

²Merveilles De La Nature. La Terre, etc., p. 315.



VIEWS OF BRINE-EVAPORATING TANKS AT SYRACUSE, NEW YORK.

From photographs by I. P. Bishop.

temperature within these chambers is very uniform, varying only between 10° and 15° C. The air is dry and healthful. The miners hew out of the salt statues of the saints, pyramids, and chandeliers, where they can place 300 lights. One chamber, called the Chapel of St. Antoine, with its altar, statues, columns, etc., is still in a condition of perfect preservation after a lapse of two centuries. The statements to the effect that the workmen, and indeed entire families, pass a good share of their lives in these mines, almost never coming to the surface, is stated by Brehm to be wholly erroneous. In reality, all the workers leave daily, only the horse remaining below.

The following statistics relative to the salt industry in the United States, are taken from Rothwell's Mineral Industry, 1892, page 419:

State.	1890.		1891.		1892.	
	Barrels.	Value.	Barrels.	Value.	Barrels.	Value.
Michigan.....	3, 837, 632	\$2, 302, 579	3, 927, 671	\$2, 136, 653	3, 812, 054	\$1, 906, 027
New York.....	2, 532, 036	1, 266, 018	3, 532, 606	1, 942, 930	4, 400, 000	2, 200, 000
Ohio.....	231, 303	136, 617	397, 000	264, 000	460, 000	276, 000
West Virginia.....	229, 938	134, 688	275, 000	192, 500	278, 000	166, 800
Louisiana.....	273, 553	132, 000	221, 430	93, 000	192, 850	81, 000
California.....	62, 363	57, 085	200, 000	100, 000	250, 000	125, 000
Utah.....	427, 500	126, 100	465, 000	150, 000	700, 000	295, 000
Nevada.....	.....	.....	15, 000	10, 000	10, 000	6, 000
Kansas.....	882, 666	397, 199	1, 000, 000	650, 000	1, 232, 850	698, 395
All other.....	300, 000	200, 000	200, 000	100, 000	250, 000	125, 000
Total barrels ..	8, 776, 991	4, 752, 286	10, 233, 701	5, 639, 083	11, 585, 754	5, 879, 222
Total tons	1, 228, 779	.....	1, 432, 718	.....	1, 622, 006	.....

The total production of salt in the United States for 1899 amounted to 19,861,948 barrels, or 2,780,677 short tons.

Uses.—The principal uses of salt have always been for culinary and preservative purposes. Aside from these, it is also used in certain metallurgical processes and in chemical manufacture, as in the preparation of the so-called soda ash (sodium carbonate), used in glass making, soap making, bleaching, etc., and in the preparation of sodium salts in general. Clear, transparent salt has been utilized in a few instances in optical and other research work. Secretary S. P. Langley of the Smithsonian Institution, in his astrophysical work made use of a salt prism some 19 centimetres in length and with faces 15 centimetres in breadth.

Composition of salt from various localities.

Varieties of salt.	Chloride of sodium.	Chloride of potassium.	Chloride of calcium.	Chloride of magnesium.	Sulphate of potash.	Sulphate of calcium.	Sulphates of magnesium and soda.	Carbonates of magnesium and lime.	Alumina and iron.	Residue.	Water.	Percentage of saline residue.	Authorities.
<i>Rock salt.</i>													
Wieliczka, white	100	.....	.....	Tr.	.....	.....	.....	.....	.....	.....	.....	.....	Bischof.
Berchtesgaden, yellow	99.928	.....	.....	0.07	.....	.....	.....	.....	.....	.....	.....	.....	Do.
Hall, in Tyrol	99.43	.....	0.25	0.12	0.20	.....	.....	.....	.....	.....	.....	.....	Do.
Schwäbire, Hall	99.63	.....	0.09	0.28	.....	.....	.....	.....	.....	.....	.....	.....	.....
Stassfurt	94.57	.....	.....	0.97	0.89	.....	.....	1.12	2.23	0.22	.....	.....	Heine.
Hallstadt in Up. Austria.	98.14	Tr.	.....	.....	1.86	.....	.....	.....	.....	.....	.....	.....	Bischof.
Wilhelmsglück	98.36	.....	.....	.....	0.55	0.03	0.65	0.53	.....	.....	.....	.....	.....
Vic in German Lorraine.	99.30	.....	.....	.....	0.50	.....	.....	0.20	.....	.....	.....	.....	Berthier.
Jeb-el-Melah, Algeria..	97	.....	.....	.....	3.00	.....	.....	.....	.....	.....	.....	.....	Fournet. (?)
Ouled Kebbah, Algeria	98.53	.....	0.93	0.57	.....	.....	.....	.....	.....	.....	.....	.....	Do.
Cheshire, England	99.32	.....	.....	0.02	0.46	.....	.....	.....	.....	.....	.....	.....	G. H. Cook.
Carrickfergus, Ireland.	96.28	.....	.....	.....	3.50	0.08	.....	.....	.....	0.14	.....	.....	Do.
Holston, Virginia	99.55	Tr.	.....	.....	.....	.....	0.45	.....	.....	.....	.....	.....	C. B. Hayden.
Petite Anse, Louisiana.	98.88	Tr.	Tr.	.....	0.79	.....	.....	.....	.....	0.33	.....	.....	Goessman.
Santo Domingo	98.33	.....	.....	0.04	1.48	.....	.....	.....	0.01	0.07	.....	.....	Do.
Cardona, Spain	98.55	.....	0.99	0.02	0.44	.....	.....	.....	.....	.....	.....	.....	.....
<i>Sea salt.</i>													
Turks Island	96.76	.....	.....	0.14	1.56	0.64	.....	.....	.....	0.90	.....	.....	G. H. Cook.
St. Martins	97.21	.....	.....	0.26	0.54	0.24	.....	.....	.....	1.75	.....	.....	Do.
St. Kitts	99.77	.....	.....	0.01	0.08	.....	.....	.....	.....	0.14	.....	.....	Do.
Curaçoa	99.85	.....	.....	0.03	0.12	.....	.....	.....	.....	.....	.....	.....	Do.
Cadiz	95.76	.....	.....	0.57	0.75	0.48	.....	.....	.....	2.44	.....	.....	Do.
Lisbon	94.17	.....	.....	1.11	0.49	1.39	.....	.....	.....	2.84	.....	.....	Do.
Trapani, Sicily	96.78	.....	.....	0.49	0.41	0.68	.....	.....	.....	1.64	.....	.....	Do.
Marthas Vineyard	94.91	.....	.....	0.24	1.42	0.19	.....	.....	.....	3.24	.....	.....	Do.
Texas	99.46	.....	.....	.....	0.10	0.30	.....	.....	.....	0.14	.....	.....	Do.
Pacific coast (Union Pacific Salt Co.).	98.435	.....	.....	.....	.....	0.365	.....	.....	.....	1.20	.....	.....	Falkenau & Reese.
<i>Salt from springs and lakes.</i>													
Cheshire, England	96.36	.....	0.01	0.02	1.17	.....	.....	.....	.....	2.44	.....	.....	Do.
Dienze, German Lorraine.	97.39	.....	.....	.....	1.02	0.89	.....	.....	.....	0.50	.....	.....	Do.
Droitwich, England ...	96.93	.....	.....	0.02	3.05	.....	.....	.....	.....	.....	.....	.....	Do.
Goderich, Ontario	97.03	.....	0.01	0.03	1.43	.....	.....	.....	.....	1.50	.....	.....	Goessman.
Onondaga, New York ..	97.41	.....	0.15	0.18	1.26	.....	.....	.....	.....	1.00	.....	.....	G. H. Cook.
Pittsburg, Pennsylvania.	96.70	.....	0.33	0.07	.....	.....	.....	.....	.....	2.70	.....	.....	Do.
Kanawha, West Virginia.	91.31	.....	1.26	0.43	.....	.....	.....	.....	.....	7.00	.....	.....	Do.
Holston, Virginia	99.11	.....	.....	.....	0.68	0.11	.....	.....	.....	0.10	.....	.....	Do.
Saginaw, Michigan	92.97	.....	1.09	0.50	0.33	.....	.....	.....	0.01	5.10	.....	.....	Do.
Hocking Valley, Ohio.	93.07	.....	0.61	0.04	0.10	.....	.....	.....	.....	3.40	.....	.....	Goessman.
Pomeroy, Ohio	96.42	.....	0.53	0.18	.....	.....	.....	0.05	0.16	2.66	.....	.....	E. S. Wayne.
Nebraska	98.12	.....	.....	0.07	0.24	0.89	.....	.....	.....	0.80	.....	.....	Goessman.
Kansas	93.06	.....	.....	0.24	1.12	0.18	.....	.....	.....	4.80	.....	.....	Do.

Composition of salt from various localities—Continued.

Varieties of salt.	Chloride of sodium.	Chloride of potassium.	Chloride of calcium.	Chloride of magnesium.	Sulphate of potash.	Sulphates of calcium.	Sulphates of magnesia and soda.	Carbonates of magnesia and lime.	Alumina and iron.	Residue.	Water.	Percentage of saline residue.	Authorities.
<i>Salt from springs and lakes.—Cont'd.</i>													
Onondaga "factory filled."	98.28	-----	-----	-----	-----	0.91	0.09	-----	-----	0.12	0.60	-----	Goessman.
Great Salt Lake	97.61	-----	-----	-----	-----	1.03	0.08	-----	-----	-----	1.28	-----	G. H. Cook.
Elton Lake, Russia	98.95	-----	-----	0.19	-----	0.51	0.35	-----	-----	-----	-----	-----	Göbel.
<i>Solid residue of brines and sea water.</i>													
Halle, in Prussia and Saxony.	94.43	0.21	1.03	1.69	-----	2.23	-----	0.39	-----	-----	-----	12.28	Meissner.
Stassfurt	94.49	-----	-----	0.99	0.34	2.80	1.20	0.18	-----	Tr.	-----	17.16	Heine.
Schönebeck	95.71	0.08	-----	1.09	0.08	1.61	1.37	0.06	-----	-----	-----	2.00	Herman.
Do.	93.72	-----	-----	0.67	1.34	2.55	1.18	0.49	0.03	-----	-----	11.10	Watts Dict. of Chem., Vol. V, p. 334.
Artern, from bore in rock salt.	95.35	0.45	-----	1.59	1.10	1.51	-----	-----	-----	-----	-----	26.50	Heine.
Dunenberg	89.88	-----	-----	1.49	0.99	0.04	0.63	0.17	6.77	0.02	-----	8.39	Do.
Manheim	82.23	1.83	6.74	1.18	-----	0.18	-----	7.63	-----	0.07	-----	2.87	Bromeis.
Soden	86.01	1.81	-----	2.24	-----	0.65	-----	8.79	-----	0.50	-----	1.27	Figuer and Mialho.
Cheshire	97.40	-----	0.25	0.25	-----	1.90	-----	-----	0.20	-----	-----	26.00	Wm. Henry.
Dieuze	84.87	-----	-----	-----	-----	1.83	3.30	-----	-----	-----	-----	15.20	G. H. Cook.
China	75.47	-----	17.92	5.97	-----	-----	-----	-----	-----	-----	-----	21.20	Boussingault.
Onondaga	95.42	-----	0.84	0.64	-----	3.09	-----	-----	0.01	-----	-----	18.54	G. H. Cook.
Pittsburg	81.27	-----	13.93	4.80	-----	-----	-----	-----	Tr.	-----	-----	2.80	Do.
Kanawha	79.45	-----	16.48	4.07	-----	-----	-----	-----	Tr.	-----	-----	9.20	Do.
Holston	98.39	-----	-----	-----	-----	1.22	0.39	-----	Tr.	-----	-----	26.40	Do.
Salt Lake, Texas	97.08	-----	-----	-----	-----	0.82	2.10	-----	-----	-----	-----	24.90	Do.
Sea water	78.61	1.34	-----	8.56	-----	3.47	6.42	0.27	-----	-----	-----	3.74	Usiglio.
Elton Lake	13.15	0.79	-----	67.80	-----	-----	18.26	-----	-----	-----	-----	29.13	Rose.
Dead Sea	29.86	2.51	11.81	55.45	-----	0.37	-----	-----	-----	-----	-----	26.42	Booth and Muckle.
Great Salt Lake	90.07	-----	-----	1.12	-----	-----	8.18	-----	-----	-----	-----	22.42	L. D. Gale.
Sea water (San Francisco Bay).	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3.033	F. Gutzkow.

2. FLUORITE.

This is a calcium fluoride, CaF_2 = fluorine 48.9 per cent, calcium 51.1 per cent. The most striking features of this mineral are its cubic crystallization (Specimens Nos. 51226, 66831, 66832, U.S.N.M.), octahedral cleavage (Specimen No. 48270, U.S.N.M.), and fine green (Specimen No. 48270, U.S.N.M.), yellow (Specimen No. 49160, U.S.N.M.), purple (Specimen No. 51226, U.S.N.M.), violet, and sky blue colors. White (Specimen No. 36091, U.S.N.M.) and red-

brown varieties are also known. The mineral is translucent to transparent, and of a hardness somewhat greater than calcite (4 of Dana's scale).

Occurrence.—The mineral occurs as a rule in veins, though sometimes in beds in gneiss, the schists, limestones, and sandstones. It is also a common gangue of metallic ores, particularly those of lead and tin.

At Rosiclare, in southern Illinois, the fluorspar veins, according to Emmons,¹ are true fissure veins, varying from 4 to 20 feet in width in limestones immediately underlying the coal measures. He regards the original crevice as formed by dynamic action, as probably comparatively small and subsequently enlarged by solution by percolating waters. The source of the fluorspar of the veins would seem to be the surrounding limestones.

The associated minerals are galena and calcite, with smaller quantities of sphalerite and iron and copper pyrites.

Uses.—The material is used mainly as a flux for iron, in the manufacture of opalescent glass and for the production of hydrofluoric acid. The chief source of supply in the United States is Rosiclare, Illinois, the annual output being some 6,000 to 10,000 tons, valued at about \$5 a ton.

3. CRYOLITE.

Composition.— Na_3AlF_6 , =aluminum 12.8 per cent; sodium 32.8 per cent; fluorine 54.4 per cent. The mineral is as a rule of snow-white color, though sometimes reddish or brownish, rarely black, and coarsely crystalline granular, translucent to subtransparent. It has a hardness of 2.5; specific gravity of 2.9 to 3, and in thin splinters may be melted in the flame of a candle.

The name is from the Greek word *κρυος*, ice, in allusion to its translucency and ice-like appearance (Specimen No. 17571, U.S.N.M.).

Mode of occurrence.—Cryolite occurs, as a secondary product, in the form of veins. It is rarely found in sufficient abundance to be of commercial value, the supply at present coming almost wholly from Evigtok in South Greenland. The country rock here is said to be granite and the vein as described in 1866² was 150 feet in greatest breadth and was exposed for a distance of 600 feet. The principal mineral of the vein was cryolite, but quartz, siderite, galena, and chalcopyrite were constant accompaniments, irregularly distributed through the mass. In 1890 the mine as worked was described as a hole in the ground elliptical in shape, 450 feet long by 150 feet wide, the pit being some 100 feet deep. The drills had penetrated 150 feet

¹ Transactions of the American Institute of Mining Engineers, XXI, 1893, p. 31.

² Paul Quale, Report of Smithsonian Institution, 1866, p. 398.

deeper and found cryolite all the way. Johnstrup, as quoted by Dana,¹ describes the cryolite as:

Limited to the granite; he distinguishes a central and a peripheral part; the former has an extent of 500 feet in length and 1,000 feet in breadth and consists of cryolite chiefly, with quartz, siderite, galena, sphalerite, pyrite, chalcopyrite, and wolframite irregularly scattered through it. The peripheral portion forms a zone about the central mass of cryolite; the chief minerals are quartz, feldspar, and ivigite, also fluorite, cassiterite, molybdenite, arsenopyrite, columbite. Its inner limit is rather sharply defined, though there intervenes a breccia-like portion consisting of the minerals of the outer zone enclosed in cryolite; beyond this it passes into the surrounding granite without distinct boundary.

Cryolite in limited quantity occurs at the southern base of Pike's Peak, in Colorado, and north and west of St. Peter's Dome (Specimen No. 48220, U.S.N.M.). It is found in vein-like masses of quartz and microcline embedded in granite.

Uses.—Until within a few years the material has been utilized only in the manufacture of soda, and sodium and aluminum salts, and to a small extent in the manufacture of glass and porcelain ware. It is also used in the electrolytic processes of extracting aluminum from its ores, as now practiced.

The principal works utilizing the Greenland cryolite in chemical manufacture are, at time of writing, those of the Pennsylvania Salt Manufacturing Company at Natrona, Pennsylvania (see series of crude and manufactured products Nos. 63327 to 63334, U.S.N.M.).

IV. OXIDES.

1. SILICA.

QUARTZ.—The mineral quartz, easily recognized by its insolubility in acids, glassy appearance (Specimen No. 67985, U.S.N.M.), lack of cleavage, and hardness, which is such that it readily scratches glass, is one of the most common and widely disseminated of minerals. Chemically it is pure silica, of the formula SiO_2 . It crystallizes in the hexagonal system with beautiful terminations, and is one of the most attractive of minerals for the amateur collector (Specimen No. 61768, U.S.N.M.). The common form is, however, massive, occurring in veins in the older crystalline rocks (Specimen No. 55244, U.S.N.M.). Common sand is usually composed mainly of quartzose grains which, owing to their hardness and resistance to atmospheric chemical agencies, have withstood disintegration to the very last.

The terms *rose*, *milky* (Specimen No. 62381, U.S.N.M.), and *smoky* (Specimen No. 67986, U.S.N.M.) are applied to quartzes which differ from the ordinary type only in tint, as indicated. Chalcedony is the name given to a somewhat hornlike, translucent or transparent form of silica occurring only as a secondary constituent in veins, or isolated concretionary masses, and in cavities in other rocks. Agate is a banded

¹System of Mineralogy, 1892, p. 167.

variety of chalcedony. The true onyx is similar to agate, except that the bands or layers of different colors lie in even planes. Jasper is a ferruginous, opaque chalcedony, sometimes used for ornamental purposes. Opal is an amorphous form of silica, containing somewhat variable amounts of water.

Quartz occurs as an essential constituent of granite, gneiss, mica schist, quartz porphyry, and liparite, and also as a secondary constituent in the form of veins, filling joints and cavities in rocks of all kinds and all ages.

Uses.—The finer clear grades of quartz are used to some extent for spectacle lenses and optical work, as well as in cheap jewelry (Specimen No. 11893, U.S.N.M.). Its main value is, however, for abrading purposes, either as quartz sand or as sandpaper (Series Nos. 55877–55884, U.S.N.M.), and in the manufacture of pottery (Specimens Nos. 62123, 63035–63038, U.S.N.M.). For abrading purposes it is crushed and bolted, like emery and corundum, and brings a price barely sufficient to cover cost of handling and transportation. Pure quartz sand is also of value for glass making (Specimens Nos. 53188, 60683, 63128, 63123, 63122, U.S.N.M.), and ground quartz to some extent as a “filler” in paints (Specimen No. 63119, U.S.N.M.), and as a scouring material in soaps. The following analyses show the composition of some glass sands from (I) Clearfield and (II) Lewistown, Pennsylvania:

Constituents.	I.	II.
Silica	99.79	98.84
Alumina	0.12	0.17
Iron oxides.....	0.014	0.34
Lime	0.8	Traces.
Ignition .....	.....	0.23
	100.724	99.58

FLINT is a chalcedonic variety of silica found in irregular nodular forms in beds of Cretaceous chalk. These nodules break with a conchoidal fracture and interiorly are brownish to black in color (Specimen No. 62120, U.S.N.M.). By the aboriginal races the flints were utilized for the manufacture of knives and general cutting implements. Later they were used in the manufacture of gun flints and the “flint and steel” for producing fire. At present they are used to some extent in the manufacture of porcelain, being calcined (Specimen No. 62061, U.S.N.M.) and ground (Specimen No. 62122, U.S.N.M.) to mix with the clay and give body to the ware. In this country the same purpose is accomplished by the use of quartz. Small round nodules of flint from Dieppe, France, are said to be used in the Trenton (New Jersey) pottery works for grinding clay by being placed in revolving vats of water and kaolin. All the flint now used in this country is imported either as ballast or as an accidental constituent of chalk.

As the material is worth but from \$1 to \$2 a ton delivered at Trenton, it may be readily understood that transportation is a rather serious item to be considered in developing home resources.

According to Mr. R. T. Hill, nodules of black flint occur in enormous quantities in the chalky limestones—the *Caprina* limestones—of Texas. Numerous localities are mentioned, the most accessible being near Austin, on the banks of the Colorado River.

BUHRSTONE, or **burrstone**, is the name given to a variety of chalcedonic silica, quite cavernous, and of a white to gray or slightly yellowish color. The cavernous structure is frequently due to the dissolving out of calcareous fossils. The rock is of chemical origin—that is, results from the precipitation of silica from solution, and presumably through the action of organic matter. In France the material occurs alternating with other unaltered Tertiary strata in the Paris basin (Specimen No. 36140, U.S.N.M.). It is also reported in Eocene strata in South America, and in Burke and Screven counties along the Savannah River in southern Georgia in the United States (Specimen No. 36051, U.S.N.M.). The toughness of the rock, together with the numerous cavities, impart a sharp cutting power such as renders them admirably adapted for millstones, and in years past material for this purpose has been sent out from French sources all over the civilized world.

TRIPOLI is the commercial name given to a peculiar porous rock regarded as a decomposed chert associated with the Lower Carboniferous limestones of southwest Missouri (Specimen No. 55028, U.S.N.M.). The rock is of a white cream or slight pink cast, fine grained and homogeneous, with a distinct gritty feel, and, though soft, sufficiently tenacious to permit of its being used in the form of thin disks of considerable size for filtering purposes (Specimen No. 62044, U.S.N.M.). According to Hovey¹ the deposit is known to underlie between 80 and 100 acres of land, in the form of a rude ellipse, with its longer diameter approximately north and south. From numerous prospect holes and borings it has been shown to have an average thickness of 15 feet, the main quarry of the present company showing a thickness of 8 feet. The following section is given from a well sunk in the northern part of the area:

	Feet.	
Earth	0	to 4
Tripoli	4	20
Stiff red clay	20	21½
Mixed chert, clay, and ochre	21½	40
Cherty limestone	40	93
Cherty limestone bearing galena	93	103
Limestone	103	128
Limestone bearing sphalerite and galena	128	136
Soft magnesian limestone	136	173

¹Scientific American Supplement, July 28, 1894, p. 15487.

The tripoli is everywhere underlain by a relatively thin bed of stiff red clay, and also traversed in every direction by seams of the same material from 1 to 2 inches thick. These seams and other joints divide the rock into masses which vary in size up to 30 inches or more in diameter. Microscopic examinations as given by Hovey show the rock to contain no traces of organic remains, but to be made up of faintly doubly refracting chalcedonic particles from 0.01 to 0.03 millimetre in diameter. The chemical composition, as shown from analysis by Prof. W. H. Seaman, is as follows:

Silica (Si O_2)	98.100
Alumina (Al_2O_3)	0.240
Iron oxide (Fe O and Fe_2O_3)	0.270
Lime (Ca O)	0.184
Soda (Na_2O)	0.230
Water (ignition)	1.160
Organic matter.....	0.008
	<hr/>
	100.192

Silica soluble in a 10 per cent solution of caustic soda on boiling three hours, 7.28 per cent.

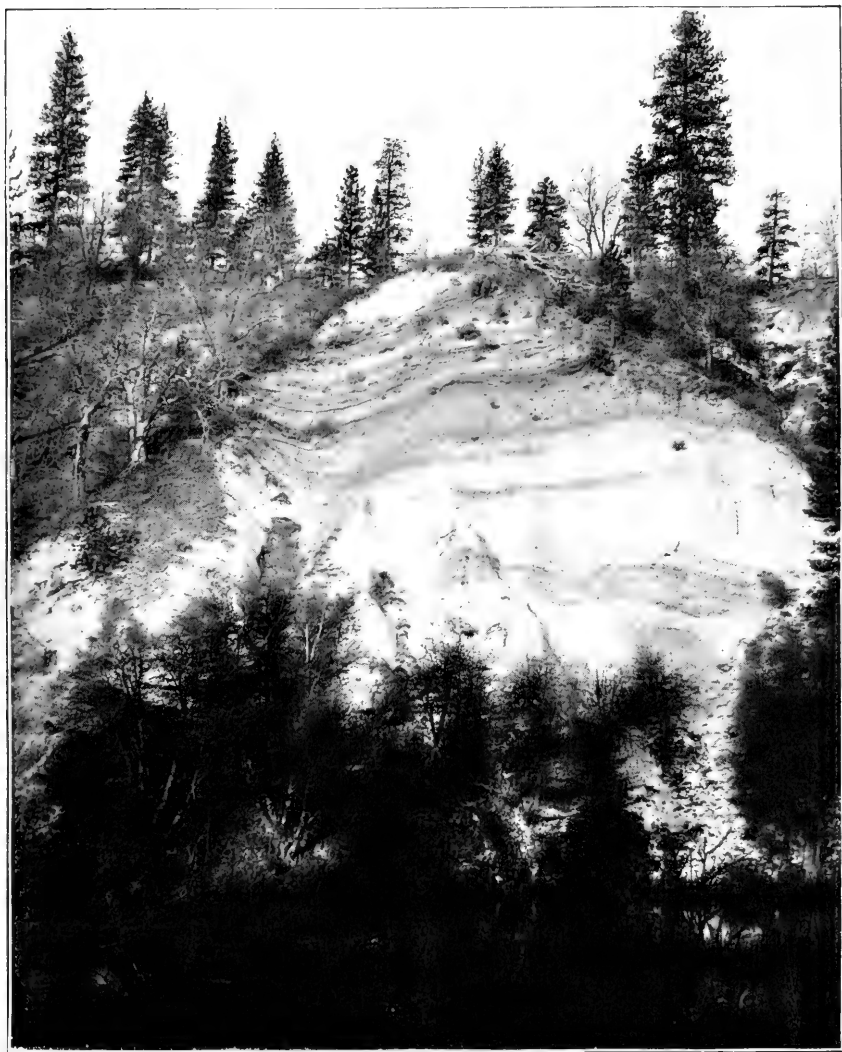
Aside from its use as a filter (Specimens Nos. 62044 and 62045, U.S.N.M.) the rock is crushed between burr stones, bolted, and used as a polishing powder (Specimens Nos. 51231 and 55029, U.S.N.M.). To a small extent it has been used in the form of thin slabs for blotting purposes, for which it answers admirably owing to its high absorptive property, but is somewhat objectionable on account of its dusty character. The view (Plate 6) shows the character of a quarry of this material as now worked by the American Tripoli Company at Seneca, in Newton County.

DIATOMACEOUS OR INFUSORIAL EARTH, as it is sometimes called, is, when pure, a soft, pulverulent material, somewhat resembling chalk or kaolin in its physical properties, and of a white or yellowish or gray color. Chemically it is a variety of opal (see analyses on page 220).

Origin and occurrence of deposits.—Certain aquatic forms of plant life known as diatoms, which are of microscopic dimensions only, have the power of secreting silica, in the same manner as mollusks secrete carbonate of lime, forming thus their tests or shells. On the death of the plant the siliceous tests are left to accumulate on the bottom of the lakes, ponds, and pools in which they lived, forming in time beds of very considerable thickness, which, however, when compared with other rocks of the earth's crust are really of very insignificant proportions. Like many other low organisms the diatoms can adapt themselves to a wide range of conditions. They are wholly aquatic, but live in salt and fresh water and under widely varying conditions of



VIEW OF TRIPOLI MINES IN CARTHAGE, MISSOURI.



DEPOSIT OF DIATOMACEOUS EARTH, GREAT BEND OF PITT RIVER, SHASTA COUNTY,
CALIFORNIA.

From a photograph by J. S. Diller.

depth and temperature. They may be found in living forms in almost any body of comparatively quiet water in the United States. The exploring steamer *Challenger* dredged them up in the Atlantic from depths varying from 1,260 to 1,975 fathoms and from latitudes well toward the Antarctic Circle. Mr. Walter Weed, of the U. S. Geological Survey, has recently reported them as living in abundance in the warm marshes of the Yellowstone National Park, while Dr. Blake reported finding over 50 species in a spring in the Pueblo Valley, Nevada, which showed a temperature of 163° F.

Although beds of diatomaceous earth are still in process of formation, and in times past have been formed at various epochs, the Tertiary period appears for some reason to have been peculiarly fitted for the growth of these organisms, and all of the known beds of any importance, both in America and foreign countries, are of Tertiary age. The best known of the foreign deposits is that of Bilin, in Bohemia. This is some 14 feet in thickness. When it is borne in mind that, according to the calculations of Ehrenberg, every cubic inch of this contains not less than 40,000,000 independent shells, one stands aghast at the mere thought of the myriads of these little forms which such a bed represents. Some of the deposits in the United States are, however, considerably larger than this. What is commonly known as the Richmond bed extends from Herring Bay, on the Chesapeake, Maryland, to Petersburg, Virginia, and perhaps beyond. This is in some places not less than 30 feet thick in thickness, though very impure (Specimen No. 67984, U.S.N.M., from Calvert County, Maryland, is fairly representative). Near Drakesville, in New Jersey, there occurs a smaller deposit, covering only some 3 acres of territory to a depth of from 1 to 3 feet. Some of the largest deposits known are in the West. Near Socorro, in New Mexico, there is stated to be a deposit of fine quality which crops out in a single section for a distance of 1,500 feet and some 6 feet in thickness.

Geologists of the fortieth parallel survey reported abundant deposits in Nevada, one of which showed in the railroad cutting west of Reno a thickness not less than 300 feet, and of a pure white, pale buff, or canary yellow color (Specimen No. 67916, U.S.N.M.). Along the Pitt River, in California, there is stated to be a bed extending not less than 16 miles and in some places over 300 feet thick (see Plate 7). Near Linkville, Klamath County, Oregon (Specimens Nos. 53402, 53093, U.S.N.M.), there occurs a deposit which has been traced for a distance of 10 miles, and shows along the Lost River a thickness of 40 feet. Beds are known also to occur in Idaho (Specimens Nos. 63843, 66950, U.S.N.M.), near Seattle, in Washington (Specimen No. 53200, U.S.N.M.), and doubtless many more yet remain to be discovered. A deposit of unknown extent, pure white color, and almost pulp-like consistency has been worked in South Beddington, Maine (Specimens

Nos. 73253, 73254, U.S.N.M.). Others of less purity occur near South Framingham, Massachusetts (Specimens Nos. 62767, 62768, U.S.N.M.), Lake Umbagog, New Hampshire (Specimen No. 29322, U.S.N.M.), at White Head Lake, Herkimer County, New York (Specimen No. 62913, U.S.N.M.), and at Grand Manan, New Brunswick (Specimen No. 57339, U.S.N.M.).

Chemical Composition.—As already intimated, this earth is of a siliceous nature, and samples from widely separated localities show remarkable uniformity in composition. Of the following analyses, No. I is from Lake Umbagog, New Hampshire, No. II, from Morris County, New Jersey, and No. III, from Popes Creek, in Maryland. As will be noted, the silica percentage is nearly the same in all.

Constituents.	I	II	III
Silica.....	80.53	80.66	81.53
Alumina	5.89	3.84	3.43
Iron oxides.....	1.03	.....	3.34
Lime.....	0.35	0.58	2.61
Soda.....	.....	.....	1.43
Potash.....	.....	.....	1.16
Water and organic matter	12.03	14.01	6.04

The substance may therefore be regarded as a variety of opal.

Uses.—The main use of infusorial earth is for a polishing powder. It is, however, an excellent absorbent, and has been utilized to mix with nitroglycerine in the manufacture of dynamite. It has also been used to some extent in the preparation of the soluble silicate known as water glass. The demand for the material is therefore quite small, not nearly equal to the supply. The Maryland and Nevada deposits are said to be the principal ones now worked. During the year 1897 the entire output was about 3,000 tons, valued at some \$30,400.

2. CORUNDUM AND EMERY.

CORUNDUM.—Composition, sesquioxide of aluminum Al_2O_3 , = oxygen, 47.1 per cent; aluminum, 52.9 per cent. In crystals often quite pure, but frequently occurring associated in crystalline granular masses with magnetic iron, and often more or less altered into a series of hydrated aluminous compounds, as damourite (Specimen No. 82492, U.S.N.M.). The crystalline form of the mineral is hexagonal, or sixsided in outline, and often with curved sides and square terminations, giving rise to roughly barrel-shaped forms, as shown in specimen No. 81450 from Bengal, India.

A prominent basal cleavage causes the crystals to break readily with smooth flat surfaces at right angles with the axis of elongation. The massive forms often show a nearly rectangular parting or pseudo-

cleavage (Specimen No. 63480, U.S.N.M., from Pine Mountain, Georgia).

The most striking physical property of the mineral is its hardness, which is 9 of Dana's scale. In this respect it ranks then next to the diamond. The color of the mineral varies from white through gray (Specimen No. 46283, U.S.N.M.), brown, yellow, blue (Specimens Nos. 73531 and 48182, U.S.N.M.), pink (Specimen No. 81922, U.S.N.M.), and red; luster adamantine to vitreous; specific gravity, 3.95 to 4.1. The highly colored transparent red and blue forms are valuable as gems, and are known under the names of ruby and sapphire. The consideration of these forms is beyond the limits of this work. (See Mineral and Gem Collections.)

Occurrences.—Although widespread as a mineral, corundum, unmixed with a large proportion of magnetite (forming emery), has been found in but few localities in sufficient abundance to be of commercial value. The most important deposits in the United States are in southwestern North Carolina and in the Laurel Creek region of northern Georgia. The country rock in both these regions is hornblende gneiss, through which has been intruded a basic eruptive (dunite, Specimen No. 70069, U.S.N.M.), and it is mainly along the decomposed lines of contact between the two that the corundum is found. According to Dr. T. M. Chatard, the Corundum Hill Mine is situated on a ridge which runs in the northeast and southwest direction characteristic of this section, the dunite outcrops being on the crest, and apparently surrounded on all sides except toward the east by hornblende gneiss. On the east side mica schist (probably damourite schist) takes the place of the gneiss, and it is on the eastern side of the dunite that the so-called "sand vein" is found. This is a vein-like mass of brown vermiculite in small scales containing an abundance of small crystals of corundum which are usually brown in color and often broken into fragments (Specimen No. 73529, U.S.N.M.). The easterly wall of this vein is the mica schist very much decomposed, while on the western side is found enstatite (Specimen No. 70070, U.S.N.M.), next vermiculite mixed with chlorite, then talc (Specimen No. 70071, U.S.N.M.), which in turn gives place to nodules of more or less altered dunite.

The specimens of corundum crystals for which this locality is so celebrated (Specimen No. 73530, U.S.N.M.) have been found mainly, if not wholly, on the westerly side of the dunite, and on or near the line of contact between the gneiss and dunite.

State Geologist Yeates has stated¹ that in the Laurel Creek region the corundum is not confined to the vermiculite and chlorite bands, but is abundant in the lime soda feldspar as well. The same authority states that in this region the dunite is not inclosed by the hornblende

¹Bulletin No. 2, Geological Survey of Georgia, 1894.

gneisses, but intruded between these and other gneiss or mica schist; also that the corundum-bearing veins lie in the dunite close to the contact and in the vicinity of the hornblendic gneiss. It should be said before leaving the subject that certain micaceous minerals, as margarite and chloritoid (Specimen No. 63107, U.S.N.M., from Chester, Massachusetts) are almost invariable accompaniments of corundum and emery deposits, and that it was the finding of these minerals that led to the discovery of the emery beds at Chester. Chatard reports that in the North Carolina mines chlorite or vermiculite is considered a "corundum sign," and in mining such indications are followed so long as they hold out (Specimen No. 63153, U.S.N.M.).

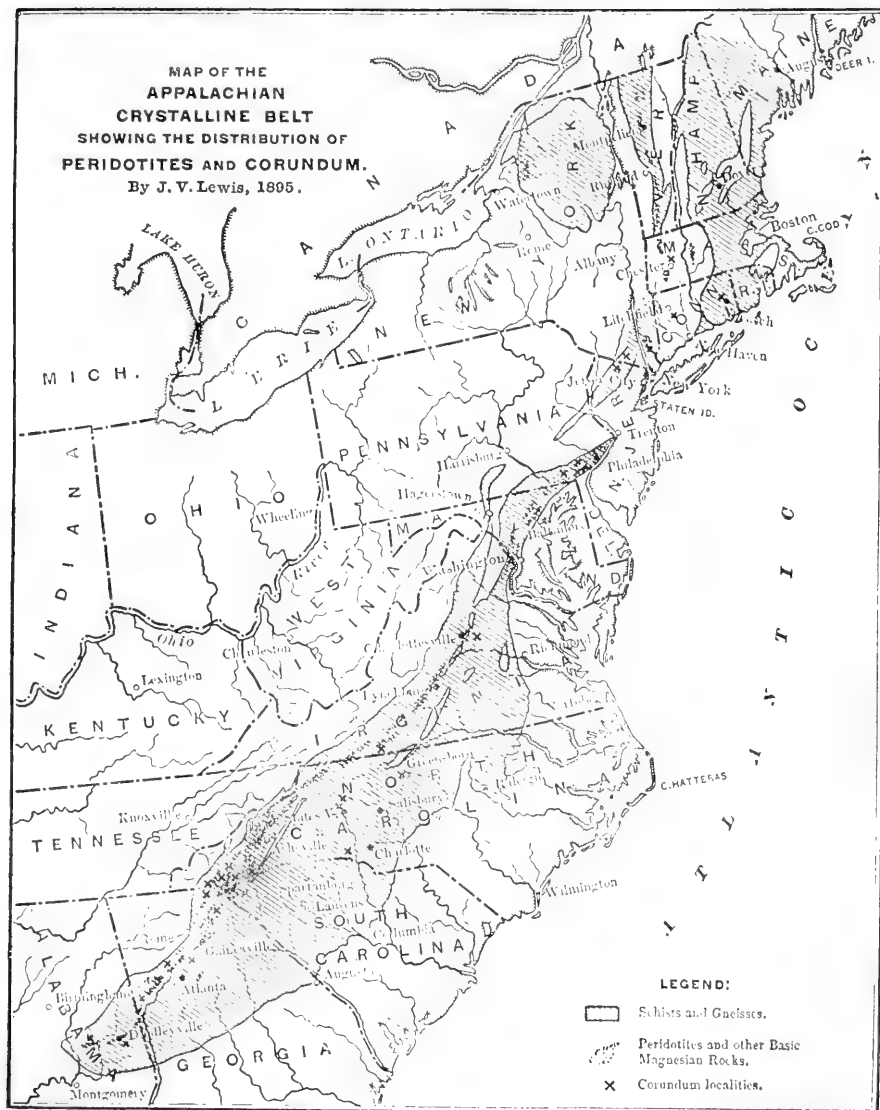
The geographical distribution of corundum-bearing rocks in the eastern United States has been worked out in detail by J. V. Lewis of the North Carolina Geological Survey, from whose report¹ the accompanying map (Plate 8) is taken. According to this authority the corundum occurring in such quantities as to be of commercial value is almost universally found in connection with basic eruptive rocks, as peridotites or their varietal forms pyroxenite and amphibolite, which are themselves intruded into gneisses.

At Yogo Gulch, Montana, corundum in the form of sapphire (see Gem Collections) occurs as a constituent of a basic eruptive rock near the line of contact with aluminous shales (Specimen No. 53519, U.S.N.M.). In Gallatin County the mineral is found in well-defined crystals of all sizes up to an inch or more in length abundantly disseminated throughout a granite (Specimen No. 83838, U.S.N.M.). In the Russian Urals it occurs in disseminated crystals and large cleavage masses in feldspar (Specimens Nos. 40323, 40315, 40334, 73532, U.S.N.M.). In India it occurs as an original constituent associated with both acid and basic rocks, but in most cases where the mineral is in the basic rocks there have been found intrusions of pegmatite (an acid rock) in the near vicinity. In the celebrated Mogok Ruby Mines the corundum is found in a crystalline limestone and the detritus resulting from its decay, the limestone itself being regarded by Professor Judd as an extreme form of alteration of rocks of igneous origin (see further under Emery).

Corundum has recently been reported as a constituent of both nepheline syenites and ordinary syenites in the counties of Renfrew, Hastings, and Peterborough, in Eastern Ontario, Canada. According to W. G. Miller² these syenites are dike rocks, consisting essentially of feldspar, nepheline, and black mica or hornblende, the corundum occurring more abundantly in the ordinary syenite than in that which carries nepheline. The dikes are from a few inches to some feet in diameter, and the corundum is distributed in a somewhat capricious

¹Bulletin No. 11. Corundum and the Basic Magnesian Rocks of Western North Carolina, by J. V. Lewis, 1896.

²Report of the Canadian Bureau of Mines, VII, Pt. 3, 1898, p. 207.



MAP SHOWING DISTRIBUTION OF CORUNDUM AND PERIDOTITE IN THE EASTERN UNITED STATES.

After J. V. Lewis, Bulletin 11, North Carolina Geological Survey.

manner, being quite uniformly distributed in some of the smaller dikes, or segregated irregularly along certain lines or patches. In some of the dikes the mineral is quite lacking. The total area covered by the corundum-bearing rocks, in the three counties mentioned, is 100 square miles (Specimen No. 53538, U.S.N.M.).

Origin.—Dr. Chatard, as a result of his observations already quoted, regards the corundum of Franklin County, North Carolina, and the Laurel Creek region of Georgia as a secondary mineral produced by a mutual reaction between the various elements of the dunite and gneiss during decomposition, the solutions formed during such decomposition giving rise to such reactions as are productive of chlorite and vermiculites, and, where the necessary conditions of proportion are reached, to corundum.

On the other hand, Dr. J. H. Pratt,¹ who has made a detailed study of the North Carolina region, regards the corundum as an original constituent of the peridotite—as having been held in solution in the molten magma at the time of its intrusion into the country rock, and having been one of the first minerals to crystallize on its cooling. This view is most in accord with recent synthetic work done by Morozewicz and others.

Pirsson, who has described² the occurrence of sapphires in a basic eruptive rock from Yogo Gulch, Montana, regards them as of pyrogenetic origin—that is, they result from the direct crystallization of the oxide, but which has been derived from aluminous material dissolved from shales by the molten rock during its intrusion. The sharp outlines of the crystals in the granite from Gallatin County, Montana (Specimen No. 83838, U.S.N.M.), is also indicative of a direct crystallization from a molten magma containing an excess of aluminum. A like origin must also be recognized for the Canadian mineral, and a part at least of that of India.

EMERY.—The rock emery takes its name from Cape *Emeri*, on the island of Naxos, where it occurs in great abundance. Mineralogically it has been regarded by various authorities as either a mechanical admixture of corundum and magnetic iron ore or as simply a massive iron spinel—hercynite. So far as the Naxos emery is concerned, the first view is undoubtedly correct. Physically emery is a massive, nearly opaque, dark gray to blue-black or black material, with a specific gravity of 4 and hardness of 8, Dana's scale, breaking with a tolerably regular fracture, and always more or less magnetic.

Chemically the material is quite variable in composition, a fact which gives support to the opinions of those who hold it to be a mixture rather than a true chemical compound. Below are the results of

¹American Journal of Science, VI, 1898, pp. 49-65.

²Idem, IV, 1897, p. 421.

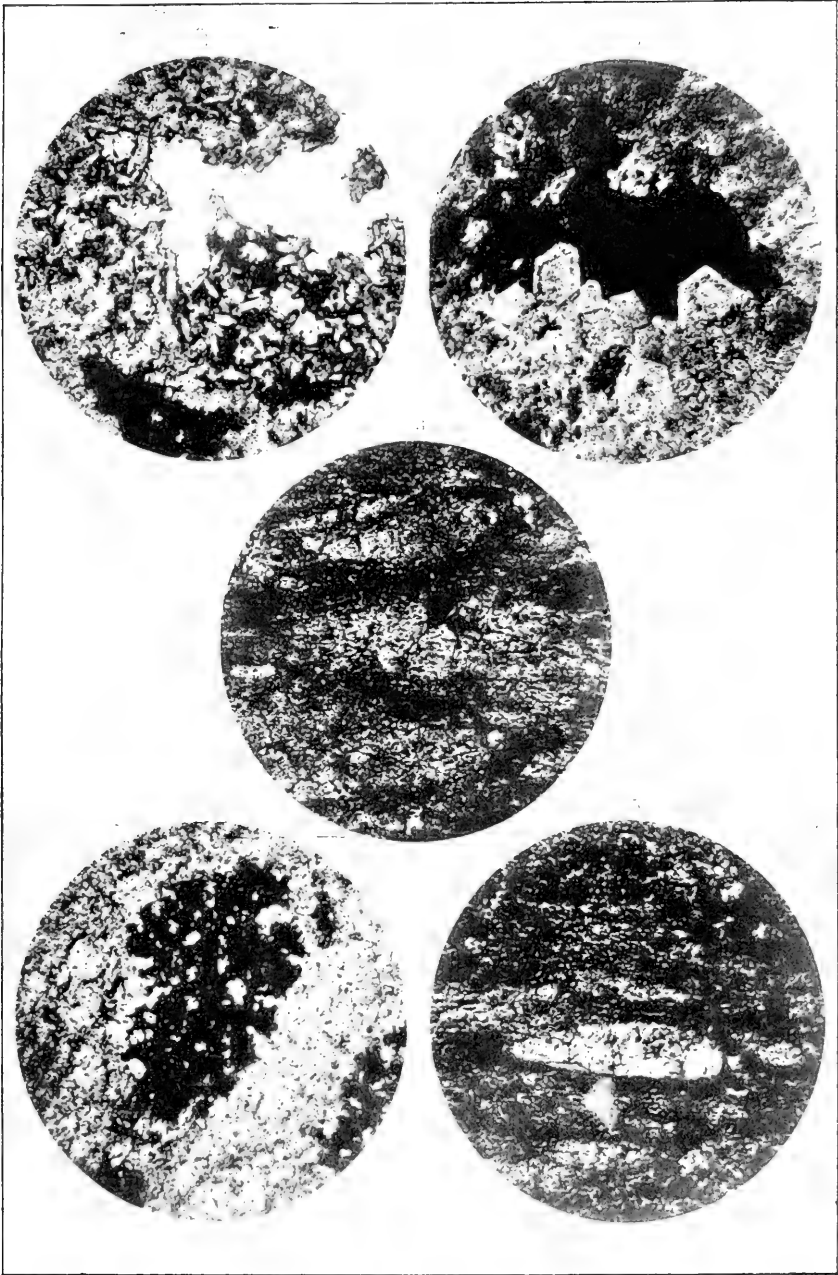
analyses by Dr. J. Lawrence Smith, from whose papers on the subject these notes are partially compiled:

Localities.	Alumina.	Iron.	Lime.	Silica.	Water.
Kulah	61.05	27.15	1.30	9.63	2.00
	63.50	33.25	0.92	1.61	1.90
Samos	70.10	22.21	0.62	4.00	2.10
Gumuch	60.10	33.20	0.48	1.80	5.62
	77.82	8.62	1.80	8.13	3.11
Nicaria	71.06	20.32	1.40	4.12	2.53
	75.12	13.06	0.72	6.88	3.10
Ephesus	60.10	33.20	0.48	1.80	5.62
	44.01	50.21	.....	3.13	.....
	50.02	44.11	.....	3.25	.....
Chester, Massachusetts	51.92	42.25	.....	5.46	.....
	74.22	19.31	.....	5.48	.....
	84.02	9.63	.....	4.81	.....

Geologically emery, like corundum, belongs mainly to the older crystalline rocks. In Asia Minor it occurs in angular or rounded masses from the size of a pea to those of several tons weight, embedded in a blue-gray or white crystalline limestone, which overlies micaceous or hornblendic schists, gneisses, and granites. Superficial decomposition has, as a rule, removed more or less of the more soluble portions of the limestone, leaving the emery nodules in a red ferruginous soil. With the emery are associated other aluminous minerals as mentioned below.

According to Tschermak¹ the Naxos emery (Specimen No. 60465, U.S.N.M.) occurs mostly in the form of an iron-gray, scaly to schistose, rarely massive, aggregate consisting essentially of magnetite and corundum, the latter mineral being in excess. In addition to these two minerals occur hematite and limonite, as alteration products of the magnetite; margarite, muscovite, biotite, tourmaline, chloritoid, diaspore, disthene, staurolite, and rutile occur as common accessories; rarely are found spinel, vesuvianite, and pyrite. Under the microscope he finds the emery rock to show the corundum in rounded granules and sometimes well-defined crystals with hexagonal outlines, particularly in cases where single individuals are embedded in the iron ores. (Plate 9, fig. 2.) In many cases, as in the emery of Krenino and Pesulas, the granules are partially colored blue by a pigment sometimes irregularly and sometimes zonally distributed. The corundum grains, which vary in size between 0.05 mm. and 0.52 mm. (averaging about 0.22 mm.), are very rich in inclusions of the iron ores, largely magnetite in the form of small, rounded granules. The quantity of these is so great as at times to render the mineral quite opaque, though at times of such dust-like fineness as to be translucent and of a brownish

¹Mineralogische und Petrographische Mittheilungen, XIV, 1894, p. 313.



MICROSTRUCTURE OF EMERY.

After Tschermak, Mineralogische und Petrographische Mittheilungen, XIV, Part 4.

color. The larger corundums are often injected with elongated, parallel-lying clusters or groups of the iron ores, as shown in fig. 3, Tschermak's paper. The corundums in turn are often surrounded by borders of very minute zircons. The iron ore, as noted above, is principally magnetite, but which, by hydration and oxidation, has given rise to abundant limonite. The magnetites are in the form of rounded granules and dust-like particles, and also at times in well-defined octahedrons. In their turn the magnetites also inclose particles of corundum very much as the metallic iron of meteorites of the pallosite group inclose the olivines and as shown in Plate 9, fig. 4. The iron ores, as a rule, occur in parallel layers and lenticular masses or nests.

The following account of these deposits and the method of working is by A. Gobantz:¹

Naxos, the largest of the Cyclades Islands, is remarkable as being one of the few localities in the world producing emery on a large scale; the deposits, which are of an irregularly bedded or lenticular form, being mostly concentrated on the mountains at the northern end of the island, the most important ones being in the immediate vicinity of the village of Bothris. The island is principally made up of archæan rocks, divisible into gneiss and schist formations, the latter consisting of mica schists alternating with crystalline limestones. The lenticular masses of emery, which are very variable in size, ranging in length from a few feet to upward of 100 yards and in maximum thickness from 5 to 50 yards, are closely associated with the limestones, and, as they follow their undulations, they vary very much in position, lying at all kinds of slope, from horizontal to nearly vertical. Seventeen different deposits have been discovered and worked at different times. These range over considerable heights from 180 to 700 meters above sea-level, the largest working, that of Malia, being one of the lowest. This important deposit covers an area of more than 30,000 square metres, extending for about 500 metres in length with a height of more than 50 metres. This was worked during the Turkish occupation, and it has supplied fully one-half of all the emery exported since the formation of the Greek Kingdom. The highest quality of mineral is obtained from two comparatively thin but extensive deposits at Aspalanthropo and Kakoryakos, which are 435 metres above the sea level. The mineral is stratified in thin bands from 1 to 2 feet in thickness, crossed by two other systems of divisional planes so that it breaks into nearly cubical blocks in the working. The floor of the deposit is invariably crystalline limestone, and the roof a loosely crystalline dolomite covered by mica schist. The underlying limestones are often penetrated by dykes of tourmaline granite, which probably have some intimate connection with the origin of the emery beds above them.

Mineralogically emery is a compact mixture of blue corundum and magnetic iron ore, its value as an abrasive material increasing with the proportion of the former constituent. This proportion has, however, been usually much overestimated. Seven samples collected by the author have been examined at the Technical High School in Vienna, and found to contain from 60 to 66 per cent of alumina. The average composition may be considered to be $\frac{2}{3}$ corundum, the remainder being magnetite and silica in the proportion of about 2 to 1, with some carbonate of lime.

The working of the deposits is conducted in an extremely primitive fashion.

¹Oesterreichische Zeitschrift für Berg- und Hüttenwesen, XLII, p. 143. Abstract in the Minutes and Proceedings of the Institute of Civil Engineers, CXVII, pp. 466-468.

During the period of Turkish rule the exclusive right of emery mining was given to two villages, and this rule has prevailed up to the present time; no Greek Government having ventured to break down the monopoly. These privileged workmen are about 600 in number, and have the right of working the mineral wherever and in what manner they may think best. The produce is taken over by the Government official at the rate of about £3 12s. for 50 cwt. The rock is exclusively broken by fire-setting. A piece of ground, about 5 feet broad and the same height, is cleared from loose material, and a pile of brushwood heaped against it and lighted. This burns out in about twenty-four or thirty hours, when water is thrown upon the heated rock to chill it and develop fractures along the secondary divisional planes in the mass of emery, and so facilitate the breaking up and removal of the material. Sometimes a crack is opened out by inserting a dynamite cartridge, but the regular use of explosives is impossible, owing to the hardness of the mineral which can not be bored with steel tools. Only the larger lumps are carried down to the shipping place, the smaller sizes, up to pieces as large as the fist, being left on the ground.

As most of the suitable places for fire-setting at the surface have been worked out, attempts have been made to follow the deposits underground, but none of these have been carried to any depth, partly on account of the suffocating smoke of the fires, rendering continuous work difficult; but more particularly from the dangerous character of the loose dolomite roof, which is responsible for many fatal accidents from falls annually. These might, of course, be prevented by the judicious use of timber or masonry to support the roof, but this appears to be beyond the skill of the native miners.

The rapid exhaustion of the forests in the neighbourhood of the mines, owing to the heavy consumption of fuel in fire-setting, has been a cause of anxiety to the Government for some years past, and competent experts have been employed to suggest new methods of working. These have been tolerably unanimous in recommending the institution of systematic quarry workings, using diamond boring machines and powerful explosives for winning the mineral, and the construction of wire-rope ways and jetties for improving the methods of conveyance and shipping; but as funds for these improvements, owing to the disastrous condition of the national finances, are not obtainable, the primitive method of working still continues. Meanwhile the competition of the mines in Asia Minor has become so intense that the export of emery from Naxos has almost entirely ceased for a year past.

According to Jackson, the principal emery deposit at Chester, Massachusetts, in the United States, occurs at South Mountain, in the form of a bed from 4 to 10 feet in width, with a nearly N. 20° E., S. 20° W., course, and dipping to the eastward at an angle of 70°. The bed widens rapidly as it rises in the mountain, and is in one place, where it is associated with a bed of iron ore (magnetite), 17 feet wide, the emery itself being not less than 10 feet in the clear. The highest point of outcrop is 750 feet above the immediate base of the mountain. The bed cuts through both the South and North Mountains, and has been traced in length 4 miles. Frequently large globular masses of the emery are found in a state of great purity, separated from the principal masses of the bed and surrounded by a thin layer of bright green chloritoid and a thicker layer of interwoven laminated crystals of delicate lilac-colored margarite (Specimen No. 63107, U.S.N.M.), sometimes 2 or more inches in thickness. Some of these balls of emery are 3 or more feet in diameter and extremely difficult to break.

(Specimens Nos. 63102, 63103, 63104, 63105, 63106, U.S.N.M.), show the character of the ore as mined and the character of the wall or country rock.

The chief commercial sources of emery are those of Gumuchi-dagh, between Ephesus and the ancient Tralles; Kulah, and near the river Hermes in Asia Minor, and the island of Naxos, whence it is quarried and shipped from Smyrna, in part as ballast, to all parts of the world. The only commercial source of importance in the United States, or indeed, in North America, is Chester, Massachusetts, as above noted. The island of Naxos is stated to have for several centuries furnished almost exclusively the emery used in the arts, the material being chiefly obtained from loose masses in the soil. The mining at Kulah and Gumuch-dagh was begun about 1847 and at Nicaria in 1850. The emery vein at Chester, Massachusetts, was discovered by Dr. H. S. Lucas in 1863, and described by Dr. C. T. Jackson in 1864.

In preparing for use the mineral, after being dug from the soil or blasted from the parent ledge, is pulverized and bolted in various grades, from the finest flour to a coarse sand (Specimens Nos. 59844 to 59864, U.S.N.M., inclusive). The commercial prices vary according to grade from 3 to 10 cents a pound. At the end of the last century the price of the Eastern emery is given at from \$40 to \$50 a ton. About 1835 an English monopoly controlled the right of mining and the price rose in 1847 to as high as \$140 a ton.

The chief uses of emery and corundum, as is well known, are in the form of powder by plate-glass manufacturers, lapidaries, and stone workers; as emery paper, or in the form of solid disks made from the crushed and bolted mineral and cement, known commercially as emery wheels. The great toughness and superior cutting power of these wheels renders them of service in grinding glass, metals, and other hard substances, where the natural stone is quite inefficient.

(See further under Grind and Whet Stones, p. 463.)

BIBLIOGRAPHY OF CORUNDUM AND EMERY.

JOHN DICKSON. Notes.

American Journal of Science, III, 1821, pp. 4, 229.

J. LAWRENCE SMITH. Memoir on Emery—First part—On the Geology and Mineralogy of Emery, from observations made in Asia Minor.

American Journal of Science, X, 1850, p. 354.

J. LAWRENCE SMITH. Memoir on Emery—Second part—On the Minerals associated with Emery.

American Journal of Science, XI, 1851, p. 53.

WILLIAM P. BLAKE. Corundum in Crystallized Limestone at Vernon, Sussex County, New Jersey.

American Journal of Science, XIII, 1852, p. 116.

CHARLES T. JACKSON. Discovery of Emery in Chester, Hampden County, Massachusetts.

Proceedings of the Boston Society of Natural History, X, 1864, p. 84.

American Journal of Science, XXXIX, 1865, p. 87.

- CHARLES U. SHEPARD. A Description of the Emery Mine of Chester, Hampden County, Massachusetts.
Pamphlet, 16 pp., London, 1865.
- J. LAWRENCE SMITH. On the Emery Mine of Chester, Hampden County, Massachusetts. *American Journal of Science*, XLII, 1866, pp. 83-93.
Original Researches in Mineralogy and Chemistry, 1884, p. 111.
- C. W. JENKS. Corundum of North Carolina.
American Journal of Science, III, 1872, p. 301.
- CHARLES U. SHEPARD. On the Corundum Region of North Carolina and Georgia.
American Journal of Science, IV, 1872, pp. 109 and 175.
- FREDERICK A. GENTH. Corundum, its Alterations and Associated Minerals.
Proceedings of the American Philosophical Society, XIII, 1873, p. 361.
- C. W. JENKS. Note on the occurrence of Sapphires and Rubies in situ with Corundum, at the Culsagee Mine, Macon County, North Carolina.
Quarterly Journal of the Geological Society, XXX, 1874, p. 303.
- W. C. KERR. Corundum of North Carolina.
Geological Survey of North Carolina, I, Appendix C, 1875, p. 64.
- C. D. SMITH. Corundum and its Associate Rocks.
Geological Survey of North Carolina, I, Appendix D, 1875, p. 91-97.
- R. W. RAYMOND. The Jenks Corundum Mine, Macon County, North Carolina.
Transactions of the American Institute of Mining Engineers, VII, 1878, p. 83.
- J. WILCOX. Corundum in North Carolina.
Proceedings, Academy of Natural Sciences, Philadelphia, XXX, 1878, p. 223.
- F. A. GENTH. The so-called Emery-ore from Chelsea, Bethel Township, Delaware County, Pennsylvania.
Proceedings, Academy of Natural Sciences, Philadelphia, XXXII, 1880, p. 311.
- C. D. SMITH. Corundum.
Geological Survey of North Carolina, II, 1881, p. 42.
- F. A. GENTH. Contributions to Mineralogy.
Proceedings of the American Philosophical Society, XX, 1882.
- A. A. JULIEN. The Dunyte Beds of North Carolina.
Proceedings of the Boston Society Natural History, XXII, 1882, p. 141.
- T. M. CHATARD. Corundum and Emery.
Mineral Resources of the United States, 1883-84, p. 714.
- T. M. CHATARD. The Gneiss-Dunyte Contacts of Corundum Hill, North Carolina, in Relation to the Origin of Corundum.
Bulletin No. 42, U. S. Geological Survey, 1887, p. 45.
- G. H. WILLIAMS. Norites of the "Cortlandt Series."
American Journal of Science, XXXIII, 1887, p. 194.
- F. A. GENTH. Contributions to Mineralogy.
American Journal of Science, XXXIX, 1890, p. 47.
- . Emery Mines in Greece.
Engineering and Mining Journal, L, 1890, p. 273.
- A. GOBAUTZ. The Emery Deposits of Naxos.
Engineering and Mining Journal, LVIII, 1894, p. 294.
- FRANCIS P. KING. Corundum Deposits of Georgia.
Bulletin No. 2, Geological Survey of Georgia, 1894, 133 pp.
- T. D. PARET. Emery and Other Abrasives.
Journal of the Franklin Institute, CXXXVII, 1894, pp. 353, 421.
- J. C. TRAUTWINE. Corundum with Diaspore, Culsagee Mine, North Carolina.
Journal of the Franklin Institute, XCIV, p. 7.
- J. VOLNEY LEWIS. Corundum of the Appalachian Crystalline Belt.
Transactions of the American Institute of Mining Engineers, XXV, 1895, p. 852.

J. VOLNEY LEWIS. Valuable Discovery of Corundum.

Canadian Mining Review, XV, 1896, p. 230.

—— The Corundum Lands of Ontario.

Canadian Mining Review, XVII, 1898, p. 192.

—— Corundum in Ontario.

Engineering and Mining Journal, LXVI, 1898, p. 303.

A. M. STONE. Corundum Mining in North Carolina.

Engineering and Mining Journal, LXV, 1898, p. 490.

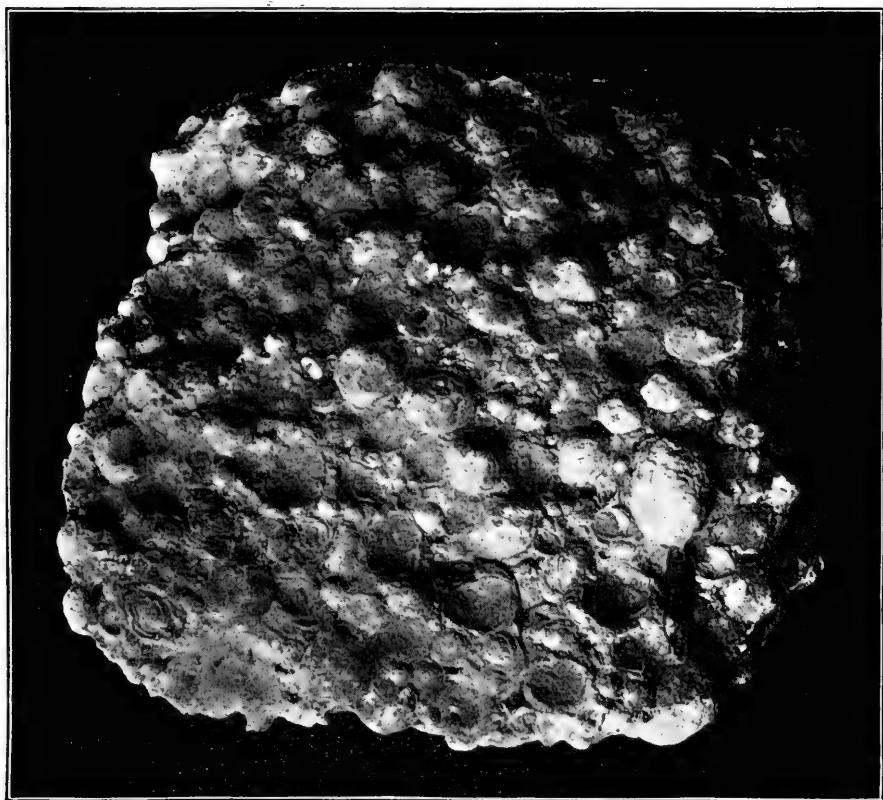


Fig. 5.

PISOLITIC BAUXITE.

Bartow County, Georgia.

Specimen No. 63335, U.S.N.M.

3. BAUXITE.

Composition $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$, =alumina, 73.9 per cent; water, 26.1 per cent. Commonly impure through the presence of iron oxides, silica, lime, and magnesia. Color, white or gray when pure, but yellowish, brown, or red through impurities. Specific gravity, 2.55; structure, massive, or earthy and clay like. According to Hayes¹ the

¹ The Geological Relations of the Southern Appalachian Bauxite Deposits. Transactions of the American Institute of Mining Engineers, XXIV, 1894, pp. 250-251.

bauxites of the Southern United States show considerable variety in physical appearance, though generally having a pronounced pisolitic structure. (See Specimens Nos. 63335, 66576, 66577, and 66578, U.S.N.M., from Floyd and Bartow counties, Georgia; also fig. 5, p. 229.)

The individual pisolites vary in size from a fraction of a millimeter to 3 or 4 centimeters in diameter, although most commonly the diameter is from 3 to 5 millimeters. The matrix in which they are embedded is generally more compact and also lighter in color. The larger pisolites are composed of numerous concentric shells, separated by less compact substance or even open cavities, and their interior portions readily crumble to a soft powder.

In thin sections the ore is seen to be made up of amorphous flocculent grains, and the various structures which it exhibits are produced by the arrangement and degree of compactness of these grains. The matrix in which the pisolites are imbedded may be composed of this flocculent material segregated in an irregularly globular form or in compact oölites, with sharply-defined outlines. Or both forms may be present, the compact oölites being embedded in a matrix composed of the less definite bodies. In some cases the interstices between the oölites are filled either wholly or in part with silica, apparently a secondary deposition.

The pisolites also show considerable diversity in structure. In some cases they are composed of exactly the same flocculent grains as the surrounding matrix, from which they are separated by a thin shell of slightly denser material. This sometimes shows a number of sharply-defined concentric rings, and is then distinctly separated from the matrix and the interior portion of the pisolite. The latter is also sometimes composed of imperfectly defined globular masses, and in other cases of compact, uniform, and but slightly granular substance. It is always filled with cracks, which are regularly radial and concentric, in proportion as the interior substance has a uniform texture. Branching from the larger cracks, which, as a rule, are partially filled with quartz, very minute cracks penetrate the intervening portions. Thus the pisolites appear to have lost a portion of their substance, so that it no longer fills the space within the outer shell, but has shrunk and formed the radial cracks. No analyses have been made of the different portions of the pisolites or of the pisolites and matrix separately, and it is impossible to say whether any differences in chemical composition exist. It may be that some soluble constituent has been removed from the interior of the pisolites, but it is more probable that the shrinking observed is due wholly to desiccation.

Scattered throughout the ground-mass are occasional fragments of pisolites, whose irregular outlines have been covered to varying depths by a deposit of the same material as forms the concentric shells, and thus have been restored to spherical or oval forms.

Composition.—The following tables will serve to show the wide range of composition of bauxites from various sources:

Composition of bauxites from various localities.

	SiO ₂ .	TiO ₂ .	Al ₂ O ₃ .	Fe ₂ O ₃ .	(ign) H ₂ O.	(100°) H ₂ O.	P ₂ O ₅ .	Analyst.
Baux, France:								
1. Compact variety.....	2.8	3.1	57.6	25.3	10.8	.....	.....	Deville.
2. Pisiform	4.8	3.2	55.4	24.8	11.6	.....	.....	Do.
3. Hard and compact calcareous paste.	.....	.....	30.3	34.9	22.1	.....	.....	Do.
4. Calabres, France	2.0	1.6	33.2	48.8	8.6	.....	.....	Do.
5. Thoronet, France, red variety.....	0.30	3.40	69.30	22.90	14.10	.....	.....

Composition of bauxites from various localities—Continued.

	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	(ign) H ₂ O	(100°) H ₂ O	P ₂ O ₅	Analyst.
6. Villeveyrac, Hérault, France, white variety	2.20	4.00	76.90	.10	15.80	.....	.....
7. Wochein, Germany	6.29	.....	64.24	2.40	25.74	.46	.....	Lill.
Langsdorf, Germany:								
8. Brownish red	5.14	.....	50.85	14.36	27.03	1.35	.48	Lang.
9. Light red	10.27	.....	49.02	12.90	25.88	.93	.38	Do.
10. Vogelsberg, Germany	1.10	3.20	50.92	15.70	27.75	.85	.....	Liebreich.
11. Cherokee County, Alabama	37.87	.....	39.44	2.27	12.80	9.20	.....	Dr. Wm. B. Phillips.
12. Jacksonville, Calhoun County, Alabama.	18.67	.....	45.94	11.86	21.20	1.40	.....	Do.
13. Red	7.73	.....	47.52	19.95	23.57	.....	.....	Do.
14. White	23.72	.....	41.38	.85	23.72	.....	.....	Do.
15. Red	10.25	2.53	41.00	25.25	20.43	.65	trace	W. F. Hillebrand.
16. White	21.08	2.52	48.92	2.14	23.41	.45	trace	Do.
17. Floyd County, Georgia	2.80	3.52	52.21	13.50	27.72	.....	.....	Nichols.
18. Do .....	.....	3.60	57.25	3.21	.....	.....	.....	Do.
19. Do	2.30	3.55	56.88	1.49	.....	.....	.07	Do.
Georgia:								
20. No. 1	19.56	2.08	52.13	1.12	24.21	.....	.....	Prof. H. C. White.
21. No. 2	41.47	.....	39.75	1.62	16.14	.....	.....	Do.
22. No. 3	2.56	.....	56.10	10.64	30.10	.....	.....	Do.
23. No. 4	8.29	3.15	58.61	2.63	27.42	.....	.....	Do.
24. No. 5	6.62	.....	59.82	2.16	31.10	.....	.....	Do.
25. No. 6	35.88	.....	45.21	0.52	17.13	.....	.....	Do.
26. Barnsley estate, Dinwood Station, Georgia, No. 7.	1.98	2.38	61.25	1.82	31.43	.....	.....	Do.
Pulaski County, Arkansas:								
27. Black	10.13	.....	55.59	6.08	28.99	.....	.....
28. Do	11.48	.....	57.62	1.83	28.63	.....	.....
29. Do	2.00	3.50	62.05	1.66	30.31	.....	.....
30. Red	4.89	.....	46.40	22.15	26.68	.....	.....
31. Do	3.34	.....	58.60	9.11	28.63	.....	.....
32. Do	10.38	3.50	55.64	1.95	27.62	.....	.....
33. Do	16.76	3.50	51.90	3.16	24.86	.....	.....

No. 1.—Contains also 0.4 CaCO₃. No. 2.—0.2 CaCO₃. No. 3.—12.7 CaCO₃. No. 5.—22.90 FeO + Fe₂O₃. No. 6.—0.10 FeO + Fe₂O₃. No. 7.—0.85 CaO, 0.38 MgO, 0.20 SO₃. No. 8.—0.35 FeO, 0.41 CaO, 0.11 MgO, 0.09 K₂O, 0.17 Na₂O, trace CO₂. No. 9.—FeO not det., 0.62 CaO, trace MgO, 0.11 K₂O, 0.20 Na₂O, 0.26 CO₂. No. 10.—0.80 CaO, 0.16 MgO.

Origin and mode of occurrence.—The mineral received its name from the village of Baux, in southern France, where a highly ferri-ferous, pisolitic variety was first found and described by Berthier in 1821. The origin of the mineral, both here and elsewhere, has been a matter of considerable discussion. The following notes relative to the foreign occurrences are from a paper by R. L. Packard:¹

The geological occurrence of the bauxite of Baux was studied by H. Coquand [Bulletin de la Société Géologique de France, XXVIII, 1871, p. 98], who describes

¹Mineral Resources of the United States, 1891, p. 148.

the mineral as of three varieties, pisolitic, compact, and earthy. The pisolitic variety does not differ in structure from the iron ores of Franche Comté and Berry, although the color and composition are different. It occurs in highly tilted beds alternating with limestones, sandstones, and clays, belonging to the upper cretaceous period, and in pockets or cavities in the limestone. The limestone containing the bauxite and that adjacent thereto is also pisolitic, some nodules being as large as the fist, and the pisolitic bauxite has sometimes a calcareous cement, and at others is included in a paste of the compact mineral. M. Coquand supposed that the alumina and iron oxide composing the bauxite were brought to the ancient lake bed in which the lacustrine limestone was formed by mineral springs, which, discharging in the bottom of the lake, allowed the alumina and iron oxide to be distributed with the other sediment. In some cases the discharge occurred on land, and the deposit then formed isolated patches. He refers to other similar deposits of bauxite of the same period in France. Sometimes the highly feriferous mineral predominates over the aluminous (white), at others diaspor is found enveloping the red mineral, while in other cases it is mixed with it, predominating largely, and sometimes manganese peroxide replaces ferric oxide. In some places the ground was strewn with fragments of tuberous menilite, very light and white.

M. Angé [Bull. Soc. Geolog. de France, XVI, 1888, p. 345] describes the bauxite of Var and Hérault and gives analyses of it. Over 20,000 tons were being mined in this region annually at the time of writing his report [1888]. In the red mineral of Var druses occur with white bauxite running as high as 85 per cent. Al_2O_3 , and 15 per cent. H_2O , corresponding to the formula $\text{Al}_2\text{O}_3 + \text{H}_2\text{O}$. He refers to the prevailing theory of the formation of bauxite, according to which solutions of the chlorides of aluminum and iron in contact with carbonate of lime undergo double decomposition, forming alumina, iron oxide, and calcium chloride. Other deposits in the south of France, in Ireland, Austria, and Italy, he says, confirm this view, because they also rest upon or are associated with limestone. The bauxite deposit in Puy de Dome which he studied could not, however, be explained by this theory because it was not associated with limestone, but rested directly upon gneiss and was partly covered by basalt. The geological sketch map of the deposit near Madriat, Puy de Dome, which he gives shows gneiss, basalt, with uncovered bauxite largely predominating, and patches of miocene clay, while a geological section of the deposit near Villeveyrac, Hérault, shows the bed of bauxite conformably following the flexures of the limestone formation when covered by more recent beds, and when exposed and denuded occupying cavities and pockets in the limestone. This occurrence is substantially the same as that of the neighboring Baux. M. Angé agrees with M. Coquand in attributing the bauxite to geyserian origin. He uses as an illustration of the contemporaneous formation of bauxite the deposits from the geysers of the Yellowstone Park, which is evidently due to a misunderstanding. He made no petrographical examination of the bauxite of Puy de Dome, nor did he attempt to trace any genetic relation between the latter and the accompanying basalt. The occurrence is, however, noteworthy, and an examination might show that it is another instance of the direct derivation of bauxite from basalt, which is maintained in the two following instances, somewhat imperfectly in the first to be sure, but with greater detail in the second.

The first is a paper by Lang [in the *Berichte der Deutschen Chemischen Gesellschaft*, XVII, 1884, p. 2892]. He describes the bauxite in Ober-Hessen, which is found in the fields in round masses up to the size of a man's head, embedded in a clay which is colored with iron oxide. The composition varies very widely. The petrographical examination showed silica, iron oxide, magnetite, and augite. The chemical composition and petrographical examination shows the bauxite to be a decomposition product of basalt. By the weathering of the plagioclase feldspars, augite, and olivine, nearly all the silica had been removed, together with the greater

part of the lime and magnesia; the iron had been oxidized and hydrate of alumina formed as shown by its easy solubility in hydrochloric acid. The residue of the silica had crystallized as quartz in the pores of the mineral.

The more detailed account of the derivation of bauxite from basalt is given in an inaugural dissertation by A. Liebreich, abstracted in the *Chemisches Centralblatt*, 1892, p. 94. This writer says that the well-known localities of bauxite in Germany are the southern slope of the Westerwald near Mühlbach, Hadamar, in the neighborhood of Lesser Steinheim, near Hanau, and especially the western slope of the Vogelsberg. Chemical analyses show certain differences in the composition of bauxite from different places, the smaller amount of water in the French bauxite referring it to diaspore, while the Vogelsberg mineral is probably Gibbsite (hydrargillite). The bauxites of Ireland, of the Westerwald, and the Vogelsberg, show by certain external indications their derivation from basalt. The bauxite of the Vogelsberg occurs in scattered lumps or small masses, partly on the surface and partly imbedded in a grayish white to reddish brown clay, which contains also similar masses of basaltic iron ore and fragments of more or less weathered basalt itself. Although the latter was associated intimately with the bauxite, a direct and close connection of the two could not be found, but an examination of thin sections of the Vogelsberg bauxite showed that most specimens still possessed a basaltic (anamesite) structure, which enabled the author to determine the former constituents with more or less certainty. The clays from different points in the district carrying basalt, basaltic iron ore, and bauxite were examined, some of which showed clearly a sedimentary character. Some of the bauxite nodules were a foot and a half in diameter and possessed no characteristic form. They were of an uneven surface, light to dark brown, white, yellowish, and gray in color, speckled and pitted, sometimes finely porous and full of small colorless or yellowish crystals of hydrargillite. The thin sections showed distinct medium-granular anamesitic structure. Lath-shaped portions filled with a yellowish substance preponderated (the former plagioclases) and filling the spaces between these were cloudy, yellow, brown, and black transparent masses which had evidently taken the place of the former augite. Laths and plates of titanite iron, often fractured, were commonly present and the contours of altered olivine could be clearly made out. The anamesitic basalt of the neighborhood showed a structure fully corresponding with the bauxite. Olivine and titanite iron oxide were found in the clay by washing. The basaltic iron ore also showed the anamesite structure.

But two localities in the United States have thus far yielded bauxite in commercial quantities. These are in Arkansas and the Coosa Valley of Georgia and Alabama.

According to Branner the Arkansas beds occur near the railway in the vicinity of Little Rock, Pulaski County, and near Benton, Saline County. "The exposures vary in size from an acre to 20 acres or more, and aggregate something over a square mile." This does not, in all probability, include the total area covered by bauxite in the counties mentioned, for the method of occurrence of the deposits leads to the supposition that there are others as yet undiscovered by the survey.

In thickness the beds vary from a few feet to over 40 feet, with the total thickness undetermined; the average thickness is at least 15 feet.

These Arkansas deposits occur only in Tertiary areas and in the neighborhood of eruptive syenites ("granites") to which they seem

to be genetically related. In elevation they occur only at and below 300 feet above tide level, and most of them lie between 260 and 270 feet above tide. They have soft Tertiary beds both above and below them at a few places, and must, therefore, be of Tertiary age. As a rule, however, they have no covering, the overlying beds having been removed by erosion, and are high enough above the drainage of the country to be readily quarried. Erosive action has removed a part of the bauxite in some cases, but there are, in all probability, many places at which it has not yet been even uncovered.

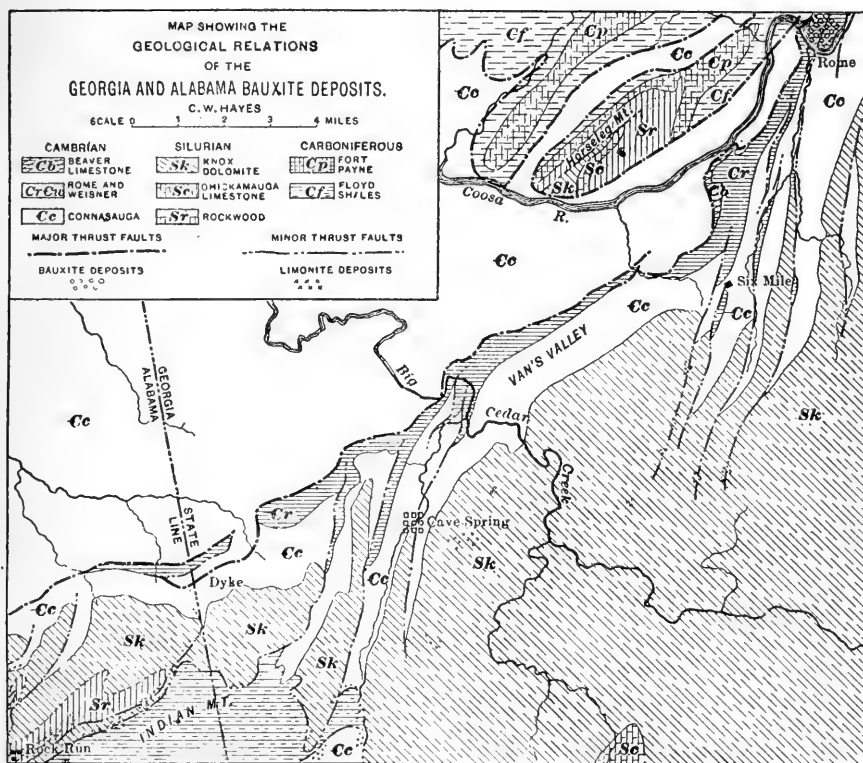
It is pisolitic in structure, and, like all bauxite, varies more or less in color and in chemical composition. (Specimen No. 67600 from Pulaski County.) At a few places it is so charged with iron that attempts have been made to mine it for iron ore. Some of the samples from these pits assay over 50 per cent of metallic iron. This ferruginous kind is exceptional, however. From the dark red varieties it grades through the browns and yellows to pearl gray, cream colored, and milky white, the pinks, browns, and grays being the more abundant. Some of the white varieties have the chemical composition of kaolin, while the red, brown, and gray have but little silica and iron, and a high percentage of alumina. The analyses given on page 231 show that this bauxite compares favorably with that of France, Austria, and Ireland, and is apparently well adapted for the manufacture of chemical products, for refractory material, and for the manufacture of aluminum by the Deville process.

The Georgia and Alabama deposits have been the subject of exhaustive study by Willard Hayes, to whose paper reference has already been made.

According to this authority the ore is found irregularly distributed within a narrow belt of country extending from Adairsville, Georgia, southwestward, a distance of 60 miles, to the vicinity of Jacksonville, Alabama. The only points at which it has been worked on a commercial scale are at Hermitage furnace, 5 miles north of Rome, Georgia, near Six Mile Station, south of Rome, and in the dike district near Rock Run, Alabama. (See fig. 6.) The oldest rocks of the region are of Cambrian age and are subdivided on lithologic grounds into two formations, the Rome sandstone below and the Connasauga shale above. The former consists of 700 to 1,000 feet of thin-bedded purple, yellow, and white sandstones and sandy shales. In the southern portion of the region the Rome sandstone is replaced by the Weisner quartzite, which consists of a series of interbedded lenticular masses of conglomerate, quartzite, and sandy shale. It apparently represents delta deposits contemporaneous with a part or the whole of the Rome sandstone. These rocks form Weisner and Indian mountains, and in the latter they attain a thickness of 10,000 feet or more.

The Connasauga is between 2,000 and 3,000 feet in thickness. It consists at the base of fine aluminous shales; the upper portion is more calcareous, and locally passes into heavy beds of blue seamy limestone.

Above Connasauga shale is the Knox dolomite, the most uniform and persistent formation of the southern Appalachian region. It consists of from 3,000 to 4,000 feet of gray, semicrystalline, siliceous dolomite. The silica is usually segregated in nodules and beds of



chert. These remain upon the surface, and with the other insoluble constituents form a heavy residual mantle covering all the outcrops of the formation. It is associated with these residual materials that the extensive deposits of limonite and bauxite are found. The geological structure of the region is complicated and for its details the present reader is referred to Dr. Hayes's original paper.

Subaerial decomposition has progressed for a long period, and the surface is deeply covered with a mantle of residual material, consisting of the more insoluble portions of the original rock masses. This

residual material consists mainly of ferruginous clay with large amounts of chert, and reaches a thickness of 100 feet or more. The bauxite deposits in the Rock Run district are regarded as typical for the entire region, and are described as follows:

Four bodies of the ore were being worked in 1893 on a considerable scale, and all show practically the same form. The southernmost of the four, called the Taylor bank, is located $3\frac{1}{2}$ miles northeast of Rock Run, near the western base of Indian Mountain. Although the heavy mantle of residual material effectually conceals the underlying rocks, the ore appears to be exactly upon the faulted contact between the narrow belt of Knox dolomite on the northwest and the sandy shales and quartzites of Indian Mountain on the southeast. The ore is covered by 3 or 4 feet of red sandy clay in which numerous fragments of quartzite are imbedded. The ore-body is an irregularly oval mass, about 40 by 80 feet in size. Its contact with the surrounding residual clay, wherever it could be observed, appeared to be sharp and distinct, and, about the greater portion of its circumference, very nearly vertical. A certain amount of bedding is observable in the ore-body, although no trace of bedding can be detected in the surrounding residual material. Upon the northwestern or down-hill side of the ore-body, this bedding is very distinct. Layers of differently colored and differently textured ore alternate in regular beds, a few inches in thickness, and above these are thinner beds of chocolate and red material, probably containing consider-

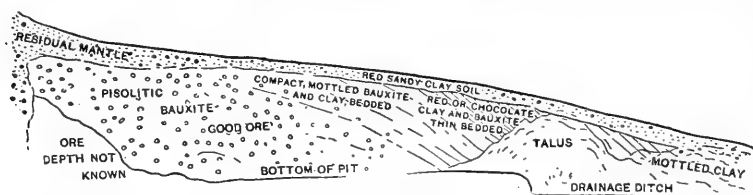


Fig. 7.

SECTION SHOWING RELATION OF BAUXITE TO MANTLE OF RESIDUAL CLAY IN GEORGIA.

After C. W. Hayes.

able kaolin. These beds have a steep dip, somewhat greater than the slope of the hill-side, but in the same direction. They are not simply inclined planes, however, but are curved, so as to form a steeply-pitching trough. With increasing distance from the ore-body, the lamination becomes less distinct, and the beds pass gradually into a homogeneous mottled clay. The accompanying section, fig. 7, shows these relations of the ore and residual mantle.

At the Dike bank [see Fig. 6], about a mile northeast of the one above described, the stratification is well shown in portions of the deposit. Beds of yellow and gray, fine-grained material, alternate with others of pisolitic ore. The beds dip at an angle of about 40° , and are curved so as to form a steep trough. The compact material also shows distinct cross-bedding; both primary and secondary planes dipping in the same direction.

In the Gain's Hill bank, about 250 yards north of the Dike bank, the ore-body shows a more regularly oval form than in most of the other deposits, and is also somewhat dome-shaped, swelling out laterally from the surface downward, as far as the working has progressed.

Although some of the workings have gone to a considerable depth (in a few cases 50 feet or more), the bottom of the ore-body has not been reached in any case. The ore varies in composition with depth, but not in a uniform manner, nor more than do different portions at the same depth. The deepest pits have not gone below the base of the surrounding residual mantle, so that no observations have yet

been made with regard to the relations between the ore and the country-rock; and nothing has yet been observed which warrants the conclusion that the ore if followed to sufficient depth, will be found inter-bedded with the underlying formations, or even that it will be found occupying cavities in the limestone—although the latter is quite possible.

Concerning the origin of these deposits the author says:

No eruptive rocks, either ancient or modern, are found in the vicinity of the latter, nor are there any rocks in this region which, by weathering, could yield bauxite as a residual product. Hence, any satisfactory explanation of the origin of these deposits must give the source from which the material was derived, the means by which it was transported, and the process of its local accumulation.

As already stated in describing the stratigraphy of the region, the ore is associated with the Knox dolomite or with calcareous sandy shales immediately overlying the dolomite. The Connasauga, consisting of 2,000 feet or more of aluminous shales, invariably underlies the dolomite at greater or less distance beneath the ore-bearing regions, and is probably the source from which the alumina was derived.

The faults of the region have been briefly described. Undoubtedly such enormous dislocations of the strata generated a large amount of heat. The fractures facilitated the circulation of water, and for considerable periods the region was probably the seat of many thermal springs. These heated waters appear to have been the agent by which the bauxite was brought to the surface in some soluble form and there precipitated.

The chemical reactions by which the precipitation was effected are not well understood, and the conditions were not such as can be readily reproduced in the laboratory. Of the few soluble compounds of aluminum which occur in nature, only the sulphate and the double sulphate of potash and alumina need be considered.

The oxygen contained in the meteoric waters percolating at great depths through the fractured strata would readily oxidize the sulphides disseminated in the aluminous shales. Sulphates would thus be formed by a process strictly analogous to that commonly employed in the manufacture of alum. Probably the most abundant product of the process in nature was ferrous sulphate. Some sulphate of aluminum must also have been formed together with the double sulphate of potassium and aluminum, especially in the absence of sufficient potash to form alum with the whole.

In its passage from the underlying shales through several thousand feet of dolomite the heated water must have become highly charged with lime, in addition to the ferrous and aluminous salts already in solution. But calcium carbonate reacts upon aluminum sulphate and to some extent also on alum, forming a gelatinous or flocculent precipitate which consists of aluminum hydroxide and the basic sulphate. This reaction may have taken place at great depth and the resulting flocculent precipitate may have been brought to the surface in suspension. From analogy with pisolitic sinter and travertine now forming, such conditions would appear to be highly favorable for the production of the structures actually found in the bauxite. The precipitate was apparently collected in globular masses by the motion of the ascending water, and constant changes in position permitted these to be coated with successive layers of more compact material. Finally, after having received many such coatings, the pisolites were deposited on the borders of the basin, and the interstices were filled by minute oölites formed in a similar manner or by the flocculent precipitate itself. Slight differences in the conditions prevailing in the several springs, such as concentration and relative proportion of the various salts in solution, also temperature and flow of the water, would produce the variation in the character of the ore observed at different points.

The bedding observed in the bauxite-deposits may have been produced by the successive layers deposited on the steeply inclined outlet of the basin. After the

cessation of the spring-action, surface-creep of the residual mantle from the higher portions of the ridges covered the deposits to varying depths, as they are found at present.

A small portion of the ferrous sulphate was oxidized and precipitated along with the bauxite, but the greater part was carried some distance from the springs and slowly oxidized, forming the widespread deposits of limonite in this region.

Uses.—The better known use of bauxite is as an ore of aluminum, for which purpose it lies beyond the scope of the present work. It may, however, be well to state that before the aluminum can be satisfactorily extracted the ore is purified by chemical processes. The principal use is for the manufacture of alums and other aluminum salts such as are used in the manufacture of baking powders and dyes. It is believed that the mineral, owing to its highly refractive qualities, will in the near future be utilized in the manufacture of fire brick and crucibles. An alumino-ferrie cake, a by-product obtained in the purifying process, is claimed as of value for sanitary and deodorizing purposes. The price of the crude ore varies greatly, according to purity. The average price for the past few years has been about \$5 a ton.

BIBLIOGRAPHY OF CRYOLITE AND BAUXITE.

PAUL QUALE. Account of the Cryolite of Greenland.

Annual Report of the Smithsonian Institution, 1866, p. 398.

M. H. COQUAND. Sur les Bauxites de la chaîne des Alpes (Bouches-du-Rhône) et leur âge géologique.

Bulletin de la Société Géologique de France, 2d ser., XXVIII, 1870-71, pp. 98-115.

EDWARD NICHOLS. An Aluminum Ore.

Transactions of the American Institute of Mining Engineers, XVI, 1887, p. 905.

P. JOHNSTRUP. Sur le Gisement de la Kryolithe au Greenland.

Bulletin de la Société Mineralogie of France, II, 1888, p. 167.

M. AUGÉ. Note sur la Bauxite, son origine, son âge et son importance géologique.

Bulletin de la Société Géologique de France, 3d ser., XVI, 1888, p. 345.

STAINSLAS MEUNIER. Réponse a des observations de M. Augé et de M. A. de Gros-souvre sur l'histoire de la Bauxite et des Minerais Sidérolithiques.

Bulletin de la Société Géologique de France, 3d ser., XVII, 1889, p. 64.

R. L. PACKARD. Aluminum.

Mineral Resources of the United States, 1891, p. 147.

This paper contains numerous references to which the present compiler has not had access.

HENRY McCALLEY. Bauxite.

The Mineral Industry, II, 1893, p. 57.

——— Bauxite Mining.

Science, XXIII, 1894, p. 29.

C. WILLARD HAYES. The Geological Relations of the Southern Appalachian Bauxite Deposits.

Transactions of the American Institute of Mining Engineers, XXIV, 1894, p. 243.

W. P. BLAKE. Alunogen and Bauxite of New Mexico.

Transactions of the American Institute of Mining Engineers, XXIV, 1894, p. 571.

FRANCIS LAUR. The Bauxites. A Study of a new Mineralogical Family.

Transactions of the American Institute of Mining Engineers, XXIV, 1894, p. 234.

——— On Bauxite.

Minutes of the Proceedings of the Institute Civil Eng., CXX, 1894-1895, pt. 2, p. 442.

4. DIASPORE.

This is a hydrous oxide of aluminum corresponding to the formula $\text{Al}_2\text{O}_3, \text{H}_2\text{O}$, =alumina, 85 per cent; water, 15 per cent; hardness, 6.5 to 7. It is a whitish, grayish, sometimes brownish or yellowish mineral, occurring in the form of thin flattened or acicular crystals and also foliated, massive and in thin plates or rarely stalactitic. (Specimen No. 53573, U. S. N. M.) It is transparent to subtranslucent, and sometimes shows violet-blue colors when looked at in one direction, or reddish-blue or asparagus-green in others. Luster, vitreous or pearly.

Occurrence.—The mineral commonly occurs with corundum and emery in dolomite and granular limestone or crystalline schists. In the United States it occurs in large plates in connection with the emery rock at Chester, Massachusetts.

Uses.—See under Gibbsite.

5. GIBBSITE; HYDRARGILLITE.

This is also, like diasporé, a hydrous oxide of aluminum, corresponding to the formula $\text{Al}_2\text{O}_3, 3\text{H}_2\text{O}$ =alumina 65.4 per cent, water 34.6 per cent. The mineral is of a whitish, grayish, or greenish color, sometimes reddish through impurities, and occurs in flattened, hexagonal crystals, or in stalactitic and mammillary and incrusting surfaces. (Specimen No. 4602, U.S.N.M.). Its occurrence is similar to that of diasporé.

Uses.—Neither diasporé nor gibbsite have as yet been found in sufficient quantities to be of economic importance. Should they be so found, their value as a source of alumina is easily apparent.

6. OCHER.

The term ocher as commonly used applies to earthy and pulverulent forms of the minerals hematite and limonite, but which are almost invariably more or less impure through the presence of other metallic oxides and argillaceous matter. In nature the material rarely occurs in a suitable condition for immediate use, but needs first to be prepared by washing and grinding and perhaps roasting.

Various varietal names are applied to the ochers, according to their natural colors or sources. The original "Indian red" was a red argillaceous ocher, with a purplish tinge, found on the island of Ormuz, in the Persian Gulf. A large part of the pigment of this name is now prepared artificially from iron pyrites. Umber is a gray, brown, or reddish variety containing manganese oxides and clay. It derives its name from Umbria, in Italy, where material of this nature was first utilized. Sienna is a highly argillaceous variety, also from Italy, near Sienna.

The natural colors of the ochers is dependent on the degree of hydration and oxidation of material and the kind and amount of impurities. In a general way the hematites are of a deep-red color (Specimen No. 56075, U.S.N.M.), while the limonites are yellow or brown (Specimen No. 61101, U.S.N.M.). Either color is liable to shade variations, according to amount and kind of impurities. The colors are intensified or otherwise varied by roasting (Specimens Nos. 63056 and 63057, U.S.N.M.).

Artificial ochers are produced by roasting iron pyrites (sulphide of iron) or an artificial sulphate (green vitriol) (Specimen No. 61122, U.S.N.M.). (See under Pyrite.) The materials known commercially as rouge, crocus, and Indian red are quite pure ferric oxide, prepared by roasting pyrite or by other artificial means.

Composition of ochers in their natural condition.

Natural color.	Locality.	Fe ₂ O ₃ .	Al ₂ O ₃ .	SiO ₂ .	H ₂ O.	Alks.
	Marksville, Page County, Virginia.....	39.0	1.50	33.0	11.5	0.5
	Rawlins, Wyoming	90.2	.....	{ Insol. 7.2 }	.....	1.2
Yellow brown...	Hancock, Berks County, Pennsylvania (Specimen No. 62787, U.S.N.M.).	a 36.67	50.00		10.60	.....
Deep brown	Anne Arundel County, Maryland (Specimen No. 60843, U.S.N.M.).	19.67	76.57		2.60	.....
Deep red brown.	Northampton County, Pennsylvania (Specimen No. 61103, U.S.N.M.).	b 42.45	30.58		11.85	.....
Gray.....	Northampton County, Pennsylvania (Specimen No. 61098, U.S.N.M.).	c 12.20	74.10		5.23	.....
Dark brown	Brandon, Vermont (Specimen No. 66732, U.S.N.M.)	d 52.92	2.88		14.62	.....
	Montgomery County, Alabama (Specimen No. 63339, U.S.N.M.).	a 10.57	69.30		7.40	.....
	Cartersville, Georgia (Specimen No. 63340, U.S.N.M.).	b 55.84	32.20		12.00	.....

a A part of the iron in a ferrous condition.

c Iron exists mainly in a ferrous condition.

b Contains also some manganese.

d Contains much manganese.

Composition of manufactured mineral paints.

Variety.	Fe ₂ O ₃	Al ₂ O ₃	SiO ₂	H ₂ O	P ₂ O ₅ , MnO, CaO.
Lowe's metallic paint a	78.87	3.29	11.96	5.07	0.80
Rossie red paint b	60.50	5.63	18.00	0.33	{ CaCO ₃ 15.66
Light-brown paint c	77.26	7.00	13.84	0.06	1.84
Brown-purple paint d	93.68	3.06	3.20	{ S. and loss. 0.06 }	.....

a Made from red fossiliferous ores mined at Atalla, Alabama, and Ooltewah, Tennessee.

b Made by Iron Clad Paint Company, of Cleveland, Ohio, from ore mined in Wayne County, New York.

c From ore mined at Lake Superior, Michigan.

d Ore from Jackson mine, Michigan.

A "blue ocher," formed by the decomposition of the Utica shales in Lehigh County, Pennsylvania, has the following composition:

Ignition (water and carbon).....	9.10
Quartz.....	44.50
Combined silica.....	26.25
Alumina with traces of ferric oxide.....	17.95
Magnesia.....	.94
Alkalies, etc.....	1.26
	<hr/> 100.00

A second variety, from $1\frac{1}{2}$ miles northwest of Breinigsville, and which was sold as a yellow ochre, yielded:

Silica, 60.53; alumina, 17.40; ferric oxide, 9.27; lime, 0.08; magnesia, 1.92; water, 5.51; alkalies, 5.27.

Origin and mode of occurrence.—These vary greatly. In some cases deposits of this nature are formed by springs. Such result from the leaching out from the rocks, by carbonated waters, of iron in the protoxide condition and its subsequent deposition as a hydrated sesquioxide. In other cases they are residual products formed by the removal by solution, of the lime carbonates of calcareous rocks, leaving their insoluble residues—the clay and iron oxides—in the form of a red, yellow, or brown ocherous clay. Again, they may result from the decomposition (oxidation) of beds of pyrite (iron disulphide) and from the decomposition of beds of hematite, and by the disintegration and perhaps partial hydration of the more compact forms of limonite. Still, again, they may result from the decomposition of schists and other rocks rich in iron-bearing silicate minerals. The yellow ochers of the Little Catocin Mountains, near Leesburg, Virginia, are thus stated to be residual products from the decomposition of hydro-mica or damourite schists.

A paint ore found near Lehigh Gap, Carbon County, Pennsylvania (Specimens Nos. 61115, 63481, 63482, U.S.N.M.), though not properly an ocher, may be described here for want of a better place. The raw material is a dull shaly or slaty rock, of a dark gray color, sandy texture, and quite hard, and if descriptions are correct is probably an arenaceous siderite, or carbonate of iron.

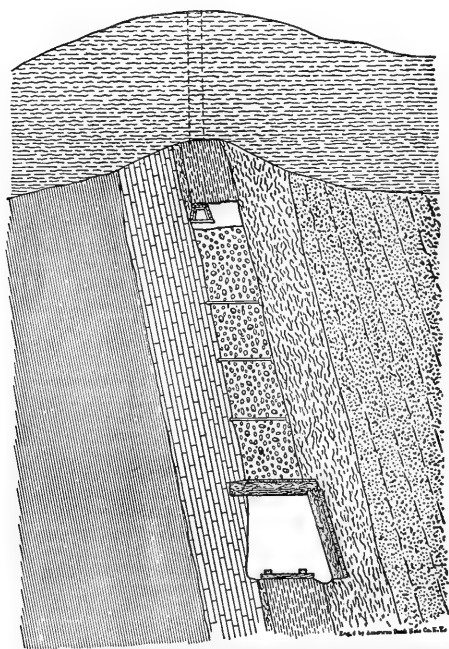
According to C. E. Hesse¹ the "paint bed" is of unknown extent except so far as indicated by outcrops along the southern border of Carbon County, about 27 miles north of Bethlehem, where it occurs in a well-defined ridge of Oriskany sandstone. Along the outcrop the beds are covered by a cap of clay and by the decomposed portion of the Marcellus slate. Beginning with this slate the measures occur in the following descending order:

a. Hydraulic cement (probably Upper Helderberg), very hard and compact.

¹Transactions of the American Institute of Mining Engineers, XIX, 1891, p. 321.

- b. Blue clay, about 6 inches thick.
- c. Paint ore, varying from 6 inches to 6 feet in thickness.
- d. Yellow clay, 6 feet thick;
- e. Oriskany sandstone, forming the crest and southern side of the ridge. It is extremely friable, and disintegrates so readily that it is worked for sand at many points. (See fig. 8.)

The paint bed is not continuous throughout its extent. It is faulted at several places; sometimes it is pinched out to a few inches, and again increases in width to 6 feet. The ore is bluish-gray, resembling lime-



SECTION ACROSS THE BED, RUTHERFORD AND BARCLAY MINE.

Fig. 8.

SECTION ACROSS PAINT MINE AT LEHIGH GAP, PA.

After C. E. Hesse.

stone, and is very hard and compact. The bed is of a lighter tint, however, in the upper than in the lower part, and this is probably due to its containing more hydraulic cement in the upper strata. The paint ore contains partings of clay and slate at various places. At the Rutherford shaft there are fine bands of ore alternating with clay and slate, as follows: Sandstone (hanging wall), clay, ore, slate, ore, clay, ore, slate, ore, cement, slate (foot wall). These partings, however, are not continuous, but pinch out, leaving the ore without the admixture of clay and slate. Near the outcrop the bed becomes brown hematite, due to the leaching out of the lime and to complete oxidation. Occasionally streaks of hematite are interleaved with the paint ore. In driving up the breasts toward the outcrop the ore is found at the top in

rounded, partially oxidized, and weathered masses, called "bomb-shells," covered with iron oxide and surrounded by a bluish clay. In large pieces the ore shows a decided cleavage.

Preparation.—As already intimated, only a small portion of the ocher is used in its natural condition, it being first roasted and then ground, the grinding being either "dry" or in oil. The roasting deepens the color to a degree dependent upon the length of time the ore is exposed. Yellows are converted into browns and reds, and the ocher rendered less hydrous at the same time. The crude ore as mined

is not infrequently separated from the coarser or heavier impurities by a process of washing in running water, whereby the ochre, in a state of suspension, is drawn off into vats, where it is allowed to settle, the water decanted, and the sediment made up into bricks and dried, when it is ready for grinding.

The following description of the occurrence of umber and its preparation at the Caldbeck Fells, in Cumberland, England, is taken from the Journal of the Society of Chemical Industry for October, 1890, p. 953:

The vein of umber contains crystals of quartz, and lies in a granitic rock largely decomposed. The method of working is as follows: The umber is brought down by an overhead tramway and passed through a hopper into a wash barrel consisting of a cylinder formed of parallel bars one-eighth of an inch apart, having a perforated pipe conveying water, for its axis. By this means the umber is washed through, the quartz being retained; the former then passes to an edge-runner, the casing of which is of sufficient depth to allow of the submersion of the rollers. The rate of revolution is about 14 to the minute, and the finer floating particles flow into the drag mill. The bed of this mill is a single block of granite and over it the four burrstone blocks are dragged; the finer "floating" particles of umber pass to a second mill of the same kind, then through a brass wire sieve (to remove particles of peat and heather that have been floating throughout the process) to settling tanks, composed of brickwork lined with cement. After settling for four hours four-fifths of the water are drawn off, and the umber, now of the consistency of slurry, filter-pressed and dried. It has the following composition:

Ferric oxide	47. 14
Manganese dioxide	11. 17
Cupric oxide.....	3. 23
Alumina.....	7. 66
Lime	Trace.
Magnesia	Trace.
Silica	24. 70
Combined water	6. 18
	<hr/> 100. 08

In this condition it may be put on the market, serving for colouring coarse brown paper (that being the chief use to which umber is put), or it may be re-ground in a conical burrstone mill and sold to paint and oil-cloth manufacturers and the makers of the finer kinds of brown paper. The fine state of division to which it is reduced may be judged from the facts that the workman in charge of the mill is compelled to wear a respirator, and the stain is not easily removed from the hands.

At the Lehigh Gap mines the ore, as it comes from the mines, is free from refuse, great care having been taken to separate slate and clay from it in the working places. It is hauled in wagons to kilns, which are situated on a hillside for convenience in charging. The platform upon which the ore is dumped is built from the top of the kiln to the side of the hill. The ore is first spalled to fist size and freed from slate, and is then carried in buggies to the charging hole of the kiln.

The kiln works continuously, calcined ore being withdrawn and fresh charges made without interruption. The ore is subjected for forty-eight hours to the heat, which expels the moisture, sulphur, and carbon dioxide. About $1\frac{1}{2}$ tons of calcined ore are withdrawn every three hours during the day. The outside of the lumps of calcined ore has a light-brown color, while the interior shows upon fracture a darker brown. Great care is necessary to regulate the heat so that the ore is not overburnt. When this happens the product has a black, scoriaceous appearance, and is unfit for the manufacture of metallic paint, as it is extremely hard to grind.

The calcined ore is carried from the kiln in wagons to the mill, where it is broken to the size of grains of corn in a rotating crusher. The broken ore is carried by elevators to the stock bins at the top of the building, and thence by shutes to the hopper of the mills, which grind it to the necessary degree of fineness. Elevators again carry it to the packing machine by a spout, and it is packed into barrels holding 500, 300, or 100 pounds each.

A "mineral paint" mined on Porter Creek, near Healdsburg, Sonoma County, California, is said¹ to consist of hematite and silicate of iron in the form of a compact mass lying between hornblendic rock, actinolite and mica schist on the one side and rotten serpentine on the other. The vein has a north of east course, and is some 60 feet in width. The material is mined from a tunnel, crushed, ground between buhrstones, and bolted, making a paint fit for mixing with oils or japan.

Uses.—The ochers are among the most widespread and readily accessible of coloring materials, and have been used by savage and civilized people both ancient and modern. The war paint of the American Indian was not infrequently an ocher mixed with oil or grease.

According to William J. Russell,² the pigments used by the Egyptians and others since the earliest times were of hematite, and mostly of an oölitic variety, apparently closely corresponding to the Clinton hematites of New York State. As tested, such were found to contain from 79.11 to 81.34 per cent ferric oxide.

Yellow ochrous pigments, presumably limonite, are also described by the same authority. These yield only about 33 per cent ferric oxide and some 7 to 10 per cent of water, together with clay. The ochers are now used mainly in the manufacture of paints for exteriors, as of buildings, the rolling stock of railways, bridges, and metal roofing. They are also used as a pigment for coloring mortars, and in the manufacture of linoleums and oilcloths. Mixed with a certain proportion of oxide of manganese, the ochers have been used to produce desirable colors in earthenware.

¹Twelfth Annual Report of the State Mineralogist, 1894, p. 406.

²Nature, XLIX, 1894, p. 374.

The raw ocher (that is, ocher not roasted), of a light-yellow color, was at one time in great demand, particularly throughout New England, for painting floors.

The value of the prepared material is but a few cents a pound.

BIBLIOGRAPHY.

- FRANK A. HILL. Report on the Metallic Paint Ores along the Lehigh River. Annual Report, Pennsylvania Geological Survey, 1886, pt. 4, pp. 1386-1408.
This is an important paper, giving position of ore beds, methods of mining and manufacture.
- CONRAD E. HESSE. The Paint Ore Mines at Lehigh Gap. Transactions of the American Institute of Mining Engineers, XIX, 1890, p. 321.

7. ILMENITE; MENACCANITE; OR TITANIC IRON.

Composition FeTiO_3 , =oxygen, 31.6; titanium, 31.6; iron, 36.8; hardness, 5 to 6; specific gravity, 4.5 to 5; color, iron black with a submetallic luster and streak; opaque. Differs from magnetite, which it somewhat resembles, by its crystalline form and by its influencing but slightly the magnetic needle.

Mode of occurrence.—Its common form is massive, or in thin plates or laminae, or as small granules, sometimes disseminated through the mass of rock or loose in the sand. In microscopic forms it is a common constituent of eruptive rocks, both acid and basic. Not infrequently it occurs in large masses, closely resembling magnetic iron ore (Specimen No. 63861, U.S.N.M.). In the parish of St. Urbain, Bay St. Paul, Province of Quebec, Canada, is such a bed, stated to be 90 feet in thickness and to have been traced, with some interruptions, for a mile. The bed is in anorthite feldspar rock of Laurentian age. The ore is quite pure, and carries some 48.6 per cent titanic acid. At Kragerö, in Norway, the mineral occurs in the form of veins in diorite. In Virginia it is found in granular masses, containing apatite. (See Phosphate Series.)

Uses.—The mineral has as yet proved of little economic importance. It is stated that the presence of titanium has an important bearing upon the qualities of iron and steel, but as such it is beyond the scope of this work. As long ago as 1846 an attempt was made to use a ferrocyanide of titanium as a green paint in place of the poisonous arsenical greens. Later (1861) other patents were granted in England for titanium pigments. A deep-blue enamel, resembling the smalt prepared with the oxide of cobalt, has also been prepared from it, but as yet the mineral, though abundant and cheap, has practically no economic use.

8. RUTILE:

Composition and general properties.—This, like ilmenite, is a titanium oxide, having the formula TiO_2 , =oxygen, 40 per cent, and titanium, 60 per cent. The hardness is 6 to 6.5; specific gravity, 4.18 to 4.25;

luster metallic-adamantine, opaque as a rule, rarely transparent; color, reddish brown to red, rarely yellowish, blue, or black; streak, pale brown. The mineral crystallizes in the tetragonal system, and is commonly found in prismatic forms longitudinally striated (Specimen No. 14410, U.S.N.M.) and often in geniculate or knee-shaped twins (Specimen No. 81904, U.S.N.M.). Not infrequently it occurs in the form of fine thread-like or acicular crystals penetrating quartz. It is insoluble in acids and infusible.

Mode of occurrence.—Rutile occurs mainly in the older crystalline granitic rocks, schists, and gneisses, but is also found in metamorphic limestones and dolomites, sometimes in the mass of the rock itself, or in the quartz of veins. Being so nearly indestructible under natural conditions, it gradually accumulates in the débris resulting from rock decomposition, and is hence not an uncommon constituent of auriferous sands.

Localities.—Some of the more noted localities are, according to authorities, the apatite deposits of Kragerö, in Norway; Yrieux, near Limoges, in France; the Ural Mountains; and the Appalachian regions of the United States. Graves Mountain, Georgia (Specimen No. 46081, U.S.N.M.); Randolph County, Alabama (Specimen No. 65354, U.S.N.M.); and the Magnet Cove region of Arkansas are celebrated localities.

Uses.—Like ilmenite, the mineral may serve as a source for titanium for a pigment for porcelain, but as yet it is little used.

Brookite (Specimen No. 45256, U.S.N.M.) and octahedrite have the same composition and essentially the same physical properties and mode of occurrence.

9. CHROMITE.

Chromite is a mineral of the spinel group, and of the theoretical formula $\text{FeO}, \text{Cr}_2\text{O}_3$. This equals a percentage of chromic oxide of 68 per cent, but the natural mineral has often alumina and ferric iron replacing a part of the chromium, so that 50 per cent chromic oxide more nearly represents the general average. The ordinary demand, it may be stated, is for an ore carrying 45 per cent and upward of chromic acid.

The analyses given below ¹ will serve to show the varying character of the mineral:

Composition of chromite from various localities.

Location.	Constituents.								
	Al ₂ O ₃ .	MgO.	Cr ₂ O ₃ .	Fe ₂ O ₃ .	FeO.	SiO ₂ .	CaO.	Miscellaneous.	Total.
Kynouria, Greece	30.17	17.27	4.74	-----	2.30	26.01	13.26	CO ₂ +H ₂ O=4.45	98.20
Near Athens, Greece . . .	20.80	11.78	9.80	2.72	7.00	4.85	5.50	FeCO ₃ =37.75	100.20
Bare Hills, Baltimore, Maryland	13.002	-----	39.514	36.004	-----	10.596	-----	-----	99.116
Chester, Pennsylvania . .	-----	-----	41.55	62.02	-----	1.25	-----	-----	104.82
Franklin, Macon County, North Carolina	22.41	15.67	44.15	5.78	11.76	-----	-----	-----	99.77
Wilmington, Delaware . .	6.66	2.06	45.50	-----	42.78	3.00	-----	-----	100.00
Bolton, Canada	3.20	15.03	45.90	-----	35.68	-----	-----	-----	99.81
Ekaterinburg, Russia . .	6.77	13.40	49.49	-----	23.27	7.07	-----	-----	100.00
Chester County, Penn- sylvania	9.723	-----	51.562	35.14	-----	2.901	-----	MnO, trace.	99.326
Monterey County, Cal- ifornia	2.18	12.29	52.12	15.24	-----	12.12	5.65	-----	+99.60
Lancaster County, Pennsylvania	5.75	9.39	55.14	-----	28.88	-----	-----	-----	99.16
Do.	0.86	9.89	56.55	-----	30.23	-----	-----	-----	97.53
Chester County, Penn- sylvania	-----	-----	63.39	38.66	-----	-----	-----	NiO=2.28	104.33
-----	-----	-----	-----	-----	-----	-----	-----	Al ₂ O ₃ +FeO	-----
Urals	-----	5.04	64.00	-----	1.03	-----	-----	29.33	99.40
-----	-----	6.15	62.25	-----	0.95	-----	-----	30.05	99.40
-----	-----	6.28	63.40	-----	2.60	-----	-----	28.60	100.88

Chromite, like magnetic iron, is black in color and of a metallic luster, but differs in being less readily if at all attracted by the magnet. On a piece of ground glass or white unglazed porcelain it leaves a brown mark, and fused with borax before the blowpipe it gives a green bead.

Occurrence.—Chromite is a common constituent in the form of disseminated granules of basic eruptive rocks belonging to the peridotite and pyroxenite groups and in the serpentinous and talcose rocks which result from their alteration (Specimens Nos. 63032, 36845, U.S.N.M., from Maryland and North Carolina). It is never found in true veins or beds, though sometimes in segregated, nodular masses somewhat simulating veins on casual inspection. Masses of pure material, like Specimen No. 17288, U.S.N.M., from Lancaster, Pennsylvania (weight 1,000 pounds), are quite usual. The more common form, as noted above, is that of detached granules, which when freed from the inclosing rock form the ore known as chrome sand (Specimens Nos. 5179, 63032, 56310, U.S.N.M.), and small masses like Specimens Nos. 11681, 40320, 63032, U.S.N.M.

Deposits of chromite are now being worked near Black Lake Station,

¹ As compiled from various sources in Wadsworth's Lithological Studies. Memoirs of the Museum of Comparative Zoology, XI, Part I, 1884, Cambridge, Massachusetts.

on the Quebec Central Railway, in close proximity to the asbestos mines. The ore here occurs in a series of pockets extending in an east and west direction. Some of the pockets are found lying in a dike of fine-grained granulite, but the possible relationship between the two has not been made out. While other deposits occur not associated with the granulite, it is to be noticed that the largest pockets of high-grade ore are thus associated. From one such pocket on the Lambly property over 500 tons of ore were taken, yielding 54 per cent to 56 per cent sesquioxide of chromium.

Aside from the localities above mentioned, chromic iron is found in pocket masses in the Cambrian and serpentinous rocks lying between the Vermont line and the Gaspé peninsula, but has never been successfully mined owing to the great uncertainty attending its occurrence.

It is rarely found in beds or veins, but in detached pockets which yield from a few pounds to hundreds of tons, the larger pockets being comparatively rare.

Chrome ore is also found in Newfoundland; the Russian Urals (Specimen No. 40322, U.S.N.M.); in Asia Minor (Specimen No. 40156, U.S.N.M.) and European Turkey (Specimen No. 4674, U.S.N.M.) and in Macedonia; in Australia (Specimens Nos. 62532, 60999, U.S.N.M.) and New Zealand (Specimen No. 70346, U.S.N.M.). In all cases so far as known the deposits occurring in peridotite or serpentine.

The principal domestic sources of chromite are at present Del Norte (Specimen No. 65349, U.S.N.M.); San Luis Obispo, Shasta (Specimen No. 66498, U.S.N.M.), and Placer (Specimen No. 65351, U.S.N.M.) counties in California, though formerly mines in Lancaster County, Pennsylvania (Specimens Nos. 11681, 5179, U.S.N.M.), and at the Bare Hills, near Baltimore, Maryland (Specimen No. 63032, U.S.N.M.) were very productive.

Uses.—Chromium is used in the production of the pigments chrome yellow, orange, and green, and in the manufacture of bichromate of potash for calico printing, and which is also used in certain forms of electric batteries. A small amount is also used in the production of what is known as chrome steel.

According to P. Speier, chrome ore linings for reverberatory furnaces have been successfully adopted in French, German, and Russian steel works. The bottom and walls of the furnace are lined with chrome ore in large blocks, united by a cement formed by two parts of chrome ore finely ground, and one part of lime as free from silica as possible.

The introduction of chromium from the lining into the bath of molten steel only takes place to a very limited extent. From 660 to 1,100 pounds of limestone is charged into the furnace, and, according to the percentage of sulphur, from 220 to 440 pounds of manganese ore, for a charge of 1.5 to 1.7 ton of pig iron and 1,100 to 1,300 pounds of cast-iron scrap. About one-third, including steel scrap, is introduced

into the furnace; and to this quantity is afterwards added from 660 to 1,100 pounds of wrought-iron scrap as soon as the melting is complete. When a suitable temperature is attained the slag is run off, and the next charge is introduced into the furnace when the bath is quiescent. A sample is then taken and tested by bending, and if it be found that the percentage of phosphorus is too high, more lime, or lime and iron scale, are added, as much being introduced as the bath will take, and the addition of ferro-manganese is also made.

The iron chromate is decomposed only under the influence exerted by the reagents and oxidizing alkaline substances. Heat alone is insufficient to decompose chromate of iron, which may float in a bath of molten steel covered with basic slag without dissolving. One of the principal conditions of success in the employment of the chrome ore lining consists in carefully picking the pieces of ore used, which should be of uniform composition; and the best composition of ore used for lining reverberatory furnaces is found to be from 36 to 40 per cent of chromic oxide, 18 to 22 per cent of clay, 9 to 10 per cent of magnesia, and at most 5 per cent of silica.¹

The total annual product of American mines does not exceed between 3,000 and 4,000 tons, valued at the mines in California at not more than \$8 a ton for 50 per cent ore. Delivered in Baltimore its value is from \$20 to \$25 a ton.

Some 4,000 tons are annually imported. The chief foreign sources are Russia, New Zealand, New Caledonia, and Australia.

The following notes relative to the chrome industry in America are of sufficient interest to warrant reprinting here:²

The chrome industry is one of the most unique and characteristic in Baltimore. It originated in the early discovery of chrome ore in the serpentine of Maryland, and has ever since maintained its prestige as one of the sources of the world's supply of the chromates of potassium and sodium, which have many applications in the arts. The following is the substance of an historical account of the Maryland chrome industry, kindly prepared by Mr. William Glenn:

In 1827 chrome ore was first discovered in America on land belonging to Mr. Isaac Tyson, in what are known as the Bare Hills, 6 miles north of Baltimore. Mr. Tyson's son, Isaac Tyson, jr., then in business with his father, was persuaded by an English workman to attempt the manufacture of "chrome yellow" from this material, and this was done in a factory on what is now Columbia avenue, in Baltimore, in 1828. In the year of the discovery of the Bare Hill ore, Mr. Isaac Tyson, jr., who seems to have possessed a very keen power of observation, as well as a considerable knowledge of chemistry, recognized in a dull black stone, which he saw supporting a cider barrel in Belair market, more of the same valuable material. Inquiry disclosed the fact that this had been brought from near Jarrettsville, in Harford County, where much more like it was to be found. Mr. Tyson at once examined the locality, and finding it covered with boulders worth \$100 a ton in Liverpool, purchased a considerable area.

¹ Journal of the Iron and Steel Institute, 1895, pp. 506, 507. Abstract from *L'Echo des Mines*, XXI, p. 584.

² From Maryland, Its Resources, Industries, and Institutions, Baltimore, 1892, pp. 120-122.

Finding that the chrome ore was always confined to serpentine, Mr. Tyson began a systematic examination of the serpentine areas of Maryland, which could be easily traced by the barren character of the soil which they produce. A narrow belt of serpentine extends across Montgomery County, and while chrome ore is occasionally found in it (as, for instance, at Etchison post-office), nothing of economic importance has ever been discovered in Maryland south of the areas known as "Soldiers Delight" and "Bare Hills." Northeastward, however, the deposits become much richer. The region near Jarrettsville was productive, and thence the serpentine was traced to the State line in Cecil County. Near Rock Springs the serpentine turns and follows the State line eastward for 15 miles. On the Wood farm, half a mile north of the State line and 5 miles north of Rising Sun, in Cecil County, Mr. Tyson discovered in 1833 a chromite deposit, which proved to be the richest ever found in America. This property was at once purchased by Mr. Tyson and the mine opened. At the surface it was 30 feet long and 6 feet wide, and the ore so pure that each 10 cubic feet produced a ton of chrome ore averaging 54 per cent of chrome oxide. The ore was hauled 12 miles by wagon to Port Deposit, and shipped thence by water to Baltimore and Liverpool. At a depth of 20 feet the vein narrowed somewhat, but immediately broadened out again to a length of 120 feet and a width of from 10 to 30 feet. The Wood mine was worked almost continuously from 1828 to 1881, except between the years 1868 and 1873. During that time it produced over 100,000 tons of ore and reached a depth of 600 feet. It is not yet exhausted, but the policy of its owners is to reserve their ores while they can be elsewhere purchased at a cheap rate. Another well-known chrome mine in this region is exactly on the State boundary at Rock Springs, and is called the Line pit. So much of this deposit as lay within the limits of Maryland was owned by Mr. Tyson, while he worked the Pennsylvania portion on a royalty.

Other chrome openings near the Line pit were known as the "Jenkins mine," "Low mine," "Wet pit," and "Brown mine." This region has proved one of the best in the country for fine specimens of rare minerals. As a mineral locality it is usually given as "Texas, Pennsylvania,"¹

During his exploration of the serpentine belt Mr. Tyson also noticed deposits of chromite sand, and to control the entire supply of this ore he either bought or leased these also, and worked them to some extent with his mines.

Between 1828 and 1850 Baltimore supplied most of the chrome ore consumed by the world; the remainder came from the serpentine deposits and platinum washings of the Urals. The ore was at first shipped to England, the principal consumers being J. and J. White, of Glasgow, whose descendants are still the chief manufacturers of chromic acid salts. In 1844 Mr. Tyson established the Baltimore Chrome Works, which are still successfully operated by his sons.

After 1850 the foreign demand for Baltimore ore declined gradually till 1860, since which time almost none has been shipped abroad. The reason for this was the discovery in 1848 of great deposits of chromite near Brusa, 57 miles southwest of Constantinople, by Prof. J. Lawrence Smith, who was employed by the Turkish Government to examine the mineral resources of that country. Other deposits were also discovered by him 15 miles farther south, and near Antioch. These regions now supply the world's demand.

After the discovery of the magnitude of Wood pit, and of the bountiful supply of

¹ P. Frazer, Second Geological Survey of Pennsylvania, CCC, Lancaster County, 1880, pp. 176, 192.

sand chrome to be found within the Baltimore region, Isaac Tyson, jr., began to fear that the sources of supply could not much longer be restricted to his ownership. In such an event he realized that he would be compelled to manufacture his ores or to sacrifice them in competition.

The method of manufacture previously in use was to heat a mixture of chrome ore and potassium nitrate upon the working hearth of a reverberatory furnace. The potash salt yielded oxygen to the chromic oxide present, forming chromic acid, which, in turn, united with the base, producing potash chromate. The process was wasteful and exceedingly costly. Afterwards the process was somewhat cheapened by substitution of potassium carbonate for the more costly nitrate; oxygen was taken from heated air in the furnace. But not until 1845, when Stromeyer introduced his process, was the manufacture of chromic acid placed upon a safe mercantile basis. In this process pulverized chromic iron is mixed with potassium carbonate and freshly slaked lime, and the mixture is heated in a reverberatory furnace. After chromic oxide is set free in the charge it is freely oxidized because of the spongy conditions of the lime-laden charge.

Among the first steps of Isaac Tyson, jr., was to apply, in 1846, to Yale College for a chemist for his chrome works. In response a young man named W. P. Blake, who was then a student in the chemical laboratory, was sent. For a while Mr. Blake did excellent service in the new factory, but he was not willing to remain.

Mr. (now Professor) Blake was the first chemist to be employed in technology upon this continent, while the Baltimore works were the first to appreciate the value of chemistry. After the departure of Mr. Blake another chemist was secured from the first laboratory ever instituted for the teaching of chemistry, that founded at Giessen by Liebig. In succession came another chemist from the same laboratory, and this gentleman is yet employed in the works.

Between 1880 and 1890 the American production of chrome ore has varied between 1,500 and 3,000 tons. The total eastern product in 1886 was 100 tons only. Chrome ore was discovered in California in 1873, and since 1886 this State has been the only one to produce this mineral. From 2,000 to 4,000 tons of Turkish chrome ore are now annually imported into the United States, most of which is utilized in Baltimore.

BIBLIOGRAPHY.

———. Lake Chrome and Mineral Company, of Baltimore County.

American Mineral Gazette and Geological Magazine, I. April 1, 1864, p. 253.

HARRIE WOOD. Chromite and Manganese. Chromic iron and manganese ores have been found in considerable quantities, but the deposits have not yet been extensively worked. The chromite occurs in the Bowling Alley Point, Grafton, Young, and Bingera districts. Manganese ores are found widely distributed throughout the Colony; but the principal deposits are at Bendemere, near Moonbi, Glanmire, Rocky, and Broken Hill.

Mineral Products of New South Wales, Department of Mines, 1887, p. 42.

Ueber schwedisches Chromroheisen und Martinchromstahl.

Berg-und Hüttenmännische Zeitung, XLVII, 1888. p. 267.

Die Chromsenerz-Lagerstätten Neuseeland.

Berg-und Hüttenmännische Zeitung, XLVII, 1888. p. 375.

Chrome Iron.

Eighth Annual Report of the State Mineralogist of California, 1888, p. 326.

Chromite Mined at Cedar Mountain.

Eighth Annual Report of the State Mineralogist of California, 1888, p. 32.

Chrome Iron Ore from Orsova.

Journal of the Iron and Steel Institute, 1889, p. 316.

Chrome Iron, Shasta County.

Tenth Annual Report of the State Mineralogist of California, 1890, p. 638.

Chromium in San Luis Obispo County.

Tenth Annual Report of the State Mineralogist of California, 1890, p. 582.

Chrome Iron in New Zealand.

Engineering and Mining Journal, LIV, 1892, p. 393.

Chromic Iron.

Twelfth Report of the State Mineralogist of California, 1894, p. 35.

J. T. DONALD. Chromic Iron in Quebec, Canada.

Engineering and Mining Journal, LVIII, 1894, p. 224.

—— Chromic Iron: Its Properties, Mode of Occurrence and Uses.

Journal of the General Mining Association of the Province of Quebec, 1894-95, p. 108.

W. F. WILKINSON. Chrome Iron Ore Mining in Asia Minor.

Engineering and Mining Journal, LX, 1895, p. 4.

WM. GLENN. Chrome in the Southern Appalachian Region.

Transactions of the American Institute of Mining Engineers, XXV, 1895, p. 481.

Chromic Iron.

Thirteenth Report of the State Mineralogist of California, 1896, p. 48.

GEORGE W. MAYNARD. The Chromite Deposits on Port au Port Bay, New Foundland.

Transactions of the American Institute of Mining Engineers, XXVII, 1897, p. 283.

J. H. PRATT. Chromite in North Carolina.

Engineering and Mining Journal, LXVII, 1899, p. 261.

—— The Occurrence, Origin, and Chemical Composition of Chromite, with especial reference to the North Carolina Deposits.

Transactions of the American Institute of Mining Engineers, XXIX, 1899, p. 17.

10. MANGANESE OXIDES.

The element manganese exists in nature under many different forms, of which those in combination as oxides, carbonates, and silicates alone need concern us in this work. The principal known oxides are manganosite (MnO); Hausmanite ($\text{MnO}, \text{Mn}_2\text{O}_3$); Braunite ($3 \text{Mn}_2\text{O}_3, \text{MnSiO}_3$); Polianite (MnO_2); Pyrolusite (MnO_2); Manganite ($\text{Mn}_2\text{O}_3, \text{H}_2\text{O}$); Psilomelane (H_4MnO_5); and Wad, the last being, perhaps, an earthy impure form of psilomelane. To this list should be added the mineral franklinite, a manganiferous oxide of iron and zinc. Of these the first named, manganosite, is rare, having thus far been reported only in small quantities associated with other oxides in Wermland, Sweden. The other forms are described somewhat in detail as below. It should be stated, however, that with the exception of the well-crystallized forms it is often difficult to discriminate between them, as they occur admixed in all proportions, and, moreover, one variety, as pyrolusite, may result from the alteration of another (manganite). The better defined species may be separated from one another by their comparative hardness, streak, and hydrous or anhydrous properties, as shown in the accompanying table.

IDEAL SECTIONS SHOWING THE FORMATION OF MANGANESE-BEARING
CLAY FROM THE DECAY OF THE ST. CLAIR LIMESTONE.

-  BOONE CHERT
-  MANGANESE-BEARING CLAY
-  IZARD LIMESTONE
-  ST. CLAIR LIMESTONE
-  SACCHAROIDAL SANDSTONE

FIG. 1. ORIGINAL CONDITION OF THE ROCKS.

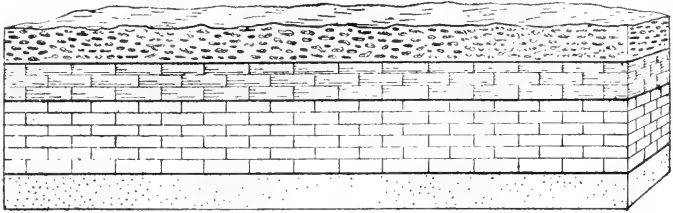


FIG. 2. FIRST STAGE OF DECOMPOSITION.

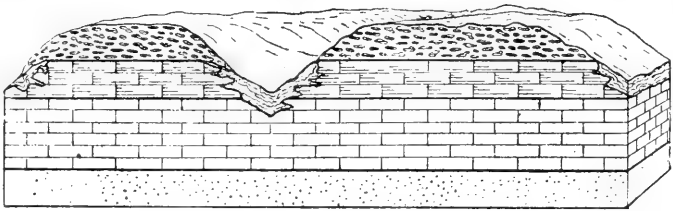


FIG. 3. SECOND STAGE OF DECOMPOSITION.

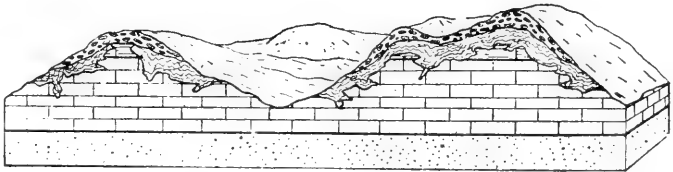
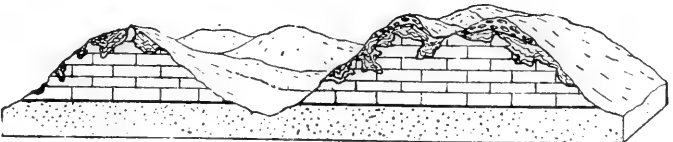


FIG. 4. THIRD STAGE OF DECOMPOSITION.



SECTION SHOWING THE FORMATION OF MANGANESE DEPOSITS FROM DECAY OF
LIMESTONE.

After Penrose, Annual Report Geological Survey of Arkansas, I, 1890.

Variety.	Hardness.		Specific gravity.		Color.	Streak.	Anhydrous or hydrous.
Franklinite ...	5.5	to 6.5	5	to 5.22	Iron black.....	Reddish brown to black.	Anhydrous.
Hausmannite ..	5	5.5	4.7	4.85	Brown black	Chestnut brown.....	Do.
Braunite	6	6.5	4.7	4.85	Brown black to steel gray.	Brown black	Do.
Polianite	6	6.5	4.8	4.9	Light steel gray	Black	Do.
Pyrolusite	2	2.5	4.8		Iron black to steel gray or bluish.	Black or blue black ..	a Do.
Manganite	4		4.2	4.4	Dark steel gray to iron black.	Red brown to black ..	Hydrous.
Psilomelane ...	5.6	3.7	4.7		Iron black to steel gray.	Brown black	Do.

a Usually yields water in closed tube.

The chemical relationship of the ores as found in nature is thus set forth by Penrose:¹

Chemical composition.	Anhydrous form.	Hydrous form.
Protoxide (MnO).....	Manganosite (MnO).....	Pyrochroite (MnO.H ₂ O).
Proto-sesquioxide (Mn ₂ O ₄)	Hausmannite (Mn ₃ O ₄)	
Sesquioxide (Mn ₂ O ₃)	Braunite (Mn ₂ O ₃)	Manganite (Mn ₂ O ₃ .H ₂ O).
Peroxide (MnO ₂).....	Pyrolusite, Polianite (MnO ₂)	{ Psilomelane. Wad.

Manganese oxides frequently occur admixed in indefinite proportions with the hydrous oxides of iron limonite, giving rise to the manganiferous limonites as shown in Specimens Nos. 66090, 10867, U.S.N.M. from Spain.

FRANKLINITE.—This may be termed rather as a manganiferous ore of iron and zinc than a true ore of manganese. Nevertheless, as the residue after the extraction of the zinc is used in the manufacture of spiegeleisen, we may briefly refer to it here. The mineral occurs in rounded granules or octahedral crystals of a metallic luster and iron black color, associated with zinc oxides and silicates in crystalline limestones, at Franklin Furnace, New Jersey. (Specimen No. 83941, U.S.N.M.) It bears a general resemblance to the mineral magnetite, but is less readily attracted by the magnet and gives a strong manganese reaction. Its average content of manganese oxides Mn₂O₃ and MnO is but from 15 to 20 per cent.

HAUSMANNITE.—This form of the ore when crystallized usually takes the form of the octahedron, and may be readily mistaken for franklinite, from which, however, it differs in its inferior hardness, lower specific gravity, and in being unacted upon by the magnet. (Specimen No. 64241, U.S.N.M.) It occurs in porphyry, associated with other

¹Annual Report of the Geological Survey of Arkansas, I, 1890, p. 541.

manganese ores, in Thuringia; is also found in the Harz Mountains; Wermland, Sweden, and various other European localities. In the United States it is reported as occurring only in Iron County, Missouri. The mineral in its ideal purity consists of sesquioxide and protoxide of manganese in the proportion of 69 parts of the former to 31 of the latter. Analyses of the commercial article as mined are not at hand.

BRAUNITE.—This, like hausmannite, crystallizes in the form of the octahedron, but is a trifle harder. Chemically it differs, in that analyses show almost invariably from 7 to 10 per cent of silica, though as to whether or no this is to be considered an essential constituent it is as yet difficult to say. Analyses 1 and 2, on p. 256, show the composition of the mineral as found. The ore is reported as occurring both crystallized and massive in veins traversing porphyry at Oehrenstock in Ilmenau, in Thuringia, near Ilfeld in the Harz; Schneeberg, Saxony (Specimen No. 68136, U.S.N.M.), and various other European localities. Also at Vizianagram in India; in New South Wales, Australia, and in the Batesville region, Arkansas.

POLIANITE.—Like pyrolusite, yet to be noted, this form of the ore is chemically a pure manganese binoxide, carrying some 63.1 per cent metallic manganese combined with 36.9 per cent oxygen. From pyrolusite it is distinguished by its anhydrous character and increased hardness. So far as reported, it is a rather rare form of manganese, though possibly much that has been set down as pyrolusite may be in reality polianite.

PYROLUSITE occurs in the form of iron black to steel gray, sometimes bluish opaque masses, granular, or commonly in divergent columnar aggregates sufficiently soft to soil the fingers, and in this respect easily separated from the other common forms excepting wad. Not known in crystals except as pseudomorphs after manganite. Its composition is quite variable, usually containing traces of iron, silica, and lime and sometimes barium and the alkalis. Analyses III and IV, on p. 256, as given by Penrose, will serve to show the general average. This is a common ore of manganese, and is extensively mined in Thuringia, Moravia, Bohemia, Westphalia, Transylvania, Australia, Japan (Specimen No. 61936, U.S.N.M.), India, New Brunswick (Specimen No. 36825, U.S.N.M.), Nova Scotia, and various parts of the United States (Specimens Nos. 42011, Tennessee, 56354, Georgia, etc.).

MANGANITE differs and is readily distinguishable from the other ores thus far described, in carrying from 3 to 10 per cent of combined water, which can readily be detected when the powdered mineral is heated in a closed tube. From either psilomelane or pyrolusite it is distinguished by its hardness. When in crystals it takes prismatic forms with the prism faces deeply striated longitudinally (Specimen No. 67922, U.S.N.M., from Thuringia). Its occurrence is essentially



BOTRYOIDAL PSILOMELANE, CRIMORA, VIRGINIA.

Weight, 37½ pounds.

Specimen No. 66722, U.S.N.M.

the same as that of braunite. The composition of the commercial ore is given in the analyses on p. 256.

PSILOMELANE.—This is, with the possible exception of pyrolusite, the commonest of the manganese minerals. The usual form of occurrence is that of irregular nodular or botryoidal masses embedded in residual clays. It is readily distinguished from manganite or wad by its hardness, and from hausmannite, braunite, or polianite by yielding an abundance of water when heated in a closed tube. The sample (Specimen No. 66722, U.S.N.M.), from the Crimora mines in Virginia, is characteristic. See Plate 11. The composition of the commercial ore is given in analyses V, VI, and VII on p. 256.

WAD OF BOG MANGANESE (Specimen No. 66602, U.S.N.M., from Cuba) is a soft and highly hydrated form of the ore, as a rule of little value, owing to impurities (analysis VIII). Asbolite is the name given to a variety of wad containing cobalt (see p. 187). See further Rhodonite and Rhodochrosite, pp. 280, 314.

Origin.—The deposits of manganese oxides which are of sufficient extent to be of commercial importance are believed to be in all cases of secondary origin; that is, to have resulted from the decomposition of preexisting manganiferous silicate constituents of the older crystalline rocks and the subsequent deposition of the oxides in secondary strata. Indeed, in many instances the ore has undergone a natural segregation, owing to the decomposition of the parent rock and the accumulate of the manganese oxide, together with other difficult soluble constituents in the residual clay. Thus Penrose has shown¹ that the deposits of the Batesville (Arkansas) region result from the decay of the St. Clair limestone, the various stages of which are shown in the accompanying Plate 10. The fresh limestone, as shown by analysis, contains but 4.30 per cent manganese oxide (MnO), while the residual clay left through its decomposition contains 14.98 per cent of the same constituent.

Occurrence.—As above noted, the ore is found in secondary rocks, and as a rule in greatest quantities in the clays and residual deposits resulting from their breaking down. The usual form of the ore is that of lenticular masses or nodules distributed along the bedding planes, or heterogeneously throughout the clay. Penrose describes the Batesville ores as sometimes evenly distributed throughout a large body of clay, but in most places as being in pockets surrounded by clay itself barren of ore. These pockets vary greatly in character, being sometimes comparatively solid bodies separated by thin films of clay, and containing from 50 to 500 tons of ore; sometimes they consist of large and small masses of ore embedded together, and again at other times of small grains, disseminated throughout the clay. In the Crimora

¹ Annual Report of the Geological Survey of Arkansas, I, 1890.

(Virginia) deposits the ore (psilomelane) is found in nodular masses in a clay resulting from the decomposition of a shale which has been preserved from erosion through sharp synclinal folds.

Bog manganese is described as occurring in an extensive deposit near Dawson settlement, Albert County, New Brunswick, on a branch of Weldon Creek, covering an area of about 25 acres. In the center it was found to be 26 feet deep, thinning out toward the margin of the bed. The ore is a loose, amorphous mass, which could be readily shoveled without the aid of a pick, and contained more or less iron pyrites disseminated in streaks and layers, though large portions of the deposit have merely a trace. The bed lies in a valley at the northern base of a hill, and its accumulation at this particular locality appears to be due to springs. These springs are still trickling down the hillside, and doubtless the process of producing bog manganese is still going on.¹ A bed of manganese ore in the government of Kutais, in the Caucasus, is described as occurring in nearly horizontally lying Miocene sandstones. The ore is pyrolusite and the bed stated as being 6 to 7 feet in thickness.

Composition of manganese oxides.

Constituents.	Braunite.		Pyrolusite.		Psilomelane.			Wad.
	I.	II.	III.	IV.	V.	VI.	VII.	
MnO.....	87.47	86.95	90.15	88.98	84.99	80.27	63.46	25.42
O.....	9.62	9.85	.....	.....	10.48	14.10	.....	.....
Fe ₂ O ₃.....	.....	.....	2.55	0.21	.....	.....	1.75	.....
CaO.....	0.34	.....	.....	.....	.....	0.51	.....	.....
BaO.....	0.48	2.25	1.12	.....	.....	4.35 K ₂ O	.....	.....
SiO ₂	0.18	.....	2.80	.....	.....	2.84	9.80	.....
H ₂ O.....	.....	0.95	2.05	.....	.....	.....	6.00	33.52

I. Batesville region, Arkansas.

II. Elgersburg, Germany.

III. Cheverie, Nova Scotia.

IV. Cape Breton.

V. Batesville region, Arkansas.

VI. Schneeberg, Saxony.

VII. Crimora, Virginia.

VIII. Big Harbor, Cape Breton.

Uses.—According to Professor Penrose,² the various uses to which manganese and its compound are put, may be divided into three classes: Alloys, oxidizers, and coloring materials. Each of these classes includes the application of manganese in sundry manufactured products, or as a reagent in carrying on different metallurgical and chemical processes. The most important of these sources of consumption may be summarized as follows:

¹ Annual Report of the Geological Survey of Canada, VII, 1894, p. 146 M.

² Annual Report of the Geological Survey of Arkansas, I, 1890.

Alloys	{	Spiegeleisen.....	{	Alloys of manganese and iron.		
		Ferromanganese.....				
		Manganese bronze..			{	Alloys of manganese and copper, with or without iron.
		Silver bronze.....				
		Alloys of manganese with aluminum, zinc, tin, lead, magnesium, etc.				
Oxidizers	{	Manufacture of chlorine.	{	An alloy of manganese, aluminum, zinc, and copper, with a certain quantity of silicon.		
		Manufacture of bromine.				
		As a decolorizer of glass (also for coloring glass, see coloring materials).				
		As a dryer in varnishes and paints.				
		LeClanché's battery.				
Coloring materials..	{	Preparation of oxygen on a small scale.	{	Alloys of manganese and copper, with or without iron.		
		Manufacture of disinfectants (manganates and permanganates).				
		Calico printing and dyeing.				
		Coloring glass, pottery, and brick.				
		Paints			{	Green.
	Violet.					

Besides these main uses a certain amount is utilized as a flux in smelting silver ores, and, in the form of its various salts, is employed in chemical manufacture and for medicinal purposes. Pyrolusite and some forms of psilomelane are utilized in the manufacture of chlorine, and for bleaching, deodorizing, and disinfecting purposes. For this purpose the ore must be very pure and free from iron, lime carbonates, and alkalis. It is also utilized in the manufacture of bromine.

In glass manufacture the manganese is used to accomplish two different results: First, to remove the green color caused by the presence of iron, and second, to impart violet, amber, and black colors.

According to Mr. J. D. Weeks¹ the amount of manganese actually used for other than strictly metallurgical purposes in the United States is small.

The value of a manganese ore depends somewhat upon the uses to which it is to be applied.

Pyrolusite and psilomelane only are of value in the production of chlorine as above noted. These are rated, as stated by Penrose, according to their percentages of peroxide of manganese (MnO_2). The standard for the German ores is given at 57 per cent MnO_2 and 70 per cent for Spanish. For the manufacture of spiegeleisen the prices are based on ores containing not more than 8 per cent silica and 0.10 per cent phosphorus, and are subject to deductions as follows: For each 1 per cent silica in excess of 8 per cent, 15 cents a ton; for each 0.02 per cent phosphorus in excess of 0.10 per cent, 1 cent per

¹Mineral Resources of the United States, 1892, p. 178.

unit of manganese. Settlements are based on analysis made on samples dried at 212° , the percentage of moisture in samples as taken being deducted from the weight. The prices paid at Bessemer, Pennsylvania in 1894, based on these percentages, were as below:

Manganese.	Prices per unit.	
	Iron.	Manganese.
	Cents.	Cents.
Ore containing above 49 per cent	6	28
Ore containing 46 to 49 per cent.....	6	27
Ore containing 43 to 46 per cent.....	6	26
Ore containing 40 to 43 per cent.....	6	25

Otherwise expressed, the value ranges from \$5 to \$12 a ton, according to quality and condition of the market.

It is probable that the total consumption in pottery and glass manufacture does not exceed 500 tons a year, of which about two-thirds is used in glass making. The amount used in bromine manufacture and the other uses enumerated probably amounts to another 500 tons. The remainder is used in connection with iron and steel manufacture, chiefly in the production of steel and a pig iron containing considerable manganese for use in cast-iron car wheels. In the crucible process of steel manufacture manganese is charged into the pots, either as an ore at the time of charging the pots or it is added as spiegeleisen or ferromanganese at the time of charging or during the melting, usually toward the close of the melting, so as to prevent too great a loss of manganese by oxidation. In the bessemer and open-hearth process the manganese is added as spiegeleisen or ferromanganese at or near the close of the process, just before the casting of the metal into ingots.

It has been found in recent years that a chilled cast-iron car wheel containing a percentage of manganese is much tougher, stronger, and wears better than when manganese is absent. For this reason large amounts of manganiferous iron ores are used in the manufacture of Lake Superior pig iron intended for casting into chilled cast-iron car wheels. (See also *The Mineral Industry*, VIII, p. 419.)

V. CARBONATES.

1. CALCIUM CARBONATE.

CALCITE, CALC SPAR, ICELAND SPAR.—These are the names given to the variety of calcium carbonate crystallizing in the rhombohedral division of the hexagonal system. The mineral occurs under a great variety of crystalline forms, which are often extremely perplexing to any but an expert mineralogist. The chief distinguishing characteristics of the mineral are (1) its pronounced cleavage, whereby it splits

Fig. 1.

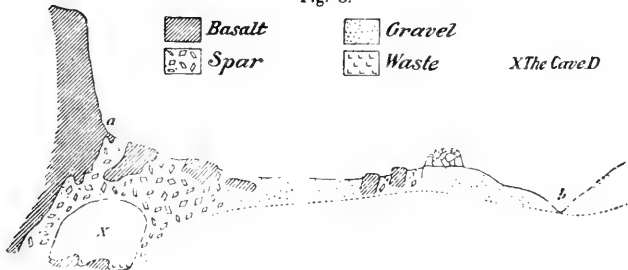


Basalt Gravel Spar

Fig. 2.



Fig. 3.



Basalt Gravel Waste X The Cave D

up into rhombohedral forms, with smooth, lustrous faces, and (2) its doubly refracting property, which is such that when looked through in the direction of either cleavage surfaces it gives a double image. (Specimen No. 53673, U.S.N.M.) It is to this property, accompanied with its transparency, that the mineral, as a crystallized compound, owes its chief value, though as a constituent of the rock limestone it is applied to a great variety of industrial purposes. When not sufficiently transparent for observing its doubly refracting properties the mineral is readily distinguished by its hardness (3 of Dana's Scale) and its easy solubility, with brisk effervescence, in cold dilute acid. This last is likewise a characteristic of aragonite, from which it can be distinguished by its lower specific gravity (2.65 to 2.75) and its cleavage. Calcium carbonate, owing to its ready solubility in terrestrial waters, is one of the most common and widely disseminated of compounds. Only the form known as double spar, or Iceland spar, need here be considered.

Origin and mode of occurrence.—Calc spar is invariably a secondary mineral occurring as a deposit from solution in cracks, pockets, and crevices in rocks of all kinds and all ages. The variety used for optical purposes differs from the rhombohedral cleavage masses found in innumerable localities only in its transparency and freedom from flaws and impurities (Specimen No. 53673, U.S.N.M.). The chief commercial source of the mineral has for many years been Iceland, whence has arisen the term Iceland spar, so often applied. For the account of the occurrences of the mineral at this locality, as given below, we are indebted mainly to Th. Thoroddsen.¹ The quarry is described as situated on an evenly sloping mountain side at Reydarfjorden, about 100 meters above the level of the ocean and a little east of the Helgustadir farm. (See Plate 12.)

The veins of spar are in basalt and at this spot have been laid bare through the erosive action of a small stream called the "Silfurlakur," the Icelandic name of the spar being "Silfurberg." The quarry opening is on the western side of this brook, and at date of writing was some 72 feet long by 36 feet wide (see fig. 1). In the bottom and sides of this opening the calc-spar is to be seen in the form of numerous interlocking veins, ramifying through the basalt in every direction and of very irregular length and width, the veins pinching out or opening up very abruptly. In fig. 2 of plate is shown an area of some 40 square feet of the basaltic wall rock, illustrating this feature of the occurrence. Fig. 3 of the same plate shows the largest and most conspicuous vein, the smaller having been omitted in the sketch. The high cliffs on the north side of the quarry are poorer in calc-spar veins, the largest dipping underneath at an angle of about 40°.

¹Geologiska Foreningens I, Stockholm Forhandlingar, XII, 1890, pp. 247-254.

A comparatively small proportion of the calc-spar as found is fit for optical purposes. That on the immediate surface is, as a rule, lacking in transparency. Many of the masses, owing presumably to the development of incipient fractures along cleavage lines, show internal, iridescent, rainbow hues, such are known locally as "litsteinar" (lightstones). Others are penetrated by fine, tube-like cavities, either empty or filled with clay, and still others contain cavities, sometimes sufficiently large to be visible to the unaided eye, filled with water and a moving bubble. The most desirable material occurs in comparatively small masses imbedded in a red-gray clay, filling the veinlike interspaces in the bottom of the pit. The nontransparent variety, always greatly in excess, occurs in cleavable masses and imperfectly developed rhombohedral, sometimes 1 to 2 feet in diameter, associated with stilbite.

Calc-spar has been exported in small quantities from Iceland since the middle of the seventeenth century, though the business was not conducted with any degree of regularity before the middle of the present century, prior to that time everyone taking what he liked or could obtain, asking no one's permission. About the time Bartholin discovered the valuable optical properties of the mineral (in 1669), the royal parliament under Frederick III granted the necessary permission for its extraction.¹ It was not, however, until 1850 that systematic work was begun, when a merchant by name of T. F. Thomsen, at Seydisfjord, obtained permission of the owner of some three-fourths the property (the pastor Th. Erlendsson) to work the same. The quarried material was then transported on horseback to the Northfjord, and thence to Seydisfjord by water. In 1854 the factor H. H. Svendsen, from Eskifjord, leased the pastor's three-fourths right for 10 rigsdalers a year, and the remaining fourth, belonging to the Government, for 5 rigsdalers. Svendsen worked the mine successfully up to 1862, when one Tullinius, at Eskifjord, purchased the pastor's three-fourths and leased the Government's share for five years, paying therefor the sum of 100 rigsdalers [about \$14 or \$15]. This lease was renewed for four years longer at the rate of 5 rigsdalers per year and for the year 1872 at the rate of 100 rigsdalers, when the entire property passed into the hands of the Government in consideration of the payment of 16,000 kroner [about \$3,800]. From that time until 1882 the mine remained idle, when operations were once more renewed, though not on an extensive scale, owing, presumably in part, to the fact that Tullinius, the last year he rented the mine, had taken out a sufficient quantity to meet all the needs of the market. Over 300 tons of the ordinary type of the spar is stated to have been sent to England and sold to "factory owners" (Fabrikanter) at about 30 kroner a ton, though to what use it was put is not stated.

¹ Laws of Iceland, I, 1668, pp. 321, 322.

Aside from the locality at Helgustadir, calc-spar in quantity and quality for optical purposes is known to occur only at Djupifjörður, in West Iceland.

The Reyðharfjörður locality was also visited by Mr. J. L. Hoskyns-Abrahall in the summer and autumn of 1889, and whose account¹ is reproduced in part below.

Sudhrmúla Sysla, of which Reyðharfjörður, the largest, bisects the east coast of Iceland, are cut out of an immense plateau, formed of horizontal sheets of volcanic rock, chiefly trachyte, between 3,000 and 4,000 feet high. This has been subsequently eroded into sharp, bare ridges with immense cliffs or steep slopes falling from them, parted by torrent valleys and fjords, the greater part of the district not reaching the present snow line. It is on one of these slopes, which slants down at an angle of forty degrees into Reyðharfjörður, that the unique quarry of Iceland spar is found. It consists of a cavity in the rock about 12 by 5 yards and some 10 feet high, originally filled almost entirely, but now only lined, with immense crystals, which are fitted so closely together as to form a compact mass, like a lump of sugar, with grains averaging 10 inches across.

The Systumadhur,² Jón Asmundarson Johnsen, had given me leave to examine the cave and take as many specimens as I liked, but the permission was not of very much use, there being about 5 feet of water nearly all over the bottom; and such specimens as I did get involved doing severe penance in walking barefoot over sharp crystals. The floor is covered with a thin layer of very fine chocolate-brown mud, which sticks as tenaciously to one's feet as to the crystals. I had to resort to tooth powder to get the latter clean, though the great heaps of spar which lie on the path side and in front of the mouth of the cave were all washed by the rain till they were as bright and transparent as ice. The water now running through the cave is incapable of forming calc-spar. It appears, like the surrounding rocks, to contain an excess of silicic acid, and either etches the surface of the spar wherever it comes in contact with it, or covers it with stilbite, the characteristic zeolite of the doleritic and basaltic rocks in Iceland. The rock in which the cave is formed is a dolerite, and darker in color than the surrounding phonolite, which is traversed by veins of black and green pitchstone. In the neighborhood of the spar it is disintegrated, colored slightly with green earth, and full of microscopic crystals of stilbite and calcite.

The quarry was worked till 1872 by Herra Tulinius, a Danish merchant of Eskifjörður. The trading station is an hour and a half's ride from Helgustadir, the nearest farm to the quarry. (In Iceland all distances are measured in terms of the hour's ride, *tíma*, and the day's

¹ Mineralogical Magazine, IX, 1890, p. 179.

² Magistrate, public notary, receiver of taxes, liquidator, auctioneer, etc.

journey, *leidh.*) The Icelandic government in that year bought a quarter share of the quarry, and stopped the work, so that Tulinius was glad to sell them the rest. Five years ago an attempt was made to reopen it. One man was employed, and after spending about a week in the cave he succeeded in pumping out the water and extracting a fine block of clear spar, which was sold at a high price in London. Here, however, the work dropped, and in consequence Tulinius remains the proprietor of the whole of the calc spar that is available for physical work, and naturally sells it at a price that is calculated to make his very moderate stock last for a considerable time.¹ The reason of the Icelandic government is not very clear, but as the working of the quarry is, perhaps from patriotic motives, delegated to Herr Gunnarsson, an Icelandic merchant, whose nearest warehouse is at Seydhisfjörðhr, a good day's ride from Eskifjörðhr, it is hardly to be expected that the buried treasure will soon see the light. Perhaps, too, the specimens of the best quality have been already removed. Certainly clear pieces do not constitute the great mass of the spar, and if M. Labonne, who visited the cave in May, 1877 (the water being at that time frozen), could extract it "en assez grande abondance"² he did not leave much exposed for me to take two years later. M. Labonne speaks in his note of ramifications into the environing rock which have never been worked and suggests that this investigation might increase the importance of the quarry. Such ramifications as I could see were on a very small scale. On the other hand, the thickness of the deposit has not yet been ascertained, but it is said that the best pieces occurred near the surface. For the most part the calcite is rendered semiopaque by innumerable cracks, generally following the gliding and cleavage planes ($-\frac{1}{2}$ R and R), and apparently produced by the pressure of the spar itself, but sometimes following the conchoidal fracture. Remarkable examples of the latter kind are in the British Museum.

CHALK.—This is the name given to a white, somewhat loosely coherent variety of limestone composed of the finely comminuted shells of marine mollusks, among which microscopic forms known as foraminifera are abundant. The older text-books gave one to understand that foraminiferal remains constituted the main mass of the rock, but the researches of Sorby³ showed that fully one-half the material was finely comminuted shallow-water forms, such as inoceramus, pecten, ostrea, sponge spicules, and echinoderms.

Chalk belongs to the Cretaceous era, occurring in beds of varying thickness, alternating with shales, sands, and clays, and often including numerous nodules of a dark chalcedonic silica to which the name

¹ It is sold by Thor E. Tulinius, Slotsholmsgade 16, Copenhagen K.

² Comptes Rendus, CV., 1887, p. 1144.

³ Address to Geological Society of London, February, 1879.

flint is given. Though a common rock in many parts of Europe, it is known to American readers mainly for its occurrence in the form of high cliffs along the English coast, as near Dover. Until within a few years little true chalk was known to exist within the limits of the United States. According to Mr. R. T. Hill¹ there are, however, extensive beds, sometimes 500 feet in thickness, extending throughout the entire length of Texas, from the Red River to the Rio Grande, and northward into New Mexico, Kansas, and Arkansas. These chalks in many instances so closely simulate the English product, both in physical properties and chemical composition, as to be adaptable to the same economic purposes. The following analyses from the report above alluded to serve to show the comparative composition:

Constituents.	Lower Cretaceous chalk, Burnet County, Texas.	Upper Cretaceous chalk, Rocky Comfort, Arkansas.	White Cliff chalk, Little River, Arkansas.	White chalk of Shoreham, Sussex, England.	Gray chalk, Folkstone, England.
Carbonate of lime	92.42	88.48	94.18	98.40	94.09
Carbonate of magnesia	1.38	Trace.	1.37	.08	.31
Silica and insoluble silicates	1.59	9.77	3.49	1.10	3.61
Ferrie oxide and alumina .....	.41	1.25	1.41	.....	.....
Phosphoric acid, alumina, and loss .....	.....	.....	.....	.42	Trace.
Chloride of sodium .....	.....	.....	.....	.....	1.29
Water .....	.18	.....	.55	.....	.70
	99.98	99.50	101	100	100

Chalk is used as a fertilizer, either in its crude form or burnt, in the manufacture of whiting (Specimen No. 26499, from Trego County, Kansas), in the form of hard lumps by carpenters and other mechanics, and in the manufacture of crayons (Specimen No. 62063, U.S.N.M.). Washed, chalk (Specimen No. 62085, U.S.N.M.) is used to give body to wall paper; as a whitewash for ceilings; as a thin coating on wood designed for gilding, being for this purpose mixed with glue; to vary the shades of gray in water-color paints, and as a polishing powder for metals.

Concerning the importation and uses of chalk, Williams states:²

Paris white is the name given to the white coloring substance prepared by grinding cliffstone, a variety of chalk or limestone which is as hard as some building stones and has a greater specific gravity than the ordinary chalk. It is imported from Hull, England, and sells at from \$2 to \$4 per ton ex vessel, according to freight rates from Hull. During the calendar year 1884 3,905½ tons of cliffstone were imported at New York.

The paris white made in this country is sold at from \$1.10 to \$1.25 per hundred-weight, in casks, according to make and quality. The paris white made in England, of which 508,185 pounds were imported at New York during the calendar year 1884,

¹ Annual Report of the Arkansas Geological Survey, II, 1888.

² Mineral Resources of the United States, 1883-84, p. 930.

sells at from \$1.25 to \$1.30 per hundredweight. There is apparently no difference in quality between the cliffstone ground in this country and the imported paris white. Its principal use is in the preparation of kalsomine. It is also employed in the manufacture of rubber, oilcloth, wall papers, and fancy glazed papers. * * *

Until recently all of the whiting used in this country was ground from chalk imported from Hull, England. [See Specimen No. 36013, U.S.N.M.] The annual production of whiting is about 300,000 barrels. The price varies, according to the quality, from 35 to 90 cents per hundredweight. There are four grades made, as follows: Common whiting, worth from 35 to 40 cents; gilders' whiting, 60 to 65 cents; extra gilders' whiting, 70 to 75 cents; American paris white, 80 to 85 cents. The uses of whiting are about the same as paris white, which it closely resembles.

The material, as should be stated, is brought mainly as ballast from England and France.

LIMESTONES; MORTARS; AND CEMENTS.—Pure limestone or calcium carbonate is a compound of calcium oxide and carbonic acid in the proportion of 56 parts of lime (CaO) to 44 parts of the acid (CO_2). In its crystalline form as exemplified in some of our white marbles the rock is therefore but an aggregate of imperfectly outlined calcite crystals, or, otherwise expressed, is a crystalline granular aggregate of calcite. In this form the rock is white or colorless, sufficiently soft to be cut with a knife, and dissolves with brisk effervescence when treated with dilute hydrochloric or nitric acid. Sulphuric acid will not dissolve it except in small proportions, since the exteriors of the granules become converted shortly into insoluble calcium sulphate (gypsum), which protects them from further attack.

As a constituent of the earth's crust, however, absolutely pure limestone is practically unknown, all being contaminated with more or less foreign material, either in the form of chemically combined or mechanically admixed impurities. Of the chemically combined impurities the most common is magnesia (MgO), which replaces the lime (CaO) in all proportions up to 21.7 per cent, when the rock becomes a dolomite. This in its pure state can readily be distinguished from limestone by its greater hardness and in its not effervescing when treated with cold dilute acid. (See p. 274.) It dissolves with effervescence in hot acids, as does limestone. As above noted, all stages of replacement exist, the name magnesian or dolomitic limestone being applied to those in which the magnesia exists in smaller proportions than that above given (21.7 per cent). Iron in the form of protoxide (FeO) may also replace a part of the lime. Of the mechanically admixed impurities silica in the form of quartz sand or various more or less decomposed silicate minerals, clayey and carbonaceous matter, together with iron oxides, are the more abundant. These exist in all proportions, giving rise to what are known as siliceous, aluminous or clayey, carbonaceous, and ferruginous limestones. Phosphatic material may exist in varying proportions, forming gradations from phosphatic limestones to true phosphates.

Limestones are sedimentary rocks formed mainly through the depo-

sition of calcareous sediments on sea bottoms; many beds, however, as the oölitic limestones, show unmistakable evidences of true chemical precipitation. They are in all cases eminently stratified rocks, though the evidences of stratification may not be evident in the small specimens exhibited in museum collections. Varietal names other than those mentioned above are given and which are dependent upon structural features or other peculiarities. A shaly limestone is one partaking of the nature of shale. Chalk is a fine pulverulent limestone composed of shells in a finely comminuted condition and very many minute foraminifera. (See p. 262.) The name chalky limestone is frequently given to an earthy limestone resembling chalk. Marl is an impure earthy form, often containing many shells, hence called shell marl. An oölitic limestone is one made up of small rounded pellets like the roe of a fish. The name marble is given to any calcareous or even serpentinous rock possessing sufficient beauty to be utilized for ornamental purposes.

Uses.—Aside from their uses as building materials, lithographic purposes, etc., as described elsewhere, limestones are utilized for a considerable variety of purposes, the more important being that of the manufacture of mortars and cements. Their adaptability to this purpose is due to the fact that when heated to a temperature of $1,000^{\circ}$ F. they gradually lose the carbonic acid, becoming converted into anhydrous calcium oxide (CaO), or quicklime, as it is popularly called; and further, that this quicklime when brought in contact with water and atmospheric air greedily combines with, first, the water, forming hydrous calcium oxide (CaOH_2O), and on drying once more with the carbonic acid of the air, forming a more or less hydrated calcium carbonate. In the process of combining with water the burnt lime (CaO) gives off a large amount of heat, swells to nearly twice its former bulk, and falls away to a loose, white powder. This when mixed with siliceous sand forms the common mortar of the bricklayers, or, if with sand and hair, the plaster for the interior walls of houses. (Specimens Nos. 63144, 63145, U.S.N.M., from Vermont; No. 53195, U.S.N.M., from Maine, and No. 53168, from Pennsylvania, show the character of the rocks commonly used for these purposes.) Quicklime formed from fairly pure calcium carbonate sets or hardens after but a few days' exposure, the induration, it is stated, being due in part to crystallization. The less pure forms of limestone, notably those which contain upwards of 10 per cent of aluminous silicates (clayey matter), furnish, when burned, a quicklime which slakes much more slowly—so slowly, in fact, that it is not infrequently necessary to crush to powder after burning. These same quicklimes when slaked are further differentiated from those already described by their property of setting (as the process of induration is called) under water. Hence they are known as hydraulic limes, and the rocks from which they are made as hydraulic limestones.

Their property of induration out of contact with the air is assumed to be due to the formation of calcium and aluminum silicates. Inasmuch as these silicates are practically insoluble in water, it follows that quite aside from their greater strength and tenacity they are also more durable; indeed, there seems no practical limit to the endurance of a good hydraulic cement, its hardness increasing almost constantly in connection with its antiquity. Certain stones contain the desired admixture of lime and clayey matter in just the right proportion for making hydraulic cement. In the majority of cases, however, it has been found that a higher grade, stronger and more enduring material, can be made by mixing in definite proportions, determined by experiment, the necessary constituents obtained, it may be, from widely separated localities. The exact relationship existing between composition and adaptability to lime making does not seem as yet to be fully worked out. As is well known, the pure white crystalline varieties yield a quicklime inferior to the softer blue-gray, less metamorphosed varieties. Nevertheless there are certain distinctive qualities, due to the presence and character of impurities, which led Gen. Q. A. Gillmore to adopt the following classification:

- (1) The common or fat limes, containing, as a rule, less than 10 per cent of impurities.
- (2) The poor or meager limes, containing free silica (sand) and other impurities in amounts varying between 10 per cent and 25 per cent.
- (3) The hydraulic limes, which contain from 30 to 35 per cent of various impurities.
- (4) The hydraulic cements, which may contain as much as 60 per cent of impurities of various kinds.

As above noted most cements are manufactured from a variety of materials, and their consideration belongs therefore more properly to technology. Nevertheless it has been thought worth the while here to give in brief the matter below relative to a few of the more important and well-known varieties now manufactured.

PORTLAND CEMENT.—This takes its name from a resemblance of the hardened material to the well-known oölitic limestone of the island of Portland in the English Channel. As originally made on the banks of the Thames and Medway it consists of admixtures of chalk and clay dredged from the river bottoms, in the proportions of three volumes of the former to one of the latter, though these proportions may vary according to the purity of the chalk. These materials are mixed with water, compressed into cakes, dried and calcined, after which it is ground to a fine powder and is ready for use. The following analyses from Heath's *Manual of Lime and Cement* will serve to show the varying composition of the chalk and clay from the English deposits.

Constituents.	Upper chalk.		Gray chalk.		Clay.
Calcium carbonate .....about..	97.90	to 98.60	87.35	to 96.52	.....
Silica .....do.....	.66	1.59	1.67	6.84	55 to 70
Magnesium carbonate.....do.....	.10	.21	.10	.50	.....
Iron oxide .....do.....	.35	.74	.38	.46	3 15
Alumina.....do.....	.....	.....	1.14	.93	11 24
Potash and soda .....do.....	.....	.....	.42	4.29	3 4
Lime.....do.....	.....	.....	.....	.....	4 8
Magnesia .....do.....	.....	.....	.....	.....	1 2
Carbonic acid.....do.....	.....	.....	.....	.....	4 5

It is stated that the presence of more than very small quantities of sand, iron oxides, or vegetable matter in the clay is detrimental. A good cement mud before burning may contain from 68 to 78 per cent of calcium carbonate, 21 to 15 per cent of silica, and from 10 to 7 per cent of alumina.

The following analyses from the same source as the above serve to show (I) the composition of the clay; (II) the mixed clay and chalk or "slurry," as it is called, and (III) the cement powder prepared from the same:

Constituents.	I. Clay.	II. Slurry.	III. Cement.
Lime .....	.....	.....	62.13
Calcium sulphate .....	.....	.....	2.13
Calcium carbonate.....	2.01	69.97	.....
Silica (soluble).....	54.14	11.77	20.45
Alumina	14.68	4.45	8.05
Magnesium carbonate	4.48	2.87	.....
Magnesia.....	.....	.....	1.48
Iron oxide	7.76	2.13	4.37
Sand .....	.87	1.24	.98
Water	15.03	7.59	.....

Several brands of Portland cement are manufactured in America, usually from a mixture of materials, the proportions of which have been worked out by experiment. At the Coplay Cement Works, in Lehigh County, Pennsylvania, a blue-gray crystalline limestone and dark gray more siliceous variety are ground and mixed into the desired proportions, molded into a brick, and burnt to the condition of a slag. The material is then ground to a powder and forms the cement. Through the courtesy of the manager, the Museum collections contain samples of the crude and manufactured materials, as follows: Limestone (Specimen No. 53541, U.S.N.M.); cement rock (No. 53542, U.S.N.M.). Composition formed by admixing the two rocks (No. 53543, U.S.N.M.); and the clinker (No. 53544, U.S.N.M.) obtained by

burning the composition. The chemical composition of the samples as given are as follows:

Constituents.	Limestone.	Cement rock.	Compound of the two.	Clinker.
Silica (SiO_2)	2.10	15.22	13.22	22.74
Alumina (Al_2O_3) .....	.84	4.24	5.20	10.50
Iron oxide (Fe_2O_3)				
Calcium carbonate (CaCO_3)...	96.17	69.88	77.00	CaO 61.82
Magnesian carbonate (MgCO_3)	Trace.	4.60	4.20	MgO 2.05

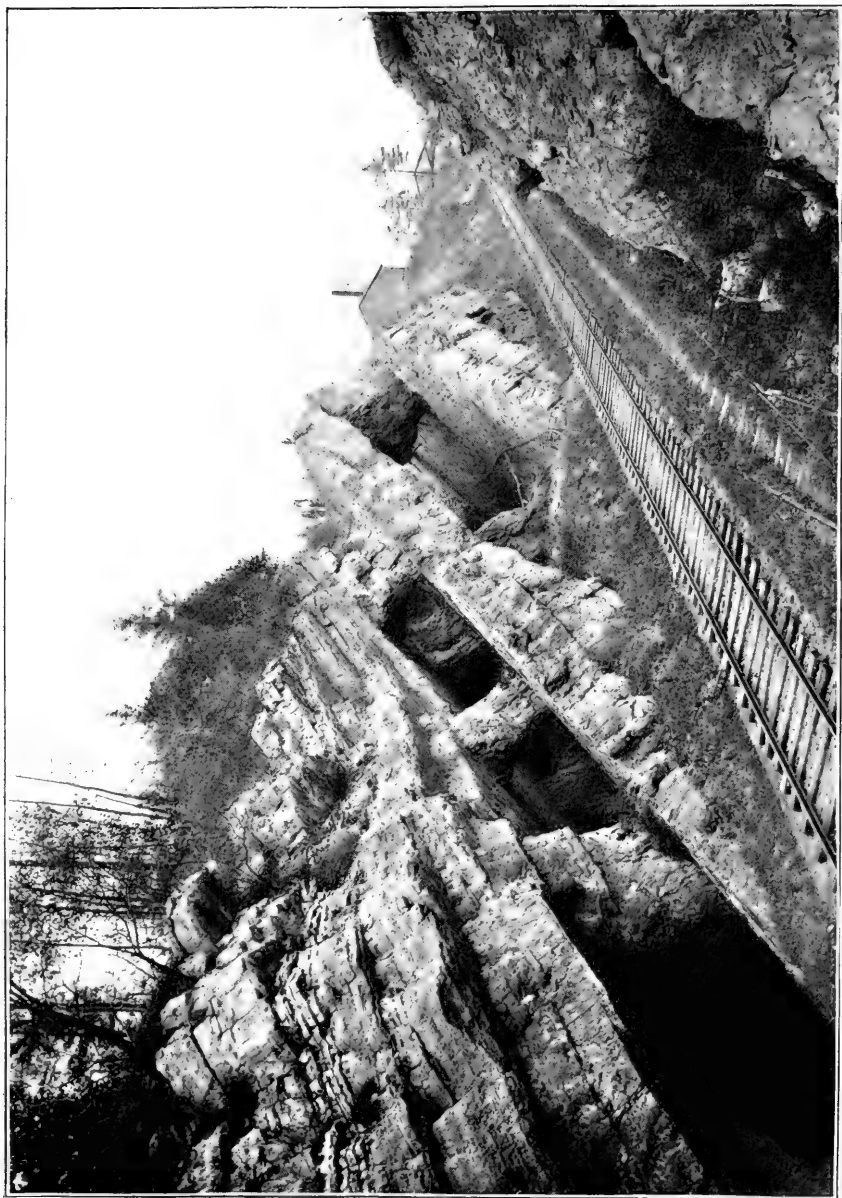
An impure limestone, forming a portion of the water-lime group of the Upper Silurian formations at Buffalo, New York, forms a "natural cement" rock which is utilized in the manufacture of the so-called Buffalo Portland cement.¹

The so-called *Rosendale cement* is made from the tentaculite or water limestones of the Lower Helderburg group as developed in the township of Rosendale, Ulster County, New York. According to Darton² there are two cement beds in the Rosendale-Whiteport region, at Rosendale the lower bed or dark cement averaging some 21 feet in thickness and the upper or light cement 11 feet, with 14 to 15 feet of water-lime intervening. In the region just south of Whiteport the upper white cement beds have a thickness of 12 feet and the lower or gray cement of 18 feet, with 19 to 20 feet of water-lime beds between them. The underlying formation is quartzite. The method of mining the material from the two beds, as well as their inclination to the horizon, is shown in Plate 13. (See Specimens, Nos. 63062-63086, U. S. N. M., from Ulster, Onondaga, and Erie Counties, New York; Nos. 63090-63099, U. S. N. M., Cumberland and Hancock, Maryland; No. 53173, from Lisbon, Ohio, and No. 53193, from Sandusky, Ohio).

ROMAN CEMENT.—The original Roman cement appears to have been made from an admixture of volcanic ash or sand (pozzuolana, peperino, trass, etc.) and lime, the proportions varying almost indefinitely according to the character of the ash. The English Roman cement is made by calcining septarian nodules dredged up from the bottoms of Chichester Harbor and off the coast of Hampshire, and from similar nodules obtained from the Whitby shale beds of the Lias formations in Yorkshire and elsewhere. The following analysis of the cement stone from Sheppey, near South End, will serve to show the character of the material:

¹ Cement Rock and Gypsum Deposits in Buffalo. J. Pohlman. Transactions of the American Institute of Mining Engineers, XVII, 1889, p. 250.

² Report of the State Geologist of New York, I, 1893.



VIEW IN A CEMENT QUARRY NEAR WHITEHALL, ULSTER COUNTY, NEW YORK.
From a photograph by N. H. Darton.

Carbonate of lime	64.00
Silica	17.75
Alumina	6.75
Magnesia .....	.50
Oxide of iron	6.00
Oxide of manganese	1.00
Water	3.00
Loss	1.00
	<hr/>
	100.00

The names concrete and beton are applied to admixtures of mortar, hydraulic or otherwise, and such coarse materials as sand, gravel, fragments of shells, tiles, bricks, or stone. According to Gillmore the matrix of the beton proper is a hydraulic cement, while that of the concrete is nonhydraulic. The terms are, however, now used almost synonymously.

Aside from their uses as above indicated limestones are used in the preparation of lime for fertilizing purposes. For this purpose, as before, the lime carbonate is reduced to the condition of oxide by burning, and then allowed to become air slaked, when it remains in the condition of a fine powder suitable for direct application to the land as is the plaster made from gypsum. A lime prepared by burning oyster shells is utilized in a similar manner.

BIBLIOGRAPHY.

Out of the many hundreds of titles that might be given, a few only are selected. Those desiring may find a very full bibliography in a series of papers on The Chemical and Physical Examinations of Portland Cement. *Journal of the American Chemical Society*, XV and XVI. 1893-1894.

Q. A. GILLMORE. *Practical Treatise on Limestones, Hydraulic Cements, and Mortars*. New York, 1863, 333 pp.

The Cement Works on the Lehigh.

Second Pennsylvania Geological Survey, Lehigh District, D. D. 1875-76, p. 59.

HENRY C. E. REID. *The Science and Art of the Manufacture of Portland Cement with Observations on some of its Constructive Applications*.

London, 1877.

JOHANN BIELENBERG. *Method for Utilizing Siliceous Earths and Rocks in the Manufacture of Cements, for the purpose of imparting to them Hydraulic Properties*. (German Patent No. 24038, November 28, 1882.)

Journal of the Society of Chemical Industry, III, 1884, p. 110.

U. CUMMINGS. *Hydraulic Cements, Natural and Artificial, their Comparative Values*. Massachusetts Institute of Technology, November, 1887.

M. H. LE CHATELIER. *Recherches Expérimentales sur la Constitution des Mortiers Hydrauliques*.

Chas. Dunod, Paris, 1887.

M. A. PROST. *Note sur la Fabrication et les Propriétés des Ciments de Laitier*. *Annales des Mines*, XVI, 1889, p. 158.

H. PEARETH BRUMELL. *Natural and Artificial Cements in Canada*. *Science*, XXI, 1893, p. 177.

M. H. LE CHATELIER. *Procédés d'Essai des Matériaux Hydrauliques*. *Annales des Mines*, IV, 1893, p. 367.

A. H. HEATH. *A Manual of Lime and Cement.*

London, 1893, 215 pp.

G. R. REDGRAVE. *Calcareous Cements: Their Nature and Uses.*

London, 1895, 222 pp.

URIAH CUMMINGS. *American Cements.*

Boston, 1898, 299, pp.

CHARLES D. JAMESON. *Portland Cement, its Manufacture and Use.*

New York, 1898, 192 pp.

BERNARD L. GREEN. *The Portland Cement Industry of the World.*

(Reprinted from *Journal of the Association of Engineering Societies*. XX, June, 1898).

PLAYING MARBLES.—At Oberstein on the Nahe, Saxony, playing marbles are made in great quantities from limestone. The stone is broken into square blocks, each of such size as to make a sphere the size of the desired marble. These cubes are then thrown into a mill consisting of a flat, horizontally revolving stone with numerous concentric grooves or furrows on its surface. A block of oak of the same diameter as the stone and resting on the cubes is then made to revolve over them in a current of water, the cubes being thus reduced to the spherical form. The process requires but about fifteen minutes.

LITHOGRAPHIC LIMESTONE.—For the purpose of lithography there is used a fine-grained homogeneous limestone, breaking with an imperfect, shell-like or conchoidal fracture, and as a rule of a gray, drab, or yellowish color. A good stone must be sufficiently porous to absorb the greasy compound which holds the ink and soft enough to work readily under the engraver's tool, yet not too soft. It must be uniform in texture throughout and be free from all veins and inequalities of any kind, in order that the various reagents used may act upon all exposed parts alike. It is evident, therefore, that the suitability of this stone for practical purposes depends more upon its physical than chemical qualities. An actual test of the material by a practical lithographer is the only test of real value for stones of this nature. Nevertheless the analyses given below are not without interest as showing the variation in composition even in samples from the same locality.

Composition of lithographic stones.

Localities.	CuO ₃ .	MgO ₃ .	Al ₂ O ₃ .	Fe ₂ O ₃ .	Soluble silica.	Insoluble silica.	Organic matter.	FeO.	H ₂ O.	Specific gravity.	Authority.
Solenhofen, Bavaria.....	81.47	13.83	0.25	0.235	4.45		0.720	0.13	0.40	2.95	J. Lewis Howe.
Solenhofen, Bavaria (dark).....	90.934	3.571	0.584	0.235	0.520	2.00	0.132	0.003	1.379	2.84	C. W. Volney.
Solenhofen, Bavaria (yellow).....	89.589	4.380	0.101	0.321	0.02	1.893					Do.
Solenhofen, Bavaria.....	96.24	0.21	2.02								Gmelin.
Kentucky (light gray).....	73.241	12.431	1.141	1.075	11.50		0.40		0.935	2.99	C. W. Volney.
Iowa (blue gray).....	82.20	4.327	1.075	1.075	6.795		3.30		0.24	2.82	Do.
Missouri (light gray).....	77.03	14.27	2.143	2.143	4.30		1.83		0.341	2.75	Do.
Missouri, Ralls County.....	81.77	15.10	0.06	0.66	3.12						
Overton, Tennessee.....	77.62	17.32	0.884		4.10						
Canada (light-blue gray).....	89.989	2.789				3.712	0.409	0.104	1.25	2.84	
Canada (dark-blue gray).....	88.034	2.50	0.577	0.359	0.49	3.60	1.29	0.41	1.360	2.89	

Localities.—Stones possessing in a greater or less degree the proper qualities for lithographic purposes have from time to time been reported in various parts of the United States; from near Bath and Stony Stratford, England; Ireland; Department of Indre, France, and also Silesia, India, and the British American possessions. By far the best stone, and indeed the only stone which has as yet been found to satisfactorily fill all the requirements of the lithographer's art, and which is the one in general use to-day wherever the art is practiced, is found at Solenhofen, near Pappenheim, on the Danube, in Bavaria. (Specimens Nos. 35888 and 35706, U.S.N.M.) These beds are of Upper Jurassic or Kimmeridgian age and form a mass some 80 feet in thickness, though naturally not all portions are equally good, or adapted for the same kind of work. The stone varies both in texture and color in different parts of the quarry, but the prevailing tints are yellowish or drab. In the United States materials partaking of the nature of lithographic stone have been reported from Yavapai County, Arizona (Specimens Nos. 62798 and 68162, U.S.N.M.); Talladega County, Alabama; Arkansas; Lawrence County, Indiana (Specimen No. 25030, U.S.N.M.); near Thebes and Anna, Illinois (Specimens Nos. 61344 and 62570, U.S.N.M.); James and Van Buren counties, Iowa; Hardin, Estelle, Kenton, Clinton, Rowan, Wayne, and Simpson counties, Kentucky (Specimen No. 36897, U.S.N.M., from Simpson County); near Saverton, Ralls County, Missouri (Specimen No. 28498, U.S.N.M.); Clay and Overton counties, Tennessee; Burnet and San Saba counties, Texas (Specimens Nos. 38624 and 70671, U.S.N.M.); near Salt Lake City, Utah, and at Fincastle, Virginia. While, however, from nearly, if not quite every one of these localities, it was possible to get small pieces which served well for trial purposes, each and every one has failed as a constant source of supply of the commercial article, and this for reasons mainly inherent in the stone itself. It is very possible that ignorance as to proper methods of quarrying may have been a cause of failure in some cases.

The Arizona stone is one of the most recent discoveries, and according to first reports seems also the most promising. Samples of the stone submitted to the writer, as well as samples of work done upon it, seemed all that could be desired (Specimens Nos. 62798 and 68162, U.S.N.M.). It is stated by Mr. W. F. Blandy that the quarries are situated on the east slope of the Verdi Range, about 2 miles south of Squaw Peak and at an elevation of about 1,200 feet above the Verdi Valley, 40 miles by wagon road east of Prescott. Two quarries have thus far been opened in the same strata, about 1,000 feet apart, the one showing two layers or beds 384 feet in thickness, and the other three beds 3,188 feet in thickness. As at present exposed the beds, which are of Carboniferous age, are broken by nearly vertical fissures into blocks rarely 4 or 5 feet in length. Owing to the massive form of

the beds and this conchoidal fracture the stone can not be split into thin slabs, but must be sawn. No satisfactory road yet exists for its transportation in blocks of any size, and such material as has thus far been produced is in small slabs such as can be "packed." Those who have inspected the properties express themselves as satisfied that blocks of good size and satisfactory quality can be had in quantity.

The Alabama stone as examined by the writer is finely granular and too friable for satisfactory work. Qualitative tests showed it to be a siliceous magnesian limestone. It is of course possible that the single sample shown does not fairly represent the product. The Arkansas deposit is situated in Township 14° N., R. 15° W. of the 5th p. m., sections 14, 23, and 24, Searcy County. The color is darker than that of the Bavarian stone. The reports of those who have tested it are represented as being uniformly favorable.

The Illinois stone is darker, but to judge from the display made in the Illinois building at the World's Columbian Exposition, 1893, is capable of doing excellent work and can be had in slabs of good size (Specimens Nos. 61344 and 62570, U.S.N.M.). The Kentucky stone is hard and brittle, though that from Rowan County is stated to have received a medal at the exposition of 1876. It is fine grained and homogeneous and very pure, only a small flocculent residue of organic matter remaining insoluble in dilute hydrochloric acid.

The Indiana stone is harder than the Bavarian, and samples examined were found not infrequently traversed by fine, hard veins of calcite. (Specimen No. 25030, U.S.N.M.)

The stone from Saverton, Missouri, is compact and fine grained, with, however, fine streaks of calcite running through it. (Specimen No. 28498, U.S.N.M.) It leaves only a small brownish residue when dissolved in dilute acid. This stone has been worked quite successfully on a small scale. The State geologist, in writing on the subject, says:¹

Some of the beds of the St. Louis limestone (Subcarboniferous) have been successfully used for lithographic work. No bed is, however, uniformly of the requisite quality, and the cost of selection of available material would seem to preclude the development of an industry for the production of lithographic stone. From the deposit at Overton, Tennessee, it is stated slabs 40 by 60 inches by 3½ inches thick were obtained, though little, if anything, is now being done. An analysis of this stone is given in the table. Other promising finds are reported from McMinn County, in the same State. According to the State geological reports, the stone lies between two beds of variegated marble. The stratum is thought to run entirely through the county, but some of the stone is too hard for lithographic purposes. The best is found 8 miles east of Athens on the farm of Robert Cochrane, and a quarry has been opened by a Cincinnati company, which only pays a royalty of \$250 per annum. It is sold for nearly the same price as the Bavarian stone. It is a calcareous and argillaceous stone, formed of the finest sediment, of uniform texture, and possesses a pearl-gray tint. The best variety of this stone has a conchoidal fracture and is free from spots of all kinds.

¹Bulletin No. 3, Geological Survey of Missouri, 1890, p. 38.

A lithographic stone is described in the State survey reports of Texas as occurring at the base of the Carboniferous formations near Sulphur Springs, west of Lampasas, on the Colorado River, and to be traceable by its outcrops for a distance of several miles, the most favorable showing being near San Saba. The texture of the stone is good; but as it is filled with fine reticulating veins of calcite (Specimen No. 70671, U.S.N.M.), and as moreover the lithographic layer itself is only some 6 or 8 inches in thickness, it is obvious that little can be expected from this source. The Texas Lithographic Stone Company, with headquarters at Burnet, have used the stone, it is said, in considerable quantities. A stone claiming many points of excellence has for some years been known to exist in the Wasatch range within a few miles of Salt Lake City, and several companies are or have been engaged in its exploitation.

Very encouraging reports of beds examined by men whose opinions should be conservative, come from Canadian sources, and it is possible a considerable industry may yet be here developed, though little is being done at present. The descriptions as given in the geological reports are as follows:¹

The lithographic stones of the townships of Madoc and Marmora and of the counties of Peterboro and Bruce have been examined and practically tested by lithographers, and in several cases pronounced of good quality; they have also obtained medals at various exhibitions. They were obtained from the surface in small quarries, and possibly when the quarries are more developed better stones, free from "specks" of quartz and calcite, will be available in large slabs.

It should be stated that in actual use the principal demand is for stones some 22 or 28 by 40 inches; the largest ones practically used are some 40 by 60 inches and 3 to 3½ inches thick. As the better grades bring as high as 22 cents a pound, it will be readily perceived that the field for exploration is one offering considerable inducement.

2. DOLOMITE.

This is a carbonate of calcium and magnesium (Ca, Mg, CO_3), = calcium carbonate 54.35 per cent, magnesium carbonate 45.65 per cent. Hardness 3.5 to 4; specific gravity, 2.8 to 2.9; colors when pure, white, but often red, green, brown, gray, or black from impurities. (Specimen No. 82167, attached crystals on limestone from Joplin, Missouri.) Dolomite, like calcite, occurs in massive beds or strata either compact (Specimen No. 37795, U.S.N.M.) or coarsely crystalline, and is to the eye alone often indistinguishable from that mineral. Like limestone, the dolomites occur in massive forms suitable for building purposes, or in some cases as marble. (Specimen No. 25075, U.S.N.M.) From the limestone they may be distinguished by their increased hardness and being insoluble in cold dilute hydrochloric acids. The dolomites, like the limestones, are sedimentary rocks, though it is doubtful

¹Geology of Canada, 1863.

if the original sediments contained sufficient magnesium carbonate to constitute a true dolomite. They are regarded rather as having resulted from the alteration of limestone strata by the replacement of a part of the calcium carbonate by carbonate of magnesium.

Uses.—Aside from its use as a building material, dolomite has of late come into use as a source of magnesia for the manufacture of highly refractory materials for the linings of converters in the basic processes of steel manufacture. According to a writer in the *Industrial World*¹ the magnesia is obtained by mixing the calcined dolomite with chloride of magnesium, whereby there is formed a soluble calcic chloride which is readily removed by solution, leaving the insoluble magnesia behind. According to another process the calcined dolomite is treated with dissolved sugar, leading to the formation of sugar of lime and deposition of the magnesia; the solution of sugar of lime is then exposed to carbonic acid gas, which separates the lime as carbonate, leaving the sugar as refuse. Recently it has been proposed to use magnesia as a substitute for plaster of paris for casts, etc.

The snow-white coarsely crystalline Archean dolomite commercially known as snowflake marble, and which occurs at Pleasantville, in Westchester County, New York (Specimen No. 30863, U.S.N.M.), is finely ground and used as a source of carbonic acid in the manufacture of the so-called soda and other carbonated waters. (Specimen No. 30864, U.S.N.M.)

3. MAGNESITE.

This is a carbonate of magnesium, MgCO_3 , = carbon dioxide 52.4 per cent, magnesia 47.6 per cent. Usually contaminated with carbonates of iron and free silica.

The following analysis will serve to show the average run of the material, both in the crude state and after calcining:

Constituents.	Styria.	Greece.
<i>Crude magnesite.</i>		
Carbonate of magnesia	90.0 to 96.0	94.46
Carbonate of lime	0.5 to 2.0	4.40
Carbonate of iron	3.0 to 6.0	FeO 0.08
Silica	1.0	0.52
Manganous oxide	0.5	Water 0.54
<i>Burnt magnesite.</i>		
Magnesia	77.6	82.46 to 95.36
Lime	7.3	0.83 to 10.92
Alumina and ferric oxide	13.0	0.56 to 3.54
Silica	1.2	0.73 to 7.98

The mineral occurs rarely in the form of crystals, but is commonly in a compact finely granular condition of white or yellowish color some-

¹ June 1, 1893.

what resembling unglazed porcelain (Specimen No. 16070, from Gilroy, California), and more rarely crystalline granular, like limestone or dolomite (Specimen No. 48273, U.S.N.M., from Wells Island).

It is hard (3.5 to 4.5) and brittle, with a vitreous luster, and is unacted upon by cold, but dissolves with brisk effervescence in hot hydrochloric acid.

Localities and mode of occurrence.—Most commonly the mineral is found in the form of irregular veins in serpentinous and other magnesian rocks, being a decomposition product either of the serpentine itself or of the original rock from which the serpentine is derived. It is also found in granular aggregates disseminated throughout serpentinous rocks. It is stated by Dana to occur associated with gypsum.

Prof. W. P. Blake has described¹ immense beds of very pure magnesite as occurring in the foothills of the Sierra Nevadas, between Four and Moore creeks, in what is now Tulare County. The beds are from 1 to 6 feet in thickness and are interstratified with talcose and chloritic schists and serpentine. Mr. H. G. Hanks, who has since inspected these deposits, reports them as existing in several hills or low mountains, the mineral cropping out boldly in distinct and clearly marked veins, varying from 2 inches to 4 feet, and of a maximum length, as exposed, of 500 feet. In section 5, T. 15 S., R. 24 E., Fresno County, California, there is stated² to be a large vein of the material averaging 10 feet in width, incased in hornblende and micaceous shales. A white marble-like crystalline granular variety has been found in the form of drift boulders on an island in the St. Lawrence River near the Thousand Islands Park. (Specimen No. 48273, U.S.N.M.) According to Canadian geologists magnesite forming rock masses occurs associated with the dolomites, serpentines, and steatites of the eastern townships of Quebec. In Bolton it occurs in an enormous bed resembling crystalline limestone in appearance. An analysis of this yielded: Carbonate of magnesia, 59.13 per cent; carbonate of iron, 8.72 per cent; silica, 32.20 per cent. In the township of Sutton a slaty variety yielding as high as 80 per cent of carbonate of magnesium occurs admixed with feldspar and green chromiferous mica. In Styria the material lies in Silurian beds consisting of argillaceous shales, quartzites, dolomites, and limestones, resting upon gneiss. The extensive deposit of magnesite occurring associated with Subcarboniferous limestones in the Swiss Tyrol is regarded by M. Koch³ as due to a decomposition of the original limestone through percolating magnesia-bearing solutions. Magnesia being the stronger base replaces the lime, which is carried away in solution.

The chief localities of magnesite, native and foreign, are as fol-

¹ Pacific Railroad Reports, V, p. 308

² Tenth Annual Report of the State Mineralogist of California, 1890, p. 185.

³ Zeitschrift der Deutschen Geologischen Gesellschaft, XLV, Pt. 2, 1893, p. 294.

lows: Maryland, Bare Hills, Baltimore County. New Jersey, Hoboken. Massachusetts, Roxbury. New York, near Rye, Westchester County; Warwick, Orange County; Stony Point, Rockland County; New Rochelle, Westchester County; Serpentine Hills, Staten Island. North Carolina, Webster, Jackson County; Hamptons, Yancey County, McMakins Mine, Cabarrus County. Pennsylvania, Goat Hill, West Nottingham, Chester County; Scotts Mine, Chester County; Low's Chrome Mine, Lancaster County (Specimen No. 53101, U.S.N.M.). California, Coyote Creek, near Madison Station, Southern Pacific Railroad, Santa Clara County (Specimen No. 16070, U.S.N.M.); Gold Run, Iowa Hill, and Damascus, Placer County; Arroyo Sero, Monterey County; Mariposa and Tuolumne counties; Diablo Range, Alameda County; between Four Creek and Moores Creek, near Visalia, Tulare County (Specimen No. 63842, U.S.N.M.); Alameda County; Napa County (Specimen No. 62594, U.S.N.M.); Millcreek, Fresno County. Washington, Spokane County (Specimen No. 53235, U.S.N.M.). Sutton, Quebec, lot 12, range 7; Bolton, Quebec. Regla, near Havana, Cuba. Kongsberg, Norway. Piedmont, Italy. Bingera Diamond Fields, New South Wales. Victoria, South Australia (Specimens Nos. 28466 and 28472, U.S.N.M.). Kosewitz and Frankenstein, Silesia. Styria, in Austria-Hungary. Greece (Specimens Nos. 62895 and 67983, U.S.N.M.).

Uses.—Magnesite is used in the preparation of magnesian salts (Epsom salts, magnesia, etc.), in the manufacture of paint, paper, and fire brick. For the last-named purpose it is said to answer admirably, particularly where a highly refractive material is needed, as in the so-called basic process of iron smelting.

Magnesia made from the carbonate [magnesite] by driving off the carbonic acid is very refractory, if pure. It is made into any shape that is required, and is one of the most refractory of substances. It was formerly very difficult to get the carbonate of magnesia, but large quantities of it have been found on the island of Eubœa, so that it can now be had for \$15 to \$25 per ton, instead of \$60 to \$70 as formerly. It can be calcined at a less cost than ordinary lime, losing half of its weight, so that if calcined before it is transported the cost may be still further reduced. It contains a little lime, silicates of iron, and some serpentine and silica. After calcination, the serpentine and silica can be separated, as it is easily crushed, but the most of the work can be done by hand-picking beforehand. Before moulding, it must be submitted to about the temperature it is to undergo in the furnace, otherwise it would contract. It is then mixed with a certain portion of less calcined material, which is one-sixth for steel fusion, and 10 to 15 per cent. water by weight, and pressed in iron moulds. If for any reason—either because there was too much or too little water, or because the material was not properly mixed, or contains silica—the crucible is not strong enough, it has only to be dipped in water, which has been saturated with boracic acid, and then heated.¹

Twenty or more years ago the mineral was mined from serpentinous

¹T. Egleston, Transactions of the American Institute of Mining Engineers, IV, 1876, p. 261.

rocks in Lancaster County, Pennsylvania, by McKim, Sines and Company, of Baltimore, by whom it was used for the manufacture of Epsom salts (sulphate of magnesia).

Although it is said¹ that these gentlemen made a pure salt at less price than it could be imported, and thereby excluded the foreign material almost exclusively, the mines are now wholly abandoned. Isaac Tyson & Co., of this same city, also operated mines in Lancaster County.

Early in the fall of 1886 a small force of men was set to work on the deposits of magnesite discovered on Cedar mountain, Alameda county, California. Since that time several carloads of the mineral have been gotten out and shipped by rail to New York, these deposits being only a few miles from the line of the Central Pacific Railroad. The mineral occurs here in a decomposed serpentine rock and in a yellow clay in which are embedded large boulders. It lies in pockets and small veins, the latter running in every direction. The richest spots are found under the boulders, where the mineral is quite pure. A machine is used to sift out the small stones from the powdered magnesite, a good deal of which is met with. A number of veins of this mineral has been exposed by the occurrence of landslides on the side of the mountain where they are situated; only a few of them, however, contain good mineral, nor is there any certainty as to how long these will last. The claims are being opened by tunnels, of which two have been started. The process of gathering this mineral is slow, as every piece has to be cleaned by hand and the whole has to be carefully assorted according to purity. Having been divided into three classes, it is put up in sacks weighing from 80 to 100 pounds each. This sacking is preliminary not only to shipping but to getting it down from the mountains, which can be done only on the backs of animals. While carbonate of magnesia occurs at a great many places in California and elsewhere on the Pacific coast, the above is the only deposit of this mineral that is being worked. An artificial article of this kind is obtained as a by-product in the manufacture of salt by the Union Pacific Salt Company of California.²

Th. Schlossing has proposed³ to utilize magnesian hydrate obtained by precipitation from sea water by lime, for the preparation of fire brick, the hydrate being first dehydrated by calcination at a white heat, after which it is made up into brick form.

According to the *Industrial World*⁴ magnesite as a substitute for barite in the manufacture of paint is likely to prove of importance. The color, weight, and opacity of powder add to its value for this purpose. In Europe it is stated the material is used as an adulterant for the cheaper grades of soap.

Prices.—During 1892 the material, 96 to 98 per cent pure, was quoted as worth \$9 to \$15 a ton in New York City. Material containing as high as 15 to 30 per cent silica and 8 to 10 per cent of iron is said to be practically worthless. In 1899 crude California magnesite was quoted as worth \$3 a ton at the mines.

¹ Report C. C. C. Second Geological Survey of Pennsylvania, p. 178.

² Mineral Resources of the United States, 1886, p. 696.

³ Comptes Rendus, 1885, p. 137.

⁴ Industrial World, XXXVI, No. 20, 1891.

4. WITHERITE.

This is a carbonate of barium of the formula BaCO_3 , = baryta 77.7 per cent, carbon dioxide 22.3 per cent. Color, white to yellow or gray, streak white; translucent. Hardness, 3 to 3.75; specific gravity, 4.29 to 4.35. When crystallized, usually in form of hexagonal prisms, with faces rough and longitudinally striated. Common in globular and botryoidal forms, amorphous, columnar, or granular in structure. The powdered mineral dissolves readily in hydrochloric acid, like calcite, but is easily distinguished from this mineral by its great weight and increased hardness, as well as by its vitreous luster and lack of rhomboidal cleavage, which is so pronounced a feature in calcite. From barite, the sulphate of barium, with which it might become confused on account of its high specific gravity, it is readily distinguished by its solubility in acids as above noted. From strontianite it can be distinguished by the green color it imparts to the blowpipe flame.

Localities and mode of occurrence.—The mineral occurs apparently altogether as a secondary product filling veins and clefts in older rocks and often forming a portion of the gangue material of metalliferous deposits. The principal localities as given by Dana are Alston Moor, Cumberland (Specimen No. 67923, U.S.N.M.), where it is associated with galena. In large quantities at Fallowfield near Hexam in Northumberland; at Anglezarke in Lancashire; at Arkendale in Yorkshire, and near St. Asaph in Flintshire, England. Tarnowitz, Silesia; Szlana, Hungary; Leogang in Salzburg; the mine of Arqueros near Coquimbo, Chile; L. Etang Island; near Lexington, Kentucky, and in a silver-bearing vein near Rabbit Mountain, Thunder Bay, Lake Superior.

Uses.—The mineral has been used to but a slight extent in the arts. As a substitute for lime it has met with a limited application in making plate glass, and is also said to have been used in the manufacture of beet sugar, but is now being superseded by magnesite.

5. STRONTIANITE.

This is a carbonate of strontium, SrCO_3 , = Carbon dioxide 29.9 per cent; strontia 70.1 per cent. Often impure through the presence of carbonates and sulphates of barium and calcium. Colors, white to gray, pale green, and yellowish. Hardness 3.5 to 4. Specific gravity 3.6 to 3.7. Transparent to translucent. When crystallized often in acute spear-shaped forms. Also in granular, fibrous, and columnar globular forms. Soluble like calcite in hydrochloric acid, with effervescence, but readily distinguished by its cleavage and greater density. The powdered mineral when moistened with hydrochloric acid and held on a platinum wire in the flame of a lamp imparts to the flame a very characteristic red color.

Occurrence.—According to Dana the mineral occurs at Strontian in Argyllshire, in veins traversing gneiss, along with galena and barite; in Yorkshire, England; at the Giants Causeway, Ireland; Clausthal, in the Harz; Bräunsdorf, Saxony; Leogang, in Salzburg; near Brixlegg, Tyrol; near Hamm and Münster, Westphalia. In the United States, at Schoharie, New York, in the form of granular and columnar masses and also in crystals, forming nests and geodes in the hydraulic limestone; at Clinton, Oneida County; Chaumont Bay and Theresa, Jefferson County; and Mifflin County, Pennsylvania.

Uses.—Strontianite, so far as the writer has information, has but a limited application in the arts. It is stated¹ that “basic bricks” are prepared from it by mixing the raw or burnt strontianite with clay or argillaceous ironstone in such proportions that the brick shall contain about 10 per cent of silica, and then working into a plastic mass with tar or some heavy hydrocarbon. After molding, the bricks are dusted with fine clay or ironstone, dried, and burned. The effect of the dusting is to form a glaze on the surface, which protects the brick from the moisture of the air. Like celestite, it is also used in the production of the red fire of fireworks. The demand for the material is small, and the price but from \$2.50 to \$4 a ton.

6. RHODOCHROSITE; DIALOGITE.

This is a pure manganese carbonate of the formula MnCO_3 , = carbon dioxide, 38.3 per cent; manganese protoxide, 61.7 per cent. The color is much like that of rhodonite (see p. 314), from which, however, it is readily distinguishable by its rhombohedral form, inferior hardness (3.5 to 4.5), and property of dissolving with effervescence in hot hydrochloric acid, while rhodonite is scarcely at all attacked. The mineral is a common constituent of the gangue of gold and silver ores, as at Butte, Montana; Austin, Nevada, etc. (Specimen No. 26745, U.S.N.M.) So far as known the mineral has as yet no commercial value.

7. NATRON, THE NITRUM OF THE ANCIENTS.

This is a hydrous sodium carbonate; $\text{Na}_2\text{CO}_3 + 10\text{H}_2\text{O}$, = carbon dioxide, 15.4 per cent; soda, 21.7 per cent; water, 62.9 per cent. Occurs in nature, according to Dana, only in solution, as in the soda lakes of Egypt and elsewhere, or mixed with other sodium carbonates. The artificially crystallized material is of white color when pure, soft and brittle, and with an alkaline taste. Crystals, thin, tabular, monoclinic. Thermonatrite, also a hydrous sodium carbonate of the formula $\text{Na}_2\text{CO}_3 + \text{H}_2\text{O}$ = carbon dioxide, 35.5 per cent; soda, 50 per cent, and water 14.5 per cent, occurs under similar conditions, and is considered as derived from natron as a product of efflorescence. (See further under Sodium sulphates, p. 405.)

¹Journal of the Society of Chemical Industry, III, 1884, p. 33.

8. TRONA; URAO.

This is a hydrous sodium carbonate, corresponding to the formula $\text{Na}_2\text{CO}_3 \cdot \text{HNaCO}_3 + 2\text{H}_2\text{O}$, = carbon dioxide, 38.9 per cent; soda, 41.2 per cent; water, 19.9 per cent.

Found in nature as an efflorescence or incrustation from the evaporation of lakes, particularly those of arid regions. W. P. Blake has recently described¹ crude carbonate of soda (Trona) occurring in the central portion of a basin-shaped depression or dry lake in southern Arizona, near the head of the Gulf of California. The deposit covers an area of some 60 acres to a depth of from 1 to 3 feet, the lower portion being saturated with water from a solution so strong that when exposed to the air soda is deposited at the rate of an inch in thickness for every ten days. In its native condition the soda is naturally somewhat impure, from silt blown in from the surrounding land. The analysis given below shows the general average:

Sand, silt, etc	13.00
Iron oxides and alumina.....	2.80
Lime	1.14
Salt (NaCl?)	4.70
Sulphate of soda	4.70
Carbonate of soda	73.66
	<hr/> 100.00

See further under Thernardite, p. 415.

VI. SILICATES.

1. FELDSPARS.

The name feldspar is given to a group of minerals resembling each other in being, chemically, silicates of aluminum with varying amounts of lime and the alkalies potash and soda. All members of the group have in common two easy cleavages whereby they split with even, smooth, and shining surfaces along planes inclined to one another at angles of nearly if not quite 90° . (Specimen No. 67361, U.S.N.M.) They vary from transparent through translucent to opaque, the opaque form being the more frequent. In colors they range from clear and colorless through white and all shades of gray to yellowish, pink and red, more rarely greenish.

On prolonged exposures to the weather they become whitish and opaque, gradually decomposing into soluble carbonates of lime and the alkalies, and soluble silica, any one of which may be wholly or in part removed by percolating waters, leaving behind a residual product, consisting essentially of hydrous silicates of alumina, to which the names kaolin and clay are given (see p. 325). The hardness of the feldspars varies from 5 to 7 of Dana's scale; specific gravity 2.5 to 2.8.

¹ Engineering and Mining Journal, LXV, 1898, p. 188.

They are fusible only with difficulty, and with the exception of the mineral quartz are the hardest of the common light-colored minerals. From quartz they are readily distinguished by their cleavage characteristics noted above. Geologically the feldspars belong to the gneisses and eruptive rocks of all ages, certain varieties being characteristic of certain rocks and furnishing important data for schemes of rock classification. Nine principal varieties are recognized, which on crystallographic grounds are divided into two groups. The first, crystallizing in the monoclinic system, including only the varieties orthoclase and hyalophane; the second, crystallizing in the triclinic system, including microcline, anorthoclase, and the albite-anorthite series, albite, oligoclase, andesine, labradorite, and anorthite. The above-mentioned properties are set forth in the accompanying table.

Constituents.	Orthoclase.	Hyalophane.	Microcline.	Anorthoclase.	Albite.	Oligoclase.	Andesine.	Labradorite.	Anorthite.
Silica SiO_2	64.7	51.6	64.7	66.0	68.0	62.0	60.0	53.0	43.0
Alumina Al_2O_3	18.4	21.9	18.4	20.0	20.0	24.0	26.0	30.0	37.0
Potash K_2O	16.9	10.1	16.9	5.0	.....	.....	.....	.....	.....
Soda Na_2O} .....	.....	.....	.....	8.0	12.0	9.0	8.0	4.0	.....
Barite BaO} .....	.....	16.4	.....	.....	.....	.....	.....	.....	.....
Lime CaO} .....	.....	.....	.....	.....	.....	5.0	7.0	13.0	20.0
Specific gravity	2.4-2.6	2.8	2.4-2.6	2.0-5.8	2.5-2.6	2.56-2.7	2.6-2.7	2.6-2.7	2.6-2.8
Hardness	6.0-6.5	6.0-6.5	6.0-6.5	.....	6.0-7.0	6.0-7.0	5.0-6.0	6.0	6.0-7.0
Crystalline system...	Monoclinic.		Triclinic.						

Of the above those which most concern us here are the potash feldspars orthoclase and microcline, two varieties which for our purposes are essentially identical, both as regards composition and general physical properties as well as mode of occurrence. Indeed, although crystallizing in different systems they are as a rule indistinguishable but by microscopic means or by careful crystallographic measurements.

Occurrence.—The feldspars are common and abundant constituents of the acid rocks—such as the granites, gneisses, syenites—the orthoclase and quartzose porphyries, and the tertiary and modern lavas—such as trachyte, phonolite, and the liparites.

Among the older rocks they not infrequently occur in large veins or dike-like masses of coarse pegmatitic crystallization, the individual crystals being in some cases a foot or more in diameter. The associated minerals are quartz and white mica, with beryl, tourmaline, garnet, and a great variety of rarer minerals. The ordinary white mica of commerce comes from deposits of this nature and often the two minerals are mined contemporaneously. Such of our feldspars as have yet been worked for economic purposes occur associated only with the older rocks—the granites and gneisses of the Archean and Lower Paleozoic formations.

Near Topsham, Maine, is one of these pegmatitic veins, running

parallel with the strike of the gneissoid schists in which it lies, i. e. northeast and southwest. The vein material is quartz, feldspar, and mica. The quarry, as described by R. L. Packard, is in the form of an open cut in the hillside, being some 300 feet long by 100 feet wide, and of very irregular contours. The present floor and the sides of the cut are of feldspar (Specimen No. 61086, U.S.N.M.), containing irregular bodies of quartz and mica, the first named occurring in large masses entirely free from other minerals, though a second grade is taken out which is in reality an intimate mixture of quartz and feldspar.

The quartz occurs, besides as mentioned above, in the form of irregular bodies, sometimes 6 or 8 feet across and 15 feet or more long. It also occurs in cavities, or geodes, in the form of flattened crystals (Specimen No. 61085, U.S.N.M.). The mica is here of little economic importance, being found in the mass of the feldspar and along the seams in the form of narrow, lanceolate masses, often arranged in small radiating conical forms with their apexes outward.

The principal feldspar quarries thus far worked are in the Eastern United States, from Maine to New Jersey. The material is mined from open cuts, being blasted out with powder and separated from adhering quartz, mica, and other minerals by hand, after which it is shipped in the rough to the potteries, or in some cases ground and bolted in the near vicinity. In Connecticut the material has in times past been ground by huge granite disks mounted like the wheels of a cart on an axle through the center of which extended a vertical shaft. By the slow revolution of this shaft the wheels traveled around in a limited circle over a large horizontal granite slab. The pieces of spar being placed upon the horizontal slab were thus slowly ground to powder, after which it was bolted and sacked. The modern method of pulverizing is by means of the so-called "Cyclone" crusher. The value of the uncrushed material delivered at the potteries is but a few dollars a ton. Hence, while there are unlimited quantities of the material in different parts of the Appalachian region, but few are so situated as to be profitably worked.

Uses.—The feldspars are used mainly for pottery, being mixed in a finely pulverized condition with the kaolin or clay. When subjected to a high temperature the feldspar fuses, forming a glaze and at the same time a cementing constituent. There are other substances more readily fusible which are utilized for this purpose in the cheaper kinds of ware, but it is stated that in the highest grades of porcelain, as those of Sevres, feldspar is the material used. The proportions used vary with different manufacturers, each having adopted a formula best adapted for his own workings.

2. MICAS.

Under this head are comprised a number of distinct mineral species, alike in crystallizing in the monoclinic system and having a highly

perfect basal cleavage, whereby they split readily into thin, translucent to transparent, more or less elastic sheets. Chemically they are in most cases orthosilicates of aluminum with potassium and hydrogen, and in some varieties magnesium, ferrous, and ferric iron, sodium, lithium, and more rarely barium, manganese, titanium, and chromium. Seven species of mica are commonly recognized, of which but three have any commercial value, though a fourth form, lepidolite, may perhaps be utilized as a source of lithia salts. Of these three forms, the white mica, muscovite, and the pearl gray, phlogopite, are of greatest importance, the black variety, biotite, being but little used. Muscovite, or potassium mica, is essentially a silicate of aluminum and potassium, with small amounts of iron, soda, magnesia, and water. Its color is white to colorless, often tinted with brown, green, and violet shades. When crystallized it takes on hexagonal or diamond-shaped forms, as do also phlogopite and biotite as shown in samples (Specimens Nos. 62377 and 30763, U.S.N.M.). Its industrial value lies in its great power of resistance to heat and acids, its transparency, and its wonderful fissile property, in virtue of which it may be split into extremely thin, flexible sheets. It has been stated, though I know not how correctly, that sheets but one two hundred and fifty thousandths ($1/250000$) of an inch in thickness have been obtained. Phlogopite, or magnesian mica, differs from muscovite in being of a darker, deep pearl gray, sometimes smoky, often yellowish, brownish red, or greenish color. Biotite, or magnesia iron mica, differs in being often deep, almost coal black and opaque in thick masses, though translucent and of a dark brown, yellow, green, or red color in thin folia. It further differs from the preceding in that its folia are less elastic, and the sheets of smaller size. Lepidolite, a lithia mica, is much more rare than either of the above, is of a pale rose or pink color, folia usually of small size, commonly occurring in scaly granular forms without crystal outlines. The following table will serve to show the varying composition of the four varieties mentioned:

Variety.	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	FeO	MgO	CaO	K ₂ O	Na ₂ O	F.	H ₂ O
Muscovite.....	45.71	36.57	1.19	1.07	0.71	0.46	9.22	0.79	0.12	4.83
	44.48	35.70	1.09	1.07	Trace.	0.10	9.77	2.41	0.72	5.50
	45.40	33.66	2.36	.....	1.86	.....	8.33	1.41	0.69	5.46
Phlogopite.....	39.66	17.00	0.27	0.20	26.49	.....	9.97	0.60	2.24	2.99
	43.00	13.27	1.71	.....	27.70	.....	10.32	0.30	5.67	0.78
	40.64	14.11	2.28	0.69	27.97	.....	8.16	1.16	0.82	3.21
Biotite.....	44.94	31.69	4.75	3.90	.....	.....	8.00	0.59	0.93	3.85
	34.67	30.09	2.42	16.99	1.98	.....	7.55	1.57	0.28	4.64
	39.30	16.95	0.48	8.45	21.89	0.82	7.79	0.49	0.89	4.02
Lepidolite.....	40.16	15.79	2.53	4.12	26.15	.....	7.64	0.37	.....	3.58
	50.39	28.19	.....	.....	5.08	Li ₂ O	12.34	.....	5.15	2.36
	49.62	27.30	0.31	0.07	4.34	Li ₂ O	11.19	2.17	5.45	1.52

Although the basal cleavage which permits of the ready splitting of the mica into thin sheets is the only one sufficiently developed to be of economic importance, the mica as found is often traversed by sharp lines of separation, called gliding planes, which may, by their abundance, be disastrous to the interests of the miner. Such partings, or gliding planes, supposed to be induced by pressure, are developed at angles of about $66\frac{1}{2}^{\circ}$ with the cleavage, and may cut entirely through a block or extend inward from the margin only a short distance and come to an abrupt stop. In many cases the mica is divided up into long narrow strips, from the breadth of a line to several inches in thickness, with sides parallel, and as sharply cut as though done with shears. (Specimens Nos. 62517, 63134, U.S.N.M.)

The imperfections in mica are due to inclosures of foreign minerals, as flattened garnets, to the presence of free iron oxides, often with a most beautiful dendritic structure, to the partings or gliding planes noted above, and to crumplings and V-like striations which destroy its homogeneity. (Specimens Nos. 63139, 44450, U.S.N.M.)

Occurrence.—Mica in quantity and sizes to be of economic importance is found only among the older rocks of the earth's crust, particularly those of the granite and gneissoid groups. Muscovite and biotite are among the commonest constituents of siliceous rocks of all kinds and ages, while phlogopite is more characteristic of calcareous rocks. It is, however, only when developed in crystals of considerable size in pegmatitic and coarsely feldspathic veins, or, in the case of phlogopite, in gneissic and calcareous rocks associated with eruptive pyroxenites, that it becomes available for economic purposes. The associated minerals are almost too numerous to mention. The more common for muscovite are quartz and potash feldspar, which form the chief gangue materials in crystals and crystalline masses, sometimes a foot or more in diameter. With these are almost invariably associated garnets, beryls, and tourmalines, with more rarely cassiterite, columbite, apatite, fluorite, topaz, spodumene, etc. Indeed, so abundant are, at times, the accessory minerals in the granitic veins, and so perfect their crystalline development, that they furnish by far the richest collecting grounds for the mineralogists. Of these minerals the quartz and feldspars are not infrequently contemporaneously with the mica and utilized in the manufacture of pottery and abrasives.

The origin of these pegmatitic veins is a matter of considerable doubt. The finer grained pegmatites are, in certain cases, undoubted intrusives, though to some authorities it seems scarcely possible that the extremely coarse aggregates of quartz, feldspar, and mica, with large garnets, beryls, and tourmalines, can be a direct result of cooling from an igneous magma. To such it seems more probable that they are portions of an original rock mass altered by exhalations of fluor-

hydric acids, like the Saxon "greisen." Others regard them as resulting from the very slow cooling of granitic material injected in a pasty condition, brought about by aqueo-igneous agencies, into rifts of the preexisting rocks. It must be remembered that the high degree of dynamic metamorphism which these older rocks have undergone render the problems relating to their origin extremely difficult.

Localities.—From what has been said regarding occurrences, it is evident that mica deposits are to be looked for only in regions occupied by the older crystalline rocks. In the United States, therefore, we need only look for them in the States bordering immediately along the Appalachian range and in the Granitic areas west of the front range of the Rocky Mountains.¹ In the Appalachian region south of Canada mica mines, worked either for mica alone or for quartz and feldspar in addition, have from time to time been opened in various parts of Maine, New Hampshire, Connecticut, Maryland, Virginia, North Carolina, and perhaps other States, but in none of them, with the exception of New Hampshire and North Carolina, has the business proven sufficiently lucrative to warrant continuous and systematic working. Indeed, were it not for the increased demand lately arising for the use of mica in electrical machines it is doubtful if any but the most favorably situated mines would remain longer in operation in the United States. This for the reason not so much that foreign mica is better as that it is cheaper.

In Maine muscovite has been mined in an intermittent manner along with quartz and feldspar at the well-known mineral localities at Paris Hill and Rumford, Oxford County; Auburn, Androscoggin County; Topsham, Sagadahoc County; Edgecomb, Lincoln County, and other counties in the southeastern part of the State. In New Hampshire the industry has assumed greater importance. The mica-bearing belt is described by Prof. C. H. Hitchcock as usually about 2 miles in width, and extending from Easton, in Grafton County, to Surry, in Cheshire County; being best developed about the towns of Rumney and Hebron. The mica occurs in immense coarse granite veins in a fibrolitic mica schist (Specimen No. 63029, U.S.N.M.) of Montalban age, and is found in sheets sometimes a yard in length, but the more common sizes are but 10 or 12 inches in length. Immense beryls, sometimes a yard in diameter, and beautiful large tourmalines occur among the accessory minerals. Mines for mica were opened at Grafton as early as 1840, and as many as six or eight mines have been worked at one time, though by no means continually. Other mines have been worked in Groton, Alexandria, Grafton, and Alstead, in Grafton County; Acworth and Springfield, Sullivan County; Marlboro, Cheshire County; New Hampton, Belknap County, and Wilmot, Merrimack County, though only those of Groton are in operation at date of writing (1894).

¹ The region of the Black Hills of South Dakota is an important exception.

As seen by the writer, the veins at the latter place cut sharply across the fibrolitic schist, and though the vein materials adhere closely to the wall rock on either side, without either selvage or slickensides, still the line of demarcation is perfectly sharp. There seems no room for doubt but that the vein material was derived by injection from below, though from their extremely irregular and universally coarsely crystalline condition we must infer that the condition of the injected magma was more in the nature of solution than fusion, as the word is ordinarily used, and also that the rate of cooling and consequent crystallization was very slow. The feldspars not infrequently occur in huge crystalline masses several feet in diameter, though sometimes more finely intercrystallized with quartz in the form known as pegmatite. [Specimen No. 62519, U.S.N.M.] The mica is by no means disseminated uniformly throughout the vein, but on the contrary is very sporadic, and the process of mining consists merely in following up the mineral wherever indications as shown in the face of the quarry are sufficiently promising. Most of the mines are in the form of open cuts and trenches, though in a few instances underground cuts have been made for a distance of a hundred feet or more. The mica blocks as removed are of a beautifully smoky-brown color, and often show a distinct zonal structure, indicating several periods of growth. The associated feldspar is not in all cases orthoclase, but, as at the Alexandria mines, sometimes a faintly greenish triclinic variety.

Samples of the New Hampshire micas, with the accompanying gangue and wall rocks, are shown in Specimens Nos. 62515 to 62519 and 63028 to 63030, U.S.N.M.

In Connecticut some mica (muscovite) has been obtained in connection with the work of mining feldspar and quartz in and about the towns of Haddam, Glastonbury, and Middletown, but the business has never assumed any importance. Mica mines have also been worked in Montgomery County, Maryland. South of the glacial limit mica mining has proven more successful from the reason that the gangue minerals (feldspar and quartz) were in a state of less compact aggregation, due to weathering, the feldspar being often reduced to the state of kaolin, and hence readily removed by pick and shovel. The following account of the deposits of North Carolina is given by Prof. W. C. Kerr:¹

I have stated elsewhere, several years ago, that these veins were wrought on a large scale and for many ages by some ancient peoples, most probably the so-called Mound Builders; although they built no mounds here, and have left no signs of any permanent habitation. They opened and worked a great many veins down to or near water-level; that is, as far as the action of atmospheric chemistry had softened the rock so that it was workable without metal tools, of the use of which no signs are apparent. Many of the largest and most profitable of the mines of the present day are simply the ancient Mound Builders' mines reopened and pushed into the hard undecomposed granite by powder and steel. Blocks of mica have often been found half imbedded in the face of the vein, with the tool-marks about it, showing the exact limit of the efficiency of those prehistoric mechanical appliances. As to the geological relations of these veins, they are found in the gneisses and schists of the Archæan horizons. * * * These rocks are of very extensive occurrence in North Carolina, constituting in fact the great body of the rocks throughout the whole length of the State,—some 400 miles east and west,—being partially covered

¹Transactions of the American Institute of Mining Engineers, VIII, 1880, p. 457.

up, and interrupted here and there by belts of later formation. Mica veins are found

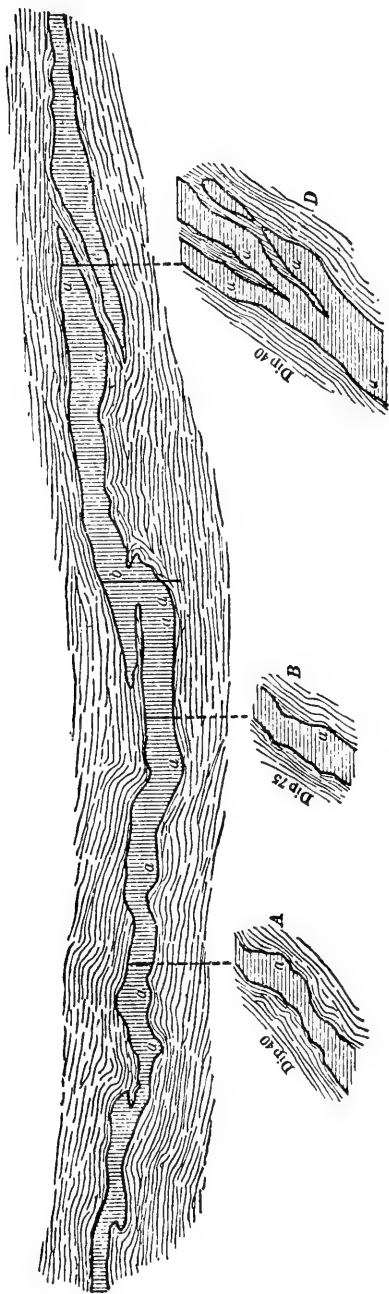


Fig. 9.

SECTION OF MICA VEINS IN YANCEY COUNTY, NORTH CAROLINA.

After W. C. Kerr.

here, in fact may be said to characterize this horizon everywhere, from its eastern outcrop, near the seaboard, to and quite under the flanks of the Smoky Mountains. It is, however, in the great plateau of the west, between the Blue Ridge and the Smoky, that the mica veins reach their greatest development, and have given rise to a very new and profitable industry,—new and at the same time very old.

It may be stated as a very general, almost universal, fact, that the mica vein is a *bedded* vein. Its position (as to strike and dip) is dependent on and controlled by, and quite nearly conformable to, that of the rocks in which it occurs, and hence, as well as on account of their great size, some observers, accustomed to the study of veins and dikes and the characters of intrusive rocks in other regions, have been disposed to question the vein character of these masses at first. But a good exposure of a single one of them is generally sufficient to remove all doubt on this score. The mica vein is simply and always a dike of *very coarse granite*. It is of any size and shape, from a few inches—generally a few feet—to many rods (in some cases several hundred feet) in thickness, and in length from a few rods to many hundred yards, extending in some cases to half a mile or more. The strike, like that of the inclosing rocks, is generally northeast, and the dip southeast, at a pretty high angle; but they are subject, in these respects, to many and great local variations, all the conditions being occasionally changed, or even reversed. An idea may be formed of the coarseness of these veins from this statement, that the masses of cleavable feldspar and of quartz (limpid, pale yellow, brown, or, more generally, slightly smoky),

and of mica, are often found to measure several yards in two or three of their dimensions, and weighing several tons. I have a feldspar *crystal* from one of these mines

of nearly a thousand pounds weight, and I have known a single block of mica to make two full two-horse wagon-loads, and sheets of mica are sometimes obtained that measure three and four feet in diameter.

There are many peculiarities about these veins. Among the most important, in a practical sense, is the arrangement of the different constituents of the vein *inter se*. Sometimes the mica, for example, will be found hugging the hanging-wall; sometimes it is found against both walls; again it may be distributed pretty equally through the whole mass of the vein; sometimes, again, it will be found collected in the middle of the vein; in other cases, where the vein varies in thickness along its course, the mica will be found in bunches in the ampullations, or bellies, of the vein; in still other cases, where the vein has many vertical embranchments, the mica will be found accumulated in nests along the upper faces of these processes or offshoots. Those features of structure will be best understood from a few representative diagrams.

Figure 9 is a horizontal section, with several transverse vertical sections, of a typical vein in Yancey County, at the Presnel Mine. The length of the section, i. e., of the portion of the vein that has been stripped, is 125 feet; the thickness varies from 3 to 10 feet, except at a few points, as *b c* where it is nearly 20 feet.

The crystals of mica are found in this mine generally near the foot wall, in the recesses or pouches; at *c*, however, as seen in section D, it is found next the hanging-wall.

The inclosing rock in this case is a hard, gray slaty to schistose gneiss. * * *

The feldspar, which constitutes the larger part of the mass of these veins, is often found converted into beds of the finest kaolin; and, curiously enough, this was one of the first and most valuable exports to England in the early part of the seventeenth century, "packed" by the Indians out of the Unaka (Smoky) Mountains, and sold under the name "unakeh" (white). This kaolin, like the mica, will doubtless soon come again into demand, after lying forgotten for generations.

Characteristic samples of the micas of the region are shown in Specimens Nos. 18205, 18207, 62962, and 62964, U.S.N.M.

In Alabama, along a line stretching from Chilton County, north-east, through Coosa, Clay, and Cleburne counties, there are numerous evidences of prehistoric mica mining. Many pits are met with around which pieces of mica are still to be seen. In some places, just as in Mitchell County, North Carolina, large pine trees have grown up on the débris, so that a considerable time must have elapsed since the mines were worked. About ten years ago, Col. James George, of Clanton, Chilton County, prospected for mica, and some fairly good specimens were obtained, but the investigations were not continued. It is not thought that any mica has been marketed from Alabama. The indications of good mica along the line mentioned are, however, sufficient to warrant additional and more extended examinations. Little mica is reported from other Southern States, though some mines have been opened in South Carolina, Georgia (Specimens Nos. 63139 to 63141, U.S.N.M.), Virginia, and West Virginia. In 1881, a mica mine was opened in Anderson County, South Carolina, and some miners from Mitchell County, North Carolina, employed. The enterprise was not successful, and the miners returned home shortly afterwards. Good mica has been found in South Carolina, notably in Anderson, Oconee, and Pickens counties. The mica-bearing rocks of western North Caro-

lina do not protrude into Tennessee, except at intervals, and then only for short distances. Some prospecting has been done in Tennessee near Roan Mountain, but the results were not considered satisfactory.¹

In Colorado mica has long been known to be widely disseminated and to occur in many places in bodies of workable size, but mining has until lately always proved the mica to be "plumose" and unfit for cutting into sheets. Many mines have been located, but the product has always proved worthless, until in the summer of 1884 the Denver Mica Company opened a mine near Turkey Creek, about 35 miles from Denver. This mica is of fair quality, and quite a considerable quantity of it has been mined. It is slightly brown and the largest plates which have yet been cut are not more than $2\frac{3}{4}$ by 6 inches in size. Only an extremely small percentage of the gross weight is available for cutting into sheets. An effort is being made to put it upon the market, and at present four workmen are employed in trimming the sheets. Mica of good quality and in large plates has also been recently reported from the neighborhood of Fort Collins.

In Wyoming, mica has been found in workable quantities near Diamond Park and in the Wind River country, as well as at many points along the mountain ranges in Laramie County. It has recently been mined to some extent at Whalen cañon, 20 miles north of Fort Laramie, and some of the product has been shipped to the Eastern market.

In New Mexico mica occurs near Las Vegas, and reports of shipments have been published. At Petaca, the Cribbenville mica mines are being worked at present by sixteen men. Work was commenced at these mines July 2, 1884, and the amount of excavation at present is 13,160 cubic feet. The plates cut range from 2 by 2 inches to 5 by 8 inches in size. Some specimen plates have been cut 10 by 12 inches, but the general average is about $3\frac{1}{2}$ by $4\frac{1}{2}$ inches. Some 12 tons of mica have been handled, but the amount sold and the average price obtained are not reported. Other localities in New Mexico also yield mica, but none have been developed, except the two above mentioned. (Specimen No. 61335, U.S.N.M.).

In California many deposits of mica have been noted, especially at Gold lake, Plumas county; in Eldorado county; Ivanpah district, San Bernardino county; near Susanville, Lassen county, and at Tehachapi pass, Kern county. In 1883 a large deposit was discovered in the Salmon mountains, in the northwestern part of the State, and some prospecting was done.²

The mica-bearing deposits of the Black Hills of South Dakota have been variously regarded by different observers as intrusive granites or true segregation veins lying parallel to the apparent bedding. New-

¹ Mineral Resources of the United States, 1887, p. 671.

² Idem, 1883-84, p. 911.

ton and Jenny,¹ Blake,² and Vincent regard them as intrusive, while Carpenter³ and Crosby⁴ hold the opposite view.

According to Blake the mica occurs in granitic masses, remarkable for the coarseness of their crystallization, the constituent minerals being usually large and separately segregated. "Large masses of pure quartz are found in one place and masses of feldspar in another, and the mica is often accumulated together instead of being regularly disseminated through the mass. It also occurs in large masses or crystals, affording sheets broad enough for cutting into commercial sizes." Associated with the mica at this point are the minerals quartz and feldspar, mainly a lamellar albite (Clevelandite), which form the gangue, and irregularly disseminated cassiterite (tinstone), gigantic spodumenes, black tourmalines, and, in small quantities, black mica, beryls, garnets, columbite, and a variety of phosphatic minerals, such as apatite, triphylite, etc.

In Nevada mines have been worked in the St. Thomas mining district, Lincoln County, the mica occurring in hard, glassy quartz rock forming an outcrop some 200 feet wide by 600 feet long in gneiss and schists. At the Czarina Mine, located in May, 1891, near Rioville, the mica occurs under similar conditions. The mineral seems to follow the division plane of the stratification, along the line or axis of fold. This line runs north and south, slightly east of north of the main trend of the range, thus running into Arizona a few miles north of Rioville. In fact, the mica belt forms the boundary line between Nevada and Arizona for 50 miles. The mica, mostly small, is abundant, but marketable sizes are rare, and not to be had without a great deal of hard work.⁵

Merchantable mica has been reported on the Payette River and Bear Creek, in the Cœur d'Alene region of Idaho, and also in Oregon and Alaska.

According to Mr. R. W. Ells⁶ the Canadian micas of commercial importance occur associated with eruptive dikes of pyroxenite and pegmatite cutting the Laurentian gneisses. More rarely, as in the Gatineau area, they are found where dikes of the pyroxenite cut the limestone. This authority gives the condition of occurrence as below:

1. In pyroxene intrusive rocks which either cut directly across the strike of greyish or other colored gneisses or are intruded along the line of stratification. Some of these deposits have been worked downward along the contact with the gneiss, where the mica is most generally found, for 250 feet, as at the Lake Girard Mine, and irregular masses of pink calcite are abundant. In certain places apatite crystals

¹ Geology of the Black Hills of Dakota, Monograph, U. S. Geological Survey, 1880.

² Engineering and Mining Journal, XXXVI, 1883, p. 145.

³ Transactions of the American Institute Mining Engineers, XVII, 1889, p. 570.

⁴ Proceedings of the Boston Society of Natural History, XXIII, 1884-1888, p. 488.

⁵ Mineral Resources of the United States, 1893, p. 754.

⁶ Bulletin of the Geological Society of America, V, 1894, p. 484.

occur associated with the mica, but at other times these are apparently wanting. As in the case of apatite deposits, mica occurring in this condition would apparently be found at almost any workable depth.

2. In pyroxene rocks near the contact of cross-dikes of diorite or feldspar, the action of which on the pyroxene has led to the formation of both mica and apatite. Numerous instances of this mode of occurrence are found, both in the mines of apatite and mica, the deposits of the latter in certain areas being quite extensive and the crystals of large size.

3. In pyroxene rock itself distinct from the contact with the gneiss. In these cases the mica crystals, often of large size but frequently crushed or broken, apparently follow certain lines of faults or fracture. Some of these deposits can be traced for several yards, but for the most part are pockety. Some of these pyroxene masses are very extensive, as in the case of the Cascade mine on the Gatineau river and elsewhere in the vicinity. In these cases calcite is rarely seen and apatite is almost entirely absent. When cut by cross-dikes conditions for the occurrence of mica or apatite should be very favorable.

4. Dikes of pyroxene, often large, cutting limestone through which subsequent dikes of diorite or feldspar have intruded as in Hincks township. The crystals occurring in the pyroxene near to the feldspar dikes are often of large size and of dark color, resembling in this respect a biotite mica.

The mica found under the conditions stated above, in one, two, three, and four is all amber-colored and of the variety known as phlogopite, or magnesia mica. [Specimens Nos. 30763, 62149, U.S.N.M.]

5. In feldspathic-quartzose rocks which constitute dikes often of very large size, cutting red and greyish gneiss, as at Villeneuve and Venosta. These are distinct from the smaller veins of pegmatite which occur frequently in the gneiss as the anorthosite areas are approached. In this case the mica is muscovite or potash mica and is invariably found in that portion of the dike near the contact with the gneiss. The crystals frequently are of large size and white in color, associated with crystals of tourmaline, garnet, et cetera, but with no apatite, unless pyroxene is also present.

6. In quartz-feldspar dikes cutting crystalline limestone, in which case the crystals are generally of small size, mostly of dark color and of but little value.

In the case of the amber micas this peculiarity was noted that when the pyroxene was of a light shade of greenish gray and comparatively soft, the mica was correspondingly light colored and clear, and in some places almost approached the muscovite in general appearance. As the pyroxene became darker in color and harder in texture, the mica assumed a correspondingly darker tint and a brittle or harder character, and in certain cases where dikes of blackish hornblendic diorite were present the mica also assumes a black color as well.

The chief Canadian localities, as given by the authority quoted, are as below:

Along the Ottawa River it is found from a point nearly 100 miles west of Ottawa to the township of Greenville, 60 miles east of that city, while on the Gatineau River, which flows into the Ottawa at the city of Ottawa, mines have been located and worked for 80 miles north from its mouth, and the mineral is reported from points many miles farther north along that stream. To the east of Quebec it is known on the branch of the Saguenay called the Manouan and in the townships of Escoumains, Bergeronnes, and Tadoussac, situated east of the mouth of that river, as well as at several other places along the river St. Lawrence. The mica found in this last district is chiefly muscovite.

The principal areas where mica is at present worked are in the belt which extends from North Burgess, in the Province of Ontario, approximately along the strike of the gneiss, into the territory adjacent to the Gatineau and Lievre. Over much of this

area south of the Ottawa River the Laurentian is concealed by the mantle of Cambro-Silurian rocks belonging to the Ottawa River basin, but it may be said that the geologic conditions and the stratigraphic sequence in the area south of the Ottawa and in the rear of Kingston are the same as those found in the mineral-bearing belts north of the Ottawa, and that the most favorable conditions under which the deposits of mica and apatite may be looked for where traces of igneous agency are visible in the presence of dikes of pyroxene and quartz feldspar, though it should be stated that the mere occurrence of these in the gneiss does not warrant the presence of either of these minerals.

The India mica mines occur in coarse intrusive pegmatitic-granite dikes, cutting what is known as the "newer gneiss" of Singrauli. At Inikurti the crystals (of mica) are as much as 10 feet in diameter. Sheets 4 or 5 feet across have been obtained free from adventitious inclusions which would spoil their commercial value.¹

Black mica (biotite, lepidomelane, etc.) is a much more common and widely distributed variety than the white, but unlike the latter is found not so much in veins as an original constituent disseminated in small flakes throughout the mass of eruptive and metamorphosed sedimentary rocks. The small sizes of the sheets, their color, and lack of transparency render the material as a rule of little value. In Renfrew County, Canada, the mineral occurs in large cleavable masses, which yield beautiful smoky-black and greenish sheets sufficiently elastic for industrial purposes (Specimens Nos. 62735, 62709, U.S.N.M.).

Lepidolite.—This variety of mica is much more rare than any of the others described. While in a few instances it has been reported as accompanying muscovite in certain granites, as those of Elba and Schaistausk, its common form of occurrence is in the coarse pegmatitic veins already described, where it is associated with muscovite, tourmalines, and other minerals of similar habit. As a rule it is readily distinguished from other micas by its beautiful peach-blossom red color, though sometimes colorless and to be distinguished only by the lithia reaction.² The folia are thicker than those of muscovite and of small size, the usual form being that of a scaly granular aggregate. At Auburn, Maine, it is found both in this form (Specimen No. 61079, U.S.N.M.) and forming a border a half inch, more or less, in width about the muscovite folia (Specimen No. 13810, U.S.N.M.). The more noted localities in the United States are Auburn, Androscoggin County; Hebron, Paris, Rumford (Specimen No. 63003, U.S.N.M.), and Norway, Oxford County, Maine, where it is associated with beautiful red and green tourmalines and other interesting minerals; Chesterfield, Massachusetts; Haddam, Connecticut (Specimen No. 53540, U.S.N.M.), and near San Diego, California (Specimen No. 62593, U.S.N.M.). The most noted foreign locality is Zinnwald, Saxony.

¹Geology of India, 2d ed., 1893, p. 34.

² The pulverized mineral when moistened with hydrochloric acid and held on a wire in the flame of a lamp imparts to the flame a brilliant lithia red color.

where the mineral occurs in large foliated masses together with quartz forming the gangue minerals of the tin veins. Also found in Moravia (Specimen No. 62580, U.S.N.M.).

Uses.—Until within a few years almost the only commercial use of mica was in the doors or windows of stoves and furnaces, the peep-holes of furnaces and similar situations where transparency and resistance to heat were essential qualities. To a less extent it was used in lanterns, and it is said, in the portholes of naval vessels, where the vibrations would demolish the less elastic glass. In early days it was used to some extent for window panes, and is, in isolated cases, still so used to some extent. For all these purposes the white variety muscovite is most suited. For use in stoves and furnaces "the mica is generally split into plates varying from about one-eighth to one sixty-fourth of an inch in thickness. In preparing these plates for market the first step is to cut them into suitable sizes. Women are frequently employed in this work, and do it as well as, if not better, than the men. The cutter sits on a special bench which is provided with a huge pair of shears, one leg of which is firmly fixed to the bench itself, while the movable leg is within convenient grasp.

The patterns according to which the mica is cut are arranged in a case near at hand. They are made of tin, wood, or pasteboard, according to the preference of the establishment. Generally they are simple rectangles, varying in size from about four square inches to eighty.

The cutter selects the pattern which will cut to the best advantage, lays it on the sheet of mica, and then, holding the two firmly together, trims off the edges of the mica to make it correspond to the pattern.

The cleaning process comes next. The cleaner sits directly in front of a window and must examine each sheet of cut mica by holding it up between her eyes and the light. If there be any imperfections, and there nearly always are, they must be removed by stripping off the offending layers of mica until a clear sheet remains.

Finally, the cut and cleaned mica is put up in pound packages and is ready for the market. There is an enormous waste in the processes of preparation. One hundred pounds of block mica will scarcely yield more than about fifteen pounds of cut mica, and sometimes it is even less. The proportion varies, of course, with different localities.¹ Professor Kerr states with reference to the North Carolina mines that there is a waste of from nine-tenths to nineteen-twentieths of the material, even in a good mine.

Mica being a nonconductor is of value for insulating purposes, and since the introduction of the present system of generating electricity there has arisen a considerable demand for it in the construction of dynamos and electric motors. For these purposes the mica must be

¹ Engineering and Mining Journal, LV, 1893, p. 4.

smooth and flexible, as well as free from spots or inequalities of any kind. It is stated that it should be sufficiently fissile to split into sheets not above three one-hundredths inch in thickness, and which may be bent without cracking into a circle of 3 inches diameter. Strips of various dimensions are used in building up the armatures, the more common sizes being about 1 inch wide by 6 or 8 inches long. Muscovite serves the purposes well, but is less used than phlogopite, the latter serving equally well, and being less desirable for stoves and furnaces. Black mica would doubtless serve for electrical purposes, could it be procured in sheets of sufficient size.

Mica scraps such as until within a few years have been thrown away as worthless are now utilized by grinding, the product being used for a variety of purposes, noted below. The material is as a rule ground to five sizes, such as will pass through sieves of 80, 100, 140, 160, and 200 meshes to the inch, respectively. The prices of this ground material vary from 5 to 10 cents a pound according to sizes. Large quantities of this ground material are used in the manufacture of wall paper, in producing the frost effects on Christmas cards, in stage scenery, and as a powder for the hair, being sold for the latter purposes under the name of diamond powder. The so-called French "silver molding" is said to be made from ground mica. It is also used as a lubricant, and as a nonconductor for steam and water heating; in the manufacture of door knobs and buttons. It is stated further that owing to its elasticity it can be used as an absorbent for nitroglycerin, rendering explosion by percussion much less likely to occur. Small amounts of inferior qualities are also mixed with fertilizers where it is claimed to be efficacious in retaining moisture. A brilliant and unalterable mica paint is said to be prepared by first lightly igniting the ground mica and then boiling in hydrochloric acid, after which it is dried and mixed with collodion, and applied with a brush. Owing to the unalterable nature of the material under all ordinary conditions, and the fact that it can be readily colored and still retain its brilliancy and transparency, the ground mica is peculiarly fitted for many forms of decoration. Much of the ground material now produced is stated to be sent to France.

The chief and indeed only use for lepidolite thus far developed is in the manufacture of the metal lithium and lithia salts.

Prices.—The total value of the cut mica produced annually in the United States during the past ten years has varied from \$50,000 to over \$360,000, while the value of the imports has varied between \$5,000 and \$100,000. The price of the cut mica, it should be stated, varies with the size of the sheets, the larger naturally bringing the higher price. The average price of the cut mica, all sizes, is not far from \$1 a pound, while the scrap mica is worth perhaps half a cent a pound. The dealers' lists, as published, include 193 sizes, varying

from $1\frac{1}{2}$ by 2 inches up to 8 by 10 inches, the prices ranging from 40 cents to \$13 a pound. For electrical work upward of 400 patterns are called for, the prices varying from 10 cents to \$2.50 a pound.

3. ASBESTOS.

The name asbestos in its original sense includes only a fibrous variety of the mineral amphibole; hence is a normal metasilicate of calcium and magnesium with usually varying amounts of iron and manganese and not infrequently smaller quantities of the alkalies. As is well known, the amphiboles crystallize in the monoclinic system in forms varying from short, stout crystals, like common hornblende, to long columnar or even fibrous forms, to which the names actinolite, tremolite, and asbestos are applied. The word asbestos is derived from the Greek *ασβεστος*, signifying incombustible, in allusion to its fireproof qualities. The name "amianthus" was given it by the Greeks and Romans, the word signifying undefiled, and was applied in allusion to the fact that cloth made from it could be readily cleansed by throwing it into the fire. As now used, this term is properly limited to fibrous varieties of serpentine. Owing to careless usage, and in part to ignorance, the name asbestos¹ is now applied to at least four distinct minerals, having in common only a fibrous structure and more or less fire and acid proof properties. These four minerals are: First, true asbestos; second, anthophyllite; third, fibrous serpentine (chrysotile), and, fourth, crocidolite. The true asbestos is of a white or gray color, sometimes greenish or stained yellowish by iron oxide. Its fibrous structure is, however, its most marked characteristic, the entire mass of material as taken from the ledge or mine being susceptible of being shredded up into fine fibers sometimes several feet in length. In the better varieties the fibers are sufficiently elastic to permit of their being woven into cloth. Often, however, through the effect of weathering or other agencies, the fibers are brittle and suitable only for felts and other nonconducting materials. The shape of an asbestos fiber is as a rule polygonal in outline and of a quite uniform diameter, as shown in the illustration (fig. 10); often, however, the fibers are splinter like, running into fine, needle-like points at the extremity. The diameters of these fibers is quite variable, and, indeed, in many instances there seems no practical limit to the shredding. Down to a diameter of 0.002 mm. and sometimes to even 0.001 mm. the fibers retain their uniform diameter and polygonal outlines. Beyond this, however, they become splinter like and irregular as above noted.

The mineral anthophyllite like amphibole occurs in both massive, platy, and fibrous forms, the fibrous form being to the unaided eye indistinguishable from the true asbestos.

¹Also spelled *asbestus*. The termination *os* seems most desirable when the derivation of the word is considered.

Chemically this is a normal metasilicate of magnesia of the formula $(\text{Mg}, \text{Fe}) \text{SiO}_3$, differing, it will be observed, from asbestos proper in containing no appreciable amount of lime. It further differs in crystallizing in the orthorhombic rather than the monoclinic system, a feature which is determinable only with the aid of a microscope.

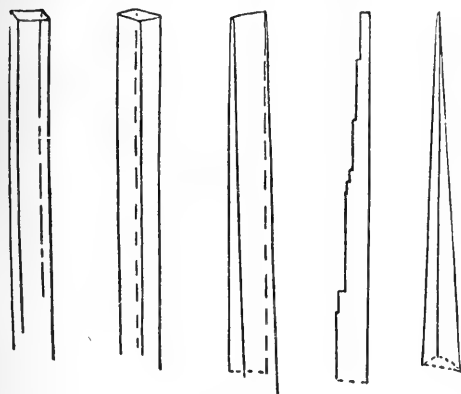


Fig. 10.
ASBESTOS FIBERS.
After G. P. Merrill.

The shape and size of the fibers is essentially the same as true asbestos. The fibrous variety of serpentine to which the name asbestos is commercially given is a hydrated metasilicate of magnesia of the formula $\text{H}_4\text{Mg}_3\text{Si}_2\text{O}_9$ with usually a part of the magnesia replaced by ferrous iron. It differs, it will be observed, from asbestos and anthophyllite in carrying nearly 14 per cent of combined water and from the first named in containing no lime. This mineral is in most cases readily distin-

guished from either of the others by its soft, silk-like fibers and further by the fact that it is more or less decomposed by acids. As found in nature the material is of a lively oil yellow or greenish color, compact and quite hard, but may be readily reduced to the fluffy, fibrous state by beating, handpicking, or running between rollers. The length of the fiber is quite variable, rarely exceeding 6 inches, but of very smooth uniform diameter and great flexibility.

The mineral crocidolite, although resembling somewhat fibrous serpentine, belongs properly to the amphibole group. Chemically it is anhydrous silicate of iron and soda, the iron existing in both the sesquioxide and protoxide states. More or less lime and magnesia may be present as combined impurities. The color varies from lavender blue to greenish, the fibers being silky like serpentine, but with a slightly harsh feeling. The composition of representative specimens of these minerals from various sources is given in the accompanying table.¹

¹From Notes on Asbestos and Asbestiform Minerals by George P. Merrill. Proceedings of the U. S. National Museum, XVIII, 1895, pp. 281-292.

Analyzes of asbestiform minerals.

No.	Locality.	Mineralogical nature.	Extinction angle.	SiO ₂	Al ₂ O ₃	FeO ₃	FeO	CaO	MgO	MnO	K ₂ O	Na ₂ O	Ign.	Totals.	Authority.
1	Salls Mountain, Georgia (61357).	Anthophyllite.	0	57.12	0.75	.....	6.36	.....	29.44	.....	(a)	(a)	5.47	99.14	R. L. Packard.
2	Nacoochee, Ga. (60842)	.....do	0	57.73	0.72	.....	8.61	0.08	28.77	.....	0.14	0.57	2.52	.....	Do.
3	Rabun County, Ga. (56351)	.....do	0	56.52	3.57	.....	10.08	Trace.	27.13	.....	(a)	(a)	2.96	100.26	Geo. P. Merrill.
4	Tallapoosa County (?), Ala.	.....do	0	55.92	3.69	11.00	.....	0.60	26.33	.....	(a)	(a)	2.40	99.94	Do.
5	Lenoir, Caldwell County, N. C.	.....do	0	56.21	2.78	.....	8.58	0.82	28.95	Trace.	(a)	(a)	2.23	99.31	Do.
6	Warrenton, Warren County, N. C. (62748).	.....do	0	57.00	.....	10.32	.....	Trace.	29.98	.....	(a)	(a)	2.29	99.59	Do.
7	Franklin, N. C. (44232)	.....do	0	54.79	.....	13.65	.....	.....	28.32	.....	(a)	(a)	2.55	99.51	Do.
8	Mitchell County, N. C. (50876)	.....do	0	59.00	0.91	.....	6.09	0.45	29.90	.....	0.43	0.68	2.55	99.81	R. L. Packard.
9	Alberton, Md. (62604)	.....do	0	56.75	1.54	.....	10.76	0.10	27.46	Trace.	(a)	(a)	2.88	99.49	Do.
10	Carbon County, Wyo. (62090)	.....do	0	54.56	1.47	.....	12.39	1.86	25.28	.....	(a)	(a)	2.95	99.51	Geo. P. Merrill.
11	San Diego, Cal. (67001)	.....do	0	57.31	1.57	.....	7.06	.....	30.24	.....	(a)	(a)	2.73	98.91	R. L. Packard.
12	Albemarle County, Va. (62550).	Amphibole, var. asbestos.	0-16	56.26	1.81	.....	6.40	11.98	20.85	Traces.	(a)	(a)	2.65	99.95	Do.
13	Parkton, Md. (8536)	.....do	0-15	56.96	0.52	.....	1.12	13.84	23.90	.....	(a)	(a)	2.37	98.71	Geo. P. Merrill.
14	Roanoke, Va. (5694)	.....do	0-15	55.81	1.66	.....	6.81	12.74	21.09	.....	.....	.....	1.81	99.92	R. L. Packard.
15	Chester, S. C. (73462)	.....do	0-15	54.66	3.72	.....	6.83	12.81	19.87	Traces.	(a)	(a)	2.88	100.17	Geo. P. Merrill.
16	Pylesville, Harford County, Md.	.....do	0-15	56.76	.....	.....	3.10	12.75	23.85	.....	(a)	(a)	2.68	98.94	Do.
17	Aston, Delaware County, Pa. (62754).	.....do	.....	53.42	.....	.....	.....	13.42	22.85	.....	(a)	(a)	4.36	98.05	Do.
18	Staten Island, New York	.....do	.....	52.50	.....	.....	11.82	.....	30.73	.....	.....	.....	2.25	100.0	Hintze, p. 1241.
19	Zillerthal, Tyrol	.....do	0-15	55.08	1.64	.....	4.57	14.65	22.56	0.81	.....	.....	2.39	100.4	Hintze, p. 1255 (av. of 4 det.).
20	Cow Flats, Bathurst, New South Wales (62450).	.....do	0-15	54.75	1.21	.....	2.79	13.99	22.93	Traces.	(a)	(a)	2.58	98.25	Geo. P. Merrill.
21	Corsica (82259)	.....do	0-17	56.72	0.545	.....	1.73	14.72	23.63	Traces.	(a)	(a)	2.33	99.67	Do.

22	Zillerthal	Amphibole, var. mountain cork.	57.20	.....	4.37	13.39	22.85	.....	2.43	100.24	Dana, p. 395.
23	Frankenstein, Silesia	Amphibole, var. asbestos.	57.69	.....	2.46	13.39	23.68	0.13	3.14	100.66	Do.
24	Cunsdorf, Saxony	do	57.98	0.58	6.32	12.95	22.38	.....	.....	100.21	Hintze, p. 1234.
25	Cow Sweden	do	59.75	.....	3.95	14.25	21.10	0.31	Fl. 1.16	100.52	Hintze, p. 1238.
26	Cow Flats, New South Wales	do	49.45	9.69	16.33	11.97	Trace.	4.39	.....	100.01	Hintze, p. 1240.
27	Bolton, Mass	do	58.80	.....	3.05	16.47	22.23	.....	.....	100.55	Hintze, p. 1242.
28	Malden, Mass	do	0-17 48.60	6.64	18.23	12.55	9.52	.....	2.85	98.39	Geo. P. Merrill.
29	Nahant, Mass	do	0-17 51.58	1.88	14.99	9.72	16.65	.....	4.98	99.8	R. L. Packard.
30	Mexico	do	0-20 55.48	2.01	12.32	10.35	17.23	.....	1.54	100.40	Bauer, Neues Jahrbuch, I, 1882, p. 159.
31	South Africa (50877)	Crocidolite	52.11	1.01	20.62	16.75	1.77	.....	6.16	1.58	Dana, p. 400.
32	Idaho (49521)	do	53.28	.....	.....	None.	22.87	.....	.....	19.53	Geo. P. Merrill.
33	Glen Urquhart, Scotland	Amphibole, var. asbestos.	47.721	3.837	0.176	5.741	28.745	0.159	0.186	0.264	M. F. Heddle.
34	The Balta, Scotland	do	56.153	1.539	0.388	3.111	11.716	0.769	0.188	0.692	Do.
35	Shinness, Sutherland, Scot- land	do	56.864	0.292	0.484	2.124	12.595	0.23	0.437	0.538	Do.
36	Portsoy, Scotland	do	56.307	0.77	0.527	2.323	23.307	0.153	0.439	0.633	Do.
37	Italy	Fibrous serpen- tine, amianthus.	0 40.30	.....	2.27	0.87	43.37	.....	.....	12.72	J. T. Donald.
38	Canada	do	0 40.57	.....	0.90	2.81	41.50	.....	.....	13.55	Do.
39	Victoria, British Columbia	do	0 41.95	.....	2.81	.....	41.62	.....	.....	14.85	Geo. P. Merrill.
40	Alberton, Md. (62778)	Hydrous antho- phyllite. (?)	0 51.84	.....	1.51	.....	24.54	(a)	0.25	0.45	Do.

b H₂O at 110°, 10.55 per cent; at bright, red heat, an additional loss of 9.63 per cent.

Mode of occurrence and origin.—Concerning the associations, occurrence, and origin of the fibrous structure of these minerals existing literature is strangely silent. It is known that all occur only in regions occupied by the older eruptive and metamorphic rocks. It is probable that in the fibrous forms the mineral is always secondary, and the fibrous structure due in part, at least, to shearing agencies; that is, to movements in the mass of a rock whereby a mineral undergoing crystallization would be compressed laterally and drawn out along a line of least resistance. This is, however, not the case with the fibrous varieties of serpentine, which undoubtedly result from the crystallization in preexisting fractures, or gash veins, of the serpentinous material. The process is evidently the same as that which is seen in studying, under the microscope, thin sections of olivine-bearing rocks which have undergone hydration. The asbestos in Alberene, in Albemarle County, Virginia (Specimen No. 62550, U.S.N.M.), occurs in thin, platy masses along slickensided zones in the so-called soapstone (altered pyroxenite) of the region, the fibers always running parallel with the direction of the movement which has taken place. At Alberton, Maryland, the fibrous anthophyllite (Specimen No. 62604, U.S.N.M.) occurs along a slickensided zone between a schistose actinolite rock and a more massive serpentinous or talcose rock, which is also presumably an eruptive peridotite or pyroxenite. The fibrillation here runs also parallel with the direction of movement as indicated by the slickensided surfaces.

Localities.—As already stated true hornblende asbestos occurs only in regions of eruptive and metamorphic rocks belonging to the paleozoic formations. The same is true of anthophyllite. Fibrous serpentine occurs sporadically with the massive forms of the same rock which is, so far as known, almost invariably an altered eruptive. The three forms are therefore likely to occur in greater or less abundance in any of the States bordering along the Appalachian system, but are necessarily lacking in the great Interior Plains regions, reoccurring once more among the crystalline rocks of the Rocky Mountains and the Pacific coast. The principal States from which either the true asbestos or anthophyllite has been obtained in anything like commercial quantities are Massachusetts, Connecticut, New York, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Alabama, though it has been reported from other Eastern as well as several of the Western States. Fibrous serpentine (chrysotile, or amianthus) occurs in small amounts at Deer Isle, Maine; in northern Vermont; at Easton, Pennsylvania; Montville, New Jersey; in the Casper Mountains of Wyoming, and in Washington. It is known also to occur in Newfoundland. The chief commercial sources of the material are, however, Canada and Italy. The Canadian source is in a belt of serpentinous rocks extending more or less interruptedly from the Vermont line northeastward to some distance beyond the Chaudière

River. The geological horizon is that subdivision of the Lower Silurian known as the Quebec Group. The material has also been found in the Laurentian rocks of this region.

Among the principal areas of serpentine which are found at so many widely scattered points, the most easterly yet known is at a point called Mount Serpentine, about 10 miles up the Dartmouth River from its outlet in Gaspé Basin. The serpentine is here associated with limestone and surrounded by strata of Devonian age. Small veins of asbestos are found in the rock, but not yet in quantity sufficient to be economically valuable. West of this the next observed is the great mass of Mount Albert, whence it extends west in a great ridge for some miles. This mass is known to contain veins of chromic-iron, and traces of asbestos have also been observed, but the area has never yet been carefully explored with a view to ascertain the presence of the mineral in quantity, owing largely to the present difficulty of access.

In Cranbourne and Ware, to the north of the Chaudière River and in the vicinity of that stream between the villages of St. Joseph and St. Francis, several small knolls are seen, in all of which small and irregular veins are visible, but apparently not in quantity sufficient to render them economically important, at least in so far as yet examined. Further to the southwest, in Broughton, Thetford, Coleraine, Wolfestow and Ham, a very great development of these rocks is observed, forming at times mountain-masses from 600 to 900 feet above the surrounding country level, and presenting very peculiar and boldly marked features in the landscape by their rugged outlines and curiously weathered surfaces. The large areas of this division terminate southward at a point termed Ham Mountain, a very prominent peak of diorite which marks the extremity of the ridge. In this great area, which we may style the central area, asbestos can be found at many points in small quantity, but at a comparatively few does it occur in quantity and quality sufficient to warrant the expenditure of much capital in its extraction.

The third area, regarding that of the Shickshocks as the first, begins near the village of Danville, and may be styled the southwestern area. Thence it extends through Melbourne, Brompton, Orford, Bolton, and Potton, in a series of disconnected hills, to the American boundary, beyond which the continuation of the serpentine can be traced into Vermont. In these areas, with the exception of the peculiar isolated knoll near Danville, the asbestos has, as yet, been observed in small quantity only, and generally of inferior quality. Large areas of soapstone are found at points throughout the area, and the associated diorites have a large development. It must, however, be said of this section, that considerable areas, whose outcrops can be seen along the roads which traverse the district, are concealed by a dense forest growth, and the true value of such portions must, for some considerable time, be largely conjectural. In fact, until the forest and soil are completely removed by the action of forest fires, as was the case at Black Lake and Thetford, the search for asbestos is likely to prove difficult and unsatisfactory. It is, however, very evident from the studies already made on this interesting group of rocks in Canada, that all serpentine are not equally productive—a fact very evident even in the heart of the great mining centers themselves, where large areas of the belt are made up of what is known as barren serpentine. As a general rule, however, the rock likely to prove asbestos-producing can be determined by certain peculiarities of texture, color or weathering.

At the Thetford mines, and in that portion of Coleraine lying to the northeast of Black Lake, certain conditions favorable to the production of asbestos appear to have prevailed, and have led to the formation of numerous veins, often of large size, which, in places, interlace the rock in all directions. These veins range in size from small threads to a width of 3 to 4 inches [fig. 11], and in rare cases even reach a thickness of over 6 inches. [See large Specimens Nos. 72836 and 61348, U.S.N.M.]. The quality of the fiber, however, varies even in these localities, and while much of

it is soft, fine and silky, other portions are characterized by a harshness or stiffness which detracts greatly from its commercial value.

The veins while not disturbed by faulting generally improve so far as quality of material is concerned as the depth below the surface increases. They are, however, very irregular in their distribution, and are rarely persistent for any great distance.

A small vein at the surface, of half an inch in thickness, may quickly enlarge to one of three inches or more, and, continuing, may die out entirely, while others come in on either side. They have much the aspect of the gash veins in slaty rocks, though there are many instances seen where the fiber maintains a tolerably uniform size for considerable distances. [See large Specimen No. 61348, U.S.N.M.].

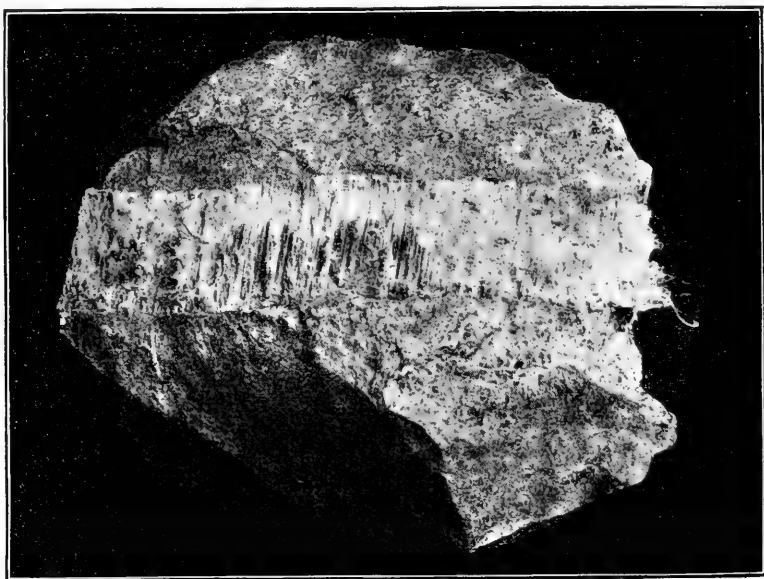


Fig. 11.

SERPENTINE ASBESTOS IN MASSIVE SERPENTINE.

Specimen No. 72836.

The containing rocks show the presence of numerous faults, as in other mineral localities, but possibly in the serpentine these are often more plainly marked. These faults throw the veins from side to side, and frequently are of sufficient extent to cut off entirely the working face of a highly productive area, the rock on the other side of the fissure being often entirely barren. The sides of the fault, in such cases, show extensive slickensides, and frequently have great sheets of coarse or woody-fibered or imperfect asbestos, along the planes of fracture. Occasionally, pockets or small veins of chromic iron are found in close proximity to the asbestos.¹

Specimens Nos. 62135, 62150, U.S.N.M. from Marmora and Thetford show the characteristic manner of the occurrence of the mineral on a small scale, while No. 62151, U.S.N.M., shows the material as freed from the wall rock, before shredding. See also Specimens Nos. 53682 to 53690 from Danville, Province of Quebec.

¹R. W. Ells, Transactions of the American Institute of Mining Engineers, XVIII, 890, p. 322.

The Italian asbestos which finds its way to the American markets is both of the amphibolic and serpentinous varieties, both being remarkable for the beautiful long fibers they yield. The amphibolic variety, the true asbestos, from Mont Cenis, is shown in Specimen No. 53164, U.S.N.M., and the serpentinous variety, from Aosta, in the sample, No. 53161, U.S.N.M. Both are in the form of fibrous aggregates over a metre in length.

Methods of mining and preparation.—The mining of asbestos is carried on almost wholly from open cuts and shallow tunnels. Rarely does it pay to follow the material to any great depth. In the United States the mines are worked very irregularly, and in most cases abandoned at the end of a short season.

The mining of the Canadian material is carried on by means of open cuts, much as a farmer cuts down a stack of hay or straw, or by open quarry on a level. The rock is blasted out and the asbestos separated from the inclosing rock by a process known as "cobbing," and which consists in breaking away the fibrous material from the walls of the vein or from other foreign ingredients by means of hammers.

The cobbled material is separated into grades, according to quality, which depends upon the length, fineness, and flexibility of the fiber. During 1888 the finest grades brought prices varying from \$80 to \$110 a ton. In 1899 the price had fallen to about \$26 a ton.

Uses.—The uses of asbestos are manifold, and ever on the increase. Among the ancient Greeks it was customary to wrap the bodies of those to be burned in asbestos cloth, that their ashes might be kept intact. In the eighth century Charlemagne is said to have used an asbestos tablecloth, which, when the feast was over, he would throw into the fire, after a time withdrawing it cleaned but unharmed, greatly to the entertainment of his guests. The most striking use to which the material is put is the manufacture of fireproof cloths for theater curtains, for suits of firemen and others liable to exposure to great heat. It is also used for packing pistons, closing joints in cylinder heads, and other fittings where heat, either dry or from steam and hot water, would shortly destroy a less durable substance. For this purpose it is used in the form of a yarn, or as millboard. The lower grades, in which the fibers are short or brittle, are made into a felt which, on account of its nonconducting powers, is utilized in covering steam boilers. It is also ground and made into cements and paints, the cement being used as a nonconductor on boilers, and the paint to render wooden structures less susceptible to fire. In the chemical laboratory the finely fibered, thoroughly purified asbestos forms an indispensable filtering medium. For this purpose the true asbestos is preferable to the fibrous serpentine.¹ Examples of the manufactured products mentioned are exhibited with the crude products.

¹Prof. A. H. Chester: Some Misconceptions Concerning Asbestos. Engineering and Mining Journal, LV, 1893, p. 531.

The chief commercial use of the material is based upon its highly refractory or noncombustible nature. The popular impression that it is a nonconductor of heat is, according to Professor Donald, erroneous, the nonconducting character of the prepared material being due rather to its porous nature than to the physical properties of the mineral itself.¹ Owing to the comparative high price of asbestos, it is, in the manufacture of the so-called nonconducting materials, largely admixed with plaster of paris, powdered limestone, dolomite, magnesite, diatomaceous earth, or carbonaceous matter, as hair, paper, sawdust, etc. With the possible exception of the magnesite (carbonate of magnesia) these are all less effective than the asbestos, and deteriorate as well as cheapen the manufactured article. The following table will serve to convey some idea of the relative portions of the various materials used as nonconducting pipe coverings, etc.:

	Parts.
Asbestos sponge, molded:	
Plaster of paris.....	95.80
Fibrous asbestos	4.20
	<hr/> 100.00 <hr/>
Fire felt sectional covering:	
Asbestos.....	82.00
Carbonaceous matter (hair, paper, sawdust, etc.).....	18.00
	<hr/> 100.00 <hr/>
Magnesia sectional covering:	
Carbonate of magnesia.....	92.20
Fibrous asbestos	7.80
	<hr/> 100.00 <hr/>
Magnesia plastic:	
Carbonate of magnesia.....	92.20
Fibrous asbestos	7.80
	<hr/> 100.00 <hr/>
Asbestos cement felting:	
Powdered limestone.....	64.50
Plaster of paris.....	3.50
Asbestos.....	32.00
	<hr/> 100.00 <hr/>
Asbestos sponge cement felting:	
Powdered limestone.....	59.00
Plaster of paris.....	10.00
Asbestos.....	31.00
	<hr/> 100.00 <hr/>
Fossil meal:	
Insoluble silicate.....	75.00
Carbonaceous matter (hair, paper, sawdust, etc.).....	11.00
Soluble mineral matter.....	8.00
Moisture.....	6.00
	<hr/> 100.00 <hr/>

¹The Mineral Industry, II, 1893, p. 4.

The following catalogue shows the mineral nature and localities represented in the Asbestos collection of the Museum:

- Fibrous anthophyllite. Tallapoosa County, Alabama. 62763.
 Fibrous anthophyllite. San Diego County, California. 67001.
 Fibrous amphibole. California. 50899.
 Fibrous amphibole. Colorado. 50878, 50879, and 50880.
 Fibrous amphibole. Connecticut. 50912.
 Fibrous amphibole. Black Hills, South Dakota. 50916, 50917.
 Fibrous amphibole. Lawrence County, South Dakota. 63487.
 Fibrous anthophyllite. Salls Mountain, Georgia. 61305, 61357.
 Fibrous anthophyllite. Cleveland, White County, Georgia. 62749.
 Fibrous anthophyllite. Near Nacoochee, White County, Georgia. 60842, 63155.
 Fibrous anthophyllite. Fulton County, Georgia. 63156.
 Fibrous anthophyllite. Albertain, Howard County, Maryland. 62604, 62605.
 Fibrous amphibole. Maryland. 50891 and 50892.
 Asbestos in limestone. West end of lower bridge, Baltimore and Ohio Railroad, over Patapsco River, just west of Albertain, Maryland. 62778.
 Fibrous amphibole. Parkton, Baltimore County, Maryland. 8536.
 Fibrous amphibole. Jefferson, Frederick County, Maryland. 63479.
 Fibrous amphibole. Harford County, Maryland. 63033.
 Fibrous amphibole. Massachusetts. 50909, 50910.
 Fibrous amphibole. Gallatin County, Montana. 53341.
 Fibrous anthophyllite. Warrenton, Warren County, North Carolina. 62748.
 Fibrous anthophyllite. Mitchell County, North Carolina. 50876, 63158, 63159.
 Fibrous amphibole. Nevada. 50885.
 Fibrous serpentine, chrysotile. New Hampshire. 50914.
 Fibrous amphibole. New York. 50867-50871 and 63160.
 Fibrous amphibole. Delaware County, Pennsylvania. 62754.
 Fibrous amphibole. Pennsylvania. 50895, 50896, 73507.
 Fibrous amphibole. Chester, Chester County, South Carolina. 73462.
 Fibrous anthophyllite. South Carolina. 50874, 50875.
 Fibrous amphibole. Tennessee. 50905.
 Mountain leather, amphibole. Minersville, Beaver County, Utah. 67266, 55379.
 Fibrous amphibole. Utah. 50907, 50908.
 Fibrous serpentine, chrysotile. Vermont. 50898, 63161.
 Fibrous amphibole in calcite. Alberene, Albemarle County, Virginia. 62550, 62551.
 Fibrous amphibole, near Roanoke, Roanoke County, Virginia. 5694.
 Fibrous amphibole. Virginia. 50872.
 Fibrous amphibole. Washington. 63206.
 Fibrous amphibole. Wisconsin. 50906.
 Fibrous anthophyllite. Carbon County, Wyoming. 62090.
 Fibrous serpentine, chrysotile. Casper Mountain. 12 miles south of Casper, Wyoming. 67377, 62091.
 Fibrous amphibole. Wyoming. 66674.
 Fibrous crocidolite. Weinthal, Cape of Good Hope, South Africa. 62107.
 Fibrous amphibole. Transvaal, South Africa. 50877.
 Fibrous crocidolite. Orange River, Mount Hopetown, Africa. 73128.
 Fibrous amphibole. Gundagai, New South Wales, Australia. 62450.
 Fibrous amphibole. Australia. 50893.
 Fibrous serpentine, chrysotile. Victoria, British Columbia. 50902.
 Fibrous serpentine in opihalcite. Canada. 72836.
 Fibrous amphibole, variety of mountain cork. Buckingham, Canada. 68138.

- Fibrous serpentine, chrysotile. Black Lake, Quebec, Canada. 62151.
 Fibrous serpentine, chrysotile. Thetford, Quebec, Canada. 62150.
 Veins of chrysotile. Marmora, Ontario, Canada. 62135.
 Fibrous serpentine, chrysotile. Algoma District, Ontario, Canada. 62134.
 Fibrous serpentine, chrysotile. Danville, Quebec, Canada. 53682-53684.
 Fibrous amphibole. Canada. 50889.
 Fibrous serpentine, chrysotile. Manitoba. 50904.
 Fibrous amphibole. Canada. 50888.
 Fibrous amphibole. Canada. 50890.
 Fibrous amphibole. Canada. 50887.
 Fibrous serpentine, chrysotile. Canada. 50886.
 Fibrous amphibole. China. 50900.
 Fibrous amphibole. Corsica. 73000.
 Fibrous amphibole. Corsica. 82359.
 Fibrous amphibole. France. 50883.
 Fibrous amphibole. France. 50882.
 Fibrous amphibole. France. 50881.
 Fibrous serpentine, chrysotile. Erèse, about 20 miles east of Aosta, Italy. 53161.
 Fibrous amphibole. Monte Lunella, spur of Monte Cenis, 5 miles from Usseglio, Italy. 53164.
 Fibrous amphibole. Italy. 50894.
 Fibrous amphibole. Zillertal, Tyrol. 66838.
 Fibrous serpentine, chrysotile. Piedmont, Italy. 73539.
 Fibrous amphibole. Caterce, San Luis Potosi, Mexico. 57168.
 Fibrous amphibole. Goldenstein, Moravia. 66837.
 Fibrous amphibole. Newfoundland. 50919.
 Fibrous amphibole. Nova Scotia. 50911.
 Fibrous amphibole. Spain. 50913.
 Fibrous amphibole. Tasmania. 50918.
 Fibrous amphibole, mountain cork. Venezuela. 50884.
 Fibrous amphibole. Argentine Republic. 63416.
 Fibrous amphibole. Bohemia. 73538.
 Fibrous amphibole. Smyrna. 50901.

BIBLIOGRAPHY.

- A. LIVERSIDGE. Minerals of New South Wales, 1888, p. 180. Gives list of localities.
 ROBERT H. JONES. Asbestos, Its Properties, Occurrence, and Uses.
 London, 1890, pp. 236.
 L. A. KLEIN. The Canadian Asbestos Industry.
 Engineering and Mining Journal, LIV, 1892, p. 273.
 J. T. DONALD. Asbestos in Canada.
 The Mineral Industry, I, 1892, p. 30.
 L. A. KLEIN. Notes on the Asbestos Industry of Canada.
 The Mineral Industry, I, 1892, p. 32.
 J. T. DONALD. Asbestos.
 The Mineral Industry, II, 1893, p. 37.
 RUDOLF MARLOCH. Asbestos in South America.
 Engineering and Mining Journal, LVIII, 1894, p. 272.
 C. E. WILLIS. The Asbestos Fields of Port-au-Port, Newfoundland.
 Engineering and Mining Journal, LVIII, 1894, p. 586.
 GEORGE P. MERRILL. Notes on Asbestos and Other Asbestiform Minerals.
 Proceedings of the U. S. National Museum, XVIII, 1895, p. 281.

H. NELLES THOMPSON. Asbestos Mining and Dressing at Thetford.

The Journal of the Federated Canadian Mining Institute, 1897, II, p. 273.

See also the Canadian Mining Review, XVI, 1897, p. 126.

ROBERT H. JONES. Asbestos and Asbestic: Their Properties, Occurrence, and Use.
London, 1897, pp. 368.

4. GARNET.

The chemical composition of the various minerals of the garnet group is somewhat variable, though all are essentially silicates of alumina, lime, iron, or magnesia. The more common types are the lime-alumina garnet *grossularite*, and the iron alumina garnet *almandite*. Other varieties of value as minerals or as gems are *pyrope*, *spessartite*, *andradite*, *breddbergite*, and *uvavovite*.

The ordinary form of the garnet is the regular 12 or 24 sided solid, the dodecahedron and trapezododron, as shown in Specimen No. 53241, U.S.N.M., from Roxbury Falls, Connecticut. The color is dull red or brown, though in the rarer forms yellow, green, and white. Hardness from 6.5 to 7.5 of the scale.

Occurrence.—Garnets occur mainly in metamorphic siliceous rocks, such as the mica schists and gneisses, and though sometimes found in limestones and in eruptive rocks, are rarely sufficiently abundant to be of economic importance. In the gneisses and schists, however, they not infrequently preponderate over every other constituent, varying from sizes smaller than a pin's head to masses of 100 pounds weight, or more.

The most important garnet-producing regions of the United States are Warren County, New York, and Delaware County, Pennsylvania. At the first-named locality, the garnets occur in laminated pockets scattered through beds of a very compact hornblende feldspar rock, the size of the pockets ranging from 5 or 6 inches in diameter to such as will yield 1,000 pounds or more (Specimen No. 53228, U.S.N.M.). In the Delaware County localities the garnets occur in aggregates of small crystals in a quartzose gneiss¹ (Specimens Nos. 53221, 66710, U.S.N.M.).

One of the most noted garnet regions of the world is that near Prague, Bohemia. According to G. F. Kunz,² the garnets of the pyrope variety are indigenous to an eruptive rock now changed to serpentine, and the mineral is found "loose in the soil or in the lower part of the diluvium, or embedded in a serpentine rock. * * In mining for garnets the earth is cut down in banks and only the lower layer removed, and the garnets are separated by washing. The earth is first dry sifted and then washed in a small jig consisting of a sieve moved back and forth in a tank of water."

Uses.—Aside from their use in the cheaper forms of jewelry garnets

¹The Mineral Industry, V, 1896.

²Transactions of the American Institute Mining Engineers, XXI, 1892, p. 241.

are used mainly for abrading purposes and mainly as a sand for sawing and grinding stone or for making sandpaper. The material is of less value than corundum or emery, owing to its inferior hardness. The commercial value is variable, but as prepared for market it is worth about 2 cents a pound.

5. ZIRCON.

This is a silicate of zirconium, ZrSiO_4 , = silica 32.8 per cent; zirconia 67.2 per cent; specific gravity 4.68 to 4.7; hardness 7.5; colorless, grayish, pale yellow to brown or reddish brown. Ordinarily in the form of square prisms. Specimens Nos. 61133 and 62581, U.S.N.M., are characteristic.

Zircon is a common constituent of the older eruptives like granite and syenite, and also occurs in granular limestone, gneiss, and the schists. It is so abundant in the *elæolite* syenites of southern Norway as to have given rise to the varietal name *Zircon syenite*. Although widespread as a rock constituent it has been reported in but few instances in sufficient abundance to make it of commercial value. Being hard and very durable it resists to the last ordinary atmospheric agencies, and hence is to be found in beds of sand, gravel, and other *débris* resulting from the decomposition of rocks in which it primarily occurs. It has thus been reported as found in the alluvial sands in Ceylon, in the gold sands of the Ural Mountains, Australia, and other places. In the United States it occurs in considerable abundance in the *elæolite* syenite of Litchfield, Maine, and is also found in other States bordering along the Appalachian Mountains. The most noted localities are in Henderson and Buncombe counties in North Carolina, whence several tons have been mined during the past few years from granite *débris*. (Specimen No. 61133, U.S.N.M.)

Uses.—See under monazite, p. 383.

6. SPODUMENE AND PETALITE.

This is an aluminum lithium silicate of the formula $\text{LiAl}(\text{SiO}_3)_2$, = silica, 64.5 per cent; alumina, 27.4 per cent; lithia, 8.4 per cent; in nature more or less impure through the presence of small amounts of ferrous oxide, lime, magnesia, potash, and soda. Luster vitreous to pearly; colors white, gray, greenish, yellow, and amethystine purple. Transparent to translucent. Usual form that of flattened prismatic crystals, with easy cleavages parallel with the faces of the prism. Also in massive forms. Crystals sometimes of enormous size, as noted below.

Mode of occurrence.—Spodumene occurs commonly in the coarse granitic veins associated with other lithia minerals, together with tourmaline, beryls, quartz, feldspar, and mica. The chief localities as given by Dana are as below:

In the United States, in granite at Goshen, Massachusetts, associated at one locality with blue tourmaline and beryl; also at Chesterfield, Chester, Huntington (formerly

Norwich) [Specimen No. 62579, U.S.N.M.], and Sterling, Massachusetts; at Windham, Maine, with garnet and staurolite; at Peru with beryl, triphylite, petalite; at Paris, in Oxford County [Specimen No. 62578, U.S.N.M.]; at Winchester, New Hampshire; at Brookfield, Connecticut, a few rods north of Tomlinson's tavern, in small grayish or greenish white individuals looking like feldspar; at Branchville, Connecticut, in a vein of pegmatite, with lithiophilite, uraninite, several manganesian phosphates, etc.; the crystals are often of immense size, embedded in quartz; near Stony Point, Alexander County, North Carolina, the variety hiddenite in cavities in a gneissoid rock with beryl (emerald), monazite, rutile, allanite, quartz, mica, etc.; near Ballground, Cherokee County, Georgia; in South Dakota at the Etta tin mine in Pennington County, in immense crystals. [Specimen No. 73,642, U.S.N.M.]. At Huntington, Massachusetts, it is associated with triphylite, mica, beryl, and albite; one crystal from this locality was $16\frac{1}{2}$ inches long and 10 inches in girth.

At the Etta tin mine, in the Black Hills of South Dakota, the mineral occurs, according to W. P. Blake, in sizes the magnitude of which exceeds all records. Crystalline masses extend across the face of the open cut from 2 to 6 feet in length and from a few inches to 12 and 18 inches in diameter. Blocks too large to lift have been freely tumbled over the dump with the waste of the feldspar, quartz, and mica. The gigantic crystals preserve the cleavage characteristics and show the common prismatic planes. The color is lighter and is without the delicate creamy pink hue of the specimens from Massachusetts. It is very hard, compact, and tough, and is difficult to break across the grain. Some of the fragments are translucent.

The chief foreign localities of spodumene are Utö in Södermanland, Sweden, where it is associated with magnetic iron ore, tourmalines, quartz, and feldspar; near Sterzing and Lizens, in Tyrol; embedded in granite at Killiney Bay near Dublin, and at Peterhead, Scotland.

Uses.—So far as the writer is aware, the mineral has as yet been put to no economic use. There seems no reason for its not being utilized as a source of lithia salts as well as amblygonite and lepidolite.

PETALITE, another lithium aluminum silicate containing 2.5 to 5 per cent lithia occurs associated with lepidolite, tourmaline, and spodumene in an iron mine at Utö, Sweden (Specimen No. 62582, U.S.N.M.), with spodumene and albite at Peru, Maine, and with scapolite at Bolton, Massachusetts.

7. LAZURITE; LAPIS LAZULI; OR NATIVE ULTRAMARINE.

Composition essentially $\text{Na}_4 (\text{NaS}_3\text{Al}) \text{Al}_2\text{Si}_3\text{O}_{12}$, = silica, 31.7 per cent; alumina, 26.9 per cent; soda, 27.3 per cent; sulphur, 16.9 per cent; hardness, 5.5; specific gravity, 2.38 to 2.45. Color, rich azure-violet or greenish blue, translucent to opaque. The ordinary lapis lazuli is not a simple mineral as given above, but a mixture of lazurite, haüyite, and various other minerals.

The following analyses quoted from Dana serve to show the heterogeneous character of the material as found:

Localities.	Silica, SiO ₂ .	Alu- mina, Al ₂ O ₃ .	Ferrie iron, Fe ₂ O ₃ .	Lime, CaO.	Soda, Na ₂ O.	Water, H ₂ O.	Sulphur, SO ₃ .
Orient	45.33	12.33	2.12	23.56	11.45	0.35	3.22
Ditró	40.54	43.00	0.86	1.14	12.54	1.92	-----
Andes	45.70	25.34	1.30	7.48	10.55	-----	4.32

Occurrence.—The localities are mostly foreign. The ultramarine reported not long since as occurring near Silver City, New Mexico, has been shown by R. L. Packard to be a magnesian silicate.

Mexico, Chile, Siberia, India, and Persia are the chief sources. The following regarding the Indian localities is taken from Ball's *Geology of India*, Part III.

According to Captain Hutton, the lapis lazuli sold in Kandahar is brought from Sadmoneir and Bijour, where it is said to occur in masses and nodules embedded in other rocks. He obtained a small specimen from Major Lynch, which was said to have been brought from Hazara, and he heard that it occurred in Khelat. Several writers speak of its occurrence in Biluchistan, but possibly this may be due to some confusion in names. Beyond a question of doubt it does exist in Badakshan, the mines south of Firgamu, in the Kokcha valleys, having been described by Wood in the narrative of his journey to the Oxus.

The entrance to the mines is on the face of the mountain at an elevation of about 1,500 feet above the level of the stream. The rocks are veined, black and white limestones. The principal mine, as represented in elevation, pursues a somewhat serpentine direction. The shaft by which you descend to the gallery is about 10 feet square, and is not so perpendicular as to prevent your walking down. The gallery is 30 paces long, with a gentle descent, but it terminates in a hole 20 feet in diameter and as many deep. The gallery is 12 feet in diameter, and as it is unsupported by pillars accidents sometimes occur. Fires are used to soften the rock and cause it to crack; on being hammered it comes off in flakes, and when the precious stone is disclosed a groove is picked round it, and together with a portion of the matrix it is prised out by means of crowbars. Three varieties are distinguished by the miners, the *nili*, or indigo colored, the *asmani*, or sky-blue, and the *sabzi*, or green. The labour was compulsory; and mining was only practised in the winter. According to Wood, these mines and also those for rubies had not been worked for four years as they had ceased to be profitable. Possibly this may have been partly due to the fall in value; according to Mr. Baden-Powell, recent returns represent the exports

as amounting to only 2 seers; but Colonel Yule, in his book of Marco Polo, states that the produce was 30 to 60 poods (36 lbs. each) annually, the best qualities selling at prices ranging from £12 to £24 a pood. Mr. Powell's figures perhaps only refer to the exports to India. Formerly the produce from these mines, which must have been considerable, was exported principally to Bokhara and China, whence a portion found its way to Europe.

Marco Polo says that the *azure* found here was the finest in the world, and that it occurred in a vein like silver. The Yamgan tract, in which the mines were situated, contained many other mines, and doubtless Tavernier referred to it when he spoke of the territory of a Raja beyond Kashmir and toward Thibet, where there were three mountains close to one another, one of which produced gold, another *granats* (garnets, or rather balas rubies), and the third lapis lazuli.

A small quantity of *lajward* is said to be imported into the Punjab from Kashgar, and a mine is reported to exist near the source of the Koultouk, a river which falls into Lake Baikal.

Uses.—Ultramarine for coloring purposes has in modern times lost much of its value, owing to the discovery by M. Guimet in 1828 of an artificial substitute. Formerly it was much used as a pigment, being preferred by artists in consequence of its possessing greater purity and clearness of tint. According to Ball,¹ the artificial substitute is now commonly sold in the bazars of India under the same name, *lajward*, for about 4 rupees a seer, while at Kandahar in the year 1841, according to Captain Hutton, the true *lajward*, which was used for house painting and book illuminating, was sold, when purified, at from 80 to 100 rupees a seer. Mr. Emanuel states that the value of the stone itself, when of good color, varies, according to size, from 10 to 50 shillings an ounce. In Europe the refuse in the manufacture is calcined, and affords delicate gray pigments, which are known as ultramarine ash.

Lajward is prescribed as a medicine internally by native physicians; it has been applied externally to ulcers. That it possesses any real therapeutic powers is of course doubtful.

Although no longer a source of any considerable amount of the ultramarine of commerce, the compact varieties of the mineral, such as that from Persia, are highly esteemed for the manufacture of mosaics, vases, and other small ornaments.

8. ALLANITE; ORTHITE.

This is a cerium epidote of the formula $HR^II R^{III}_3 Si_3 O_{13}$, in which R^{II} may be either calcium or iron (or both) and R^{III} aluminum, iron, cerium, didymium, or lanthanum. The following analyses are selected

¹ Geology of India, III, p. 528.

from Dana's Mineralogy as showing variation in the composition sufficiently for present purposes:

Constituents.	I.	II.	III.
Silica (SiO_2).....	31.63	33.03	30.04
Thorina (ThO_2).....	0.87	1.12	None.
Alumina (Al_2O_3).....	13.21	17.63	16.10
Iron sesquioxide (Fe_2O_3).....	8.39	5.26	5.06
Cerium sesquioxide (Ce_2O_3).....	8.67	2.84	11.61
Didymium sesquioxide (Di_2O_3).....	5.60	7.68	5.39
Lanthanum sesquioxide (La_2O_3).....	5.46	None.	4.11
Yttrium sesquioxide (Y_2O_3).....	0.87	2.92	None.
Erbinum sesquioxide (Er_2O_3).....	0.52	None.	None.
Iron protoxide (FeO).....	7.86	7.01	9.89
Manganese (MnO).....	1.66	0.64	Trace.
Lime (CaO).....	10.48	12.78	13.02
Magnesia (MgO).....	0.08	0.11	1.11
Potash (K_2O).....	0.28	0.40	0.02
Soda (Na_2O).....	None.	None.	0.28
Water (H_2O).....	3.49	9.87	2.56
	99.07	100.79	99.19

(I) Hitterö, Norway; (II) Ytterby, Sweden; (III) Nelson County, Virginia.

When in crystals often in long slender nail-like forms (orthite); also massive and in embedded granules. Color pitch black, brownish, and yellow. Brittle. Hardness 5.5 to 6. Specific gravity 3.5 to 4.2. Before the blowpipe fuses and swells up to a dark, slaggy, magnetic glass.

Localities and mode of occurrence.—The more common occurrence is in the form of small acicular crystals as an original constituent in granitic rocks. It also occurs in white limestone, associated with magnetic iron ore, and in igneous rocks as andesite, diorite, and rhyolite. At the Cook Iron Mines, near Port Henry, New York, it is reported as occurring in great abundance and in crystals of extraordinary size, in a gangue of quartz and orthoclase.

The variety orthite occurs in forms closely simulating rusty nails in the granitic rock about Brunswick, Maine. In Arendal, Norway, it is found in massive forms (Specimen No. 66853, U.S.N.M.). At Finbo, near Falun, Sweden, in acicular crystals a foot or more in length. In Amherst and Fauquier counties, Virginia, it occurs in large masses (Specimen No. 68661, U.S.N.M.) from Fauquier County, as it also does near Bethany Church, Iredell County, North Carolina, and Llano County, Texas (Specimen No. 62756, U.S.N.M.). At Balsam Gap, Buncombe County, North Carolina, it occurs in slender crystals 6 to 12 inches long and in crystalline masses, in a granitic vein and under similar conditions at the Buchanan and Wiseman mines in Mitchell County.

Uses.—See under Monazite, p. 383.

9. GADOLINITE.

This is a basic orthosilicate of yttrium, iron, and glucinum, though with frequently varying amounts of didymium, lanthanum, etc. The formula as given by Dana is $\text{Gl}_2\text{FeY}_2\text{Si}_2\text{O}_{10}$, = silica 23.9 per cent, yttrium oxides 51.8 per cent, iron protoxide 14.3 per cent, and glucina 10 per cent. Actual analyses yielded results as below:

Constituents.	I.	II.
Silica (SiO_2)	24.35	23.79
Thorina (ThO_2)	0.30	0.58
Yttrium sesquioxide (Y_2O_3)	45.96	41.55
Cerium sesquioxide (Ce_2O_3)	1.65	2.62
Didymium sesquioxide (Di_2O_3)	3.06	5.22
Lanthanum sesquioxide (La_2O_3)		
Iron sesquioxide (Fe_2O_3)	2.03	0.96
Iron protoxide (FeO)	11.39	12.42
Beryllium (Glucina) protoxide (BeO) ...	10.17	11.33
Lime (CaO)	0.30	0.74
Soda (Na_2O)	0.17	Trace.
Water (H_2O)	0.52	1.03
	99.90	100.24

(I) Ytterby, near Stockholm, Sweden; (II) Llano County, Texas.

The mineral is sometimes found in form of rough and coarse crystals, but more commonly in amorphous, glassy forms. Hardness 6.5 to 7; specific gravity 4 to 4.47. Color brown, black and greenish black, usually translucent in thin splinters and of a grass green to olive green color by transmitted light. No true cleavage; fracture conchoidal or splintery like glass, and with a vitreous or somewhat greasy luster. Through oxidation and hydration the mineral becomes opaque, brown, and earthy. Hence masses are not infrequently found consisting of the normal glassy gadolinite enveloped in a brown red crust of oxidation products. (Specimen No. 62780, U.S.N.M.) On casual inspection the mineral closely resembles samarskite and the dark, opaque varieties of orthite, but is easily distinguished from the fact that before the blowpipe it glows brightly for a moment and then swells up, cracks open, and becomes greenish without fusing. Some varieties (the normal anisotropic forms) swell up into cauliflower-like forms and fuse to a whitish mass. Like orthite, it gives a jelly when the powdered mineral is boiled in hydrochloric acid.

Localities and mode of occurrence.—The mineral occurs mainly in coarse pegmatitic veins associated with allanite, and other allied minerals. The principal locality in the United States thus far described is some five miles south of Bluffton on the west bank of the Colorado River, in Llano County, Texas (Specimen No. 62780, U.S.N.M.). The region is described¹ as occupied by Archæan rocks with granite, and occasional cappings of limestone.

¹American Journal of Science, XXXVIII, 1889, p. 474.

A coarse deep red granite is the most abundant, and is cut by numerous extensive veins of quartz and feldspar which carry the gadolinite, in pockety masses, and the other minerals mentioned. Most of the mineral thus far found is altered into the brown-red waxy material noted above and occurs in the form of masses weighing half a pound and upward. One "huge pointed mass, in reality a crystal, weighed fully 60 pounds;" another 42 pounds. One of the earliest opened pockets yielded some 500 kilos (227 pounds) of the mineral.

Of the foreign localities those of Kårarfvet, Broddbo and Finbo, near Falun, Sweden, and at Ytterby, near Stockholm (Specimen No. 62793, U.S.N.M.), are important, the mineral here occurring in the form of rounded masses embedded in a coarse granite. On the island of Hitterö, in the Flecke fiord, southern Norway, crystals sometimes four inches across have been obtained.

Uses.—See under monazite, p. 383.

10. CERITE.

This is a silicate of the metals of the cerium group; of a complex and doubtful formula. The analyses below, taken from Dana's System of Mineralogy, will serve to show the varying character of the mineral.

Constituents.	I.	II.	III.
Silica (SiO_2)	19.18	22.79	18.18
Cerium oxide (Ce_2O_3)	64.55	24.06	33.25
Didymium oxide (Dy_2O_3)	7.28	35.37	34.60
Lanthanum (La_2O_3)			
Iron oxide (FeO)	1.54	3.92	3.18
Alumina (Al_2O_3)		1.26	
Lime (CaO)	1.35	4.35	1.69
Water (H_2O)	5.71	3.44	5.18

The mineral occurs in gneiss and mica schist, and is of a prevailing pink to gray color. Specimen No. 62794, U.S.N.M., from Bastnäss, Westmanland, Sweden, is characteristic.

Uses.—See under monazite, p. 383.

11. RHODONITE.

This is a metasilicate of manganese of the formula MnSiO_3 , =Silica 45.9 per cent; manganese protoxide 54.1. As a rule, iron, calcium, or zinc replaces a part of the manganese. The prevailing form of the mineral when in crystals is that of rough, tabular, or elongated prisms with rounded edges (Specimen No. 83927, U.S.N.M., from Franklin, New Jersey). It is also common in massive highly cleavable forms, and in disseminated granules (Specimens Nos. 83927 and 83929, U.S.N.M.). Rarely, as in the Ekaterinburg district of Russia, it occurs in massive

forms suitable for ornamental work. (See Collection Building and Ornamental Stones.) Color brownish red, flesh red, and pink; sometimes rose red. Hardness, 5.5 to 6.5. Specific gravity, 3.4 to 3.68.

On exposure the mineral undergoes oxidation, becoming coated with a black film and giving rise thus to indefinite admixtures of silicate, oxides, and carbonates of manganese.

The mineral occurs in abundance associated with the iron ores of Wermland, Sweden, and at other localities in Europe; in Ekaterinburg, Russia, as above noted. The zinciferous variety commonly associated with the zinc ores in granular limestones of Sussex County, New Jersey, is known as fowlerite. (Specimen No. 67405, U.S.N.M.)

So far as the writer has information, rhodonite has as yet little commercial value, excepting as an ornamental stone. To some extent it has been utilized in glazing pottery and as a flux in smelting furnaces.

12. STEATITE; TALC; AND SOAPSTONE.

The mineral steatite, or talc, is a soft micaceous mineral, consisting when pure of 63.5 per cent of silica, 31.7 per cent of magnesia, and 4.8 per cent of water. Its most striking characteristics are its softness, which is such that it can be readily cut with a knife or even with the thumb nail, and soapy feeling, there being an entire absence of anything like grit. The prevailing colors are white or gray and apple green. Several varietal forms are recognized; the name *talc* as a rule being applied to the distinctly foliaceous or micaceous variety (Specimen No. 72838, U.S.N.M.), while that of *steatite* is reserved for the compact cryptocrystalline to coarsely granular forms (Specimens Nos. 26137 and 63448, U.S.N.M.).

Pyrallolite and rensseleerite are names given to varied forms of talc resulting from the alteration of hornblende or pyroxene. Such forms are found in various portions of northern New York, Canada, and Finland.

According to Dana, a part of the so-called agalmatolite used by the Chinese is steatite.

The name soapstone is given to dark gray and greenish talcose rocks, which are soft enough to be readily cut with a knife, and which have a pronounced soapy or greasy feeling; hence the name. Such rocks are commonly stated in text-books to be compact forms of steatite, or talc, but as the writer has elsewhere pointed out, and as shown by the analyses here given, few of them are even approximately pure forms of this mineral, but all contain varying proportions of chlorite, mica, and tremolite, together with perhaps unaltered residuals of pyroxene, granules of iron ore, iron pyrites, quartz, and in seams and veins calcite and magnesian carbonates.¹

¹ Rocks, Rockweathering, and Soils, p. 101.

Composition.—The varying composition of talc is shown in the series of analyses given below.

Analyses of talc.

Locality.	SiO ₂ .	Al ₂ O ₃ .	FeO.	MgO.	CaO.	MnO.	Na ₂ O.	K ₂ O.	H ₂ O.	Totals.
St. Lawrence County, New York.....	60.59	0.13	0.21	34.72	.....	1.16	.....	.....	3.77	100.58
Do	62.10	.....	1.30	32.40	.....	2.15	.....	.....	2.05	100.00
							0.17			
Luzenach, France.....	61.85	2.61	0.25	34.52	Trace.	.....	.....	.....	0.60	100.00
Valley of Pignerolles, Italy.	60.60	0.30	0.60	35.30	0.40	.....	2.80	.....	Not determined.	100.00

The following analyses of soapstone have been made in the laboratory of the department:

Analyses of soapstone.

Locality.	SiO ₂ .	Al ₂ O ₃ .	FeO.	MgO.	CaO.	MnO.	Na ₂ O.	K ₂ O.	H ₂ O.	Totals.
Francetown, New Hampshire (Specimen No. 63166, U.S.N.M.).....	42.43	6.08	13.07	25.71	3.27	Trace	0.16	0.32	8.45	99.49
Grafton, Vermont (Specimen No. 17569, U.S.N.M.)..	51.20	5.22	8.45	26.79	1.17	0.32	.....	.....	6.90	100.05
Dana, Massachusetts (Specimen No. 26439, U.S.N.M.)..	38.37	5.64	8.86	28.62	3.90	Trace	.....	.....	14.49	99.88
Baltimore County, Maryland (Specimen No. 26628, U.S.N.M.).....	52.70	5.57	7.63	26.88	1.77	.....	.....	.....	5.48	100.03
Guilford County, North Carolina (Specimen No. 27662, U.S.N.M.).....	40.03	10.86	9.59	26.97	1.70	.....	.....	.....	10.78	99.93
Lafayette, Pennsylvania (Specimen No. 63168, U.S.N.M.).....	33.47	0.45	7.38	33.72	1.34	0.21	.....	.....	23.00	99.57

Occurrence and origin.—Talc in all its forms is presumably always a secondary mineral, a product of alteration of other magnesian silicates.

Smyth has shown¹ that the talc beds of St. Lawrence County, New York (Specimen No. 63173), are alteration products from schistose aggregates of enstatite or tremolite, principally the former. According to this author, the talc occurs, not as has been stated, in the form of a well-defined vein with walls of granite or gneiss, but in the beds lying wholly within the schistose portions of the prevailing limestone.

The following account of these deposits as occurring near Gouverneur is by A. Sahlin:²

The village of Gouverneur is situated near the northwest edge of a geological island of Azoic rocks; granite, gneiss, limestone, and marble

¹School of Mining and Forestry, XVII, No. 4, 1896. Also Fifteenth Annual Report of the State Geologist of New York, 1895, pp. 665-671.

²Mining and Scientific Press, May 11, 1893.

being the representative features of the formation. To the west of Gouverneur, extending to and beyond the St. Lawrence River, the Potsdam sandstone is encountered; to the southeast, the Trenton limestones extend toward the Adirondack Mountains. The talc belt is found in the towns of Fowler and Edwards, from 7 to 14 miles southeast of Gouverneur. It has a length of about 8 miles, a width of 1 mile, more or less, and crosses the above-named Azoic island in the general direction of WNW. to ESE. The "veins" generally dip from 45° to 75° toward the northeast. Their width varies from a few inches to 20 feet or more. Surface outcroppings are frequent, and local experts contend that there is no use in looking for talc where it does not appear on the surface. The abrupt change of formation precludes the probability of discovering new deposits beyond the small, and now most thoroughly explored, belt already known. Within this narrow territory, "veins" of talc minerals, separated by layers of granite and gneiss, are found and worked. They are principally made up of the hydrated silicates of magnesia, known as agalite and rensseleerite, the former of a smooth, fibrous texture, the latter scaly and lamellar, and both beautifully white or bluish-white. In the agalite veins are found nodules of handsome pink to purple, columnar crystals of hexagonite, and also large "horses" of yellowish-white hornblende. The occurrence of the two latter minerals, representing the anhydrous silicates of magnesia, has given rise to the theory that the talc deposits originally occurred as hornblende, which has gradually become hydrated.

Since 1879, ten distinct mines have been opened, and some of these have reached a depth of 400 feet or more on the slope. The present output from these ten mines amounts, according to a close estimate, to 51,000 tons a year, which figure, however, could be readily doubled if the reducing mills had the capacity to handle the larger quantity. (Specimens Nos. 53590 to 53592, U.S.N.M., from Gouverneur are characteristic.)

In western North Carolina and northern Georgia, particularly in Cherokee, Moore, Guilford, and Murphy counties in the first-named State, and in the Cohutta Mountains of Murray County in the last, are numerous beds of very clean white or greenish fibrous talc occurring in part, at least, in connection with the marble beds. Some of the material is soft, white, and almost translucent (Specimens Nos. 26137, 27654, 63448, U.S.N.M.), while other is tough and semitranslucent, hornlike. The beds are mostly very irregular in extent as well as in quality of material.

In Stockbridge, Windsor County, Vermont, talc is mined from veins from 3 to 12 feet in width in soapstone. (Specimen No. 53206, U.S.N.M.) A greenish schistose talc is also mined in Murray County, Georgia. (Specimen No. 53226, U.S.N.M.)

Soapstone occurs mainly associated with the older crystalline rocks,

and in some cases is undoubtedly an altered eruptive; in others there is a possibility of its being a product of metamorphism of magnesian sediments. The principal beds now known lie in the Appalachian regions of the eastern United States, though others have recently been found in California, and there is no reason for supposing that many more may not exist in the Rocky Mountain regions. The beds, if such they can be called, are not extensive as a rule, but occur in lenticular masses of uncertain age intercalated with other magnesian and hornblendic or micaceous rocks frequently more or less admixed with serpentine. The rock, like serpentine, is, as a rule, traversed by bad seams and joints, and the opening of any new deposit is always attended with more or less risk, as there is in many cases no guarantee that sound blocks of sufficient size to be of value will ever be obtainable. The following facts relative to the occurrence of soapstone in the United States are taken mainly from a handbook by the writer on *Stones for Building and Decoration*, issued by Messrs. Wiley & Co., of New York.

An extensive bed of fine quality soapstone was discovered as early as 1794 at Francestown, New Hampshire (Specimen No. 10774, U.S.N.M.). This was worked as early as 1802, and up to 1867 some 5,500 tons had been quarried and sold. In this latter year some 3,700 stoves were manufactured by one company alone. The business has been conducted on a large scale ever since, and the bed has been followed some 400 feet, the present opening being 40 feet wide 80 feet long and 80 feet deep. Other beds, constituting a part of the same formation, occur in Weare, Warner, Canterbury, and Richmond, in the same State, and all of which have been operated to a greater or less extent.

Fine beds of the stone also occur in the town of Orford, and an important quarry was opened as early as 1855 in Haverhill, but it has not been worked continuously.

At least sixty beds of soapstone are stated to occur in Vermont, mostly located along the east side of the Green Mountain range, and extending nearly the entire length of the State. The rock occurs associated with serpentine and hornblende, and the beds as a rule are not continuous for any distance, but have a great thickness in comparison with their length. It not infrequently happens that several isolated outcrops occur on the same line of strata, sometimes several miles apart, and in many cases alternating with beds of dolomitic limestone that are scattered along with them.

The sixty beds above mentioned occur mainly in the towns of Readsboro, Marlboro, New Fane, Windham (Specimen No. 26626, U.S.N.M.), Townsend, Athens, Grafton, Andover, Chester (Specimen No. 53244, U.S.N.M.), Cavendish, Baltimore, Ludlow, Plymouth, Bridgewater, Thetford, Bethel, Rochester, Warren, Braintree, Waitsfield, Moretown, Duxbury, Waterbury, Bolton, Stow, Cambridge, Waterville, Berkshire, Eden, Lowell, Belvidere, Johnson, Enosburg, Westfield, Rich-



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ford, Troy, and Jay. Of these beds those of Grafton (Specimen No. 17569, U.S.N.M.) and Athens are stated to have been longest worked and to have produced the most stone. The beds lie in gneiss, and were profitably worked as early as 1820. Another important bed occurs in the town of Weatherfield. This, like that of Grafton, is situated in gneiss, but has no overlying rock, and the material can be had in inexhaustible quantities. It was first worked about 1847. The Rochester beds were also of great importance, the stone being peculiarly fine-grained and compact. It was formerly much used in the manufacture of refrigerators. The bed at New Fane occurs in connection with serpentine, and is some half mile in length by not less than 12 rods in width at its northern extremity. The soapstone and serpentine are strangely mixed, the general courses of the bed being like that of an irregular vein of granite in limestone.

In Massachusetts quarries of soapstone have been worked from time to time in Lynnfield and North Dana (Specimen No. 26439, U.S.N.M.). The Lynnfield stone occurs associated with serpentine. It has not been quarried of late, but was formerly used for stove backs, sills, and steps. In New York State soapstone and talc occur in abundance near Fowler and Edwards in St. Lawrence County. Some of this is very pure, nearly snow-white talc, and is quarried and pulverized for commercial purposes, as already noted.

In Pennsylvania, in the southern edge of Montgomery County, extending from the northern brow of Chestnut Hill between the two turnpikes across the Wissahickon Creek and the Schuylkill to a point about a mile west of Marion Square, there occurs a long, straight outcrop of steatite and serpentine. The eastern and central part of this belt on the southern side consists chiefly of steatite, while the northern side contains much serpentine, interspersed through it in lumps. Only in a few neighborhoods, as at Lafayette, does either the steatite or serpentine occur in a state of sufficient purity to be profitably quarried. On the east bank of the Schuylkill, about 2 miles below Spring Mill, a good quality of material occurs that has long been successfully worked (Specimen No. 63168, U.S.N.M.) The material is now used principally for stoves, fireplaces, and furnaces, though toward the end of the last century and during the early part of the present one, before the introduction of the Montgomery County marble, it was in considerable demand for doorsteps and sills. It proved poorly adapted for this purpose, owing to the unequal hardness of the different constituents, the soapstone wearing away rapidly, while the serpentine was left projecting like knots, or "hobnails in a plank."

Several small deposits of soapstone occur in Maryland and some of them have been worked on a small scale. The material is of good quality, but apparently to be had only in small pieces (Specimens Nos. 25010 and 26628) from Montgomery and Baltimore Counties.

In Virginia soapstone occurs in Fairfax (Specimens Nos. 25254, 28649,

U.S.N.M.), Fluvanna and Buckingham, counties. There is also a bed at Alberene, Albemarle County, a little west of Green Mountain. This is the bed so extensively worked by the Albemarle Soapstone Company (Specimen No. 62547, U.S.N.M.) From these points the beds extend in a southwesterly direction through Nelson County, where they are associated with serpentine; thence across the James River above Lynchburg and present an outcrop about 2 miles west of the town on the road leading to Liberty; also one some $2\frac{1}{2}$ miles west of New London. Continuing in the same direction the bed is seen at the meadows of Goose Creek, where it has been quarried to some extent. Parallel ranges of soapstone appear near the Pigg River in Franklin County. About 30 miles southwest from Richmond, at Chula, in Amelia County, there are outcrops of soapstone said to be of fine quality, and which in former times were quite extensively operated by the Indians. They have been reopened within a few years and the material is now on the market.

North Carolina contains, in addition to an abundance of the finest grades of talc and steatite as already noted, beds of the compact common soapstone. Deposits in Cherokee and Moore counties furnish especially desirable material for lubricating and other purposes. Murphy, Guilford, Ashe, and Alamance counties (Specimen No. 27664, U.S.N.M.) are also capable of affording good materials, but much of it is inaccessible at present on account of poor railroad facilities (Specimens Nos. 27662, 28118, U.S.N.M.) from Greensboro and Ball Mountain.

Beds of soapstone are stated to occur in Salina County, Arkansas (Specimen No. 39061, U.S.N.M.), and in Chester, Spartanburg, Union, Pickens, Oconee, Anderson, Abbeville, Kershaw, Fairfield, and Richland counties in South Carolina (Specimens Nos. 37590, 39019, U.S.N.M.). Texas is also stated to have an abundance of material and of good quality on the Hondo and Sandy creeks in Llano County. The District of Columbia contains a bed which is, however, probably too small to ever prove of value (Specimen No. 38510, U.S.N.M.).

Uses.—The use to which the material is put varies greatly according to its purity and physical characteristics. The white, fibrous variety of great purity from St. Lawrence County, New York, is used as a filler in paper manufacture, something like 30 per cent of the weight of printing paper being made up of this material. For the purpose it is run successively through coarse and finer crushers and then through buhrstones, after which it is placed into what is known as an Alsing cylinder, some 6 feet in diameter by about the same length. This cylinder is lined with porcelain brick and filled to one-third its volume with rounded pebbles or quartz, and when in motion revolves at about the rate of 20 revolutions a minute. At the end of some three to four hours the talc is reduced to the form of an impalpable powder. The so-called cyclone crusher has also been used to good advantage in this

work. The pulverized material is also used as a lubricator, for which purposes it is remarkably well adapted. Rubbed between the thumb and finger the powder is smooth and oily without a particle of grit. It is also used in soap making, for which purpose it can, however, be considered only as an adulterant, increasing the weight but not the cleaning properties of the article. It is further used as a dressing for fine leathers. Small quantities are used by shoe and glove dealers also. The pure, creamy white tale, such as is obtained from North Carolina, is used for crayons and slate pencils, while the still finer, cryptocrystalline varieties, such as are at present obtained almost wholly from abroad, are used by tailors under the name of "French chalk" and for making the tips for gas burners. Fine compact grades of a somewhat similar rock (agalmatolite) are used extensively in China and Japan for small ornaments. The stone is readily carved in fine sharp lines, and is a general favorite for making the grotesque images for which these countries are noted, and which are often sold throughout the country under the name of jadestone.

The following account of the soapstone industry of China is taken from the *Engineering and Mining Journal* of September 30, 1893. The material referred to as soapstone is, however, very probably agalmatolite. (See p. 322.)

The British consul at Wenchow, in his last report, gives some interesting details respecting the manufacture of steatite or soapstone ornaments in China. The mines are distant 42 miles from Wenchow, and are reached by a boat journey of 35 miles up the river, followed by a land journey of 7 miles over rough ground. The hills containing steatite are owned by 20 to 30 families, who in some cases work the mines themselves, in others engage miners to do it on their account. The galleries are driven into the sides of the hills, and are often nearly a mile in length. The composition of the hills is soft, and the shafts require to be propped up by supports of timber; for the same reason the floors are full of mire and clay, so that the miners wear special clothing, made principally of rhea fiber. They lead a hard life, living in straw huts on the hillside. The stone when first extracted is soft, hardening on exposure to the air. It is brought out of the mine in shovels, and is sold at the pit mouth to the carvers at a uniform price of about one-half a penny per pound. This would be when the purchaser buys it in gross, without first selecting it in any way. When picked over, the mineral varies very considerably in value—according to the size of the lump, its shape, and above all, its colors. The colors are given as purple, red, mottled red, black, dark blue, light blue, gray, white, eggshell white, "jade," beeswax, and "frozen." Of these "jade" (the white variety, not the green) and "frozen" are the most valuable. Indeed so valuable is the latter that good specimens of it are said to fetch more than real jade itself. The industry finds employment at the present time for some 2,000 miners and carvers. A great impetus was given to it by the opening of Wenchow to foreign trade. Previous to that event the chief purchasers of soapstone were officials and literary men, and the article most often carved was a stamp or seal. When it was discovered that foreigners admired the stone, articles were produced to meet what was supposed to be their taste. Such were landscapes in low or high relief, flower vases, plates, card trays, fruit dishes, cups, teapots, and pagodas. If left to his own devices, the native carver proceeds first to examine his stone, much as a cameo cutter would do, to discover how best he can take advantage of its shape and shades of color. (See further under Agalmatolite.)

The following quotation from an English writer will serve to show the advantages gained by a use of talc in paper making:

There is a decided advantage in substituting agalite for China clay, because not only is there an increase of dry paper, but such is obtained by a saving of fiber, as well as a decrease of the waste in the actual loading material and a lessened amount of polluting matter to be dealt with. Moreover, the fibrous character of the agalite causes it to yield a paper of higher class quality than is the case with China clay. The extra gloss which it is possible to obtain with papers containing agalite is shown in various American journals and books.

The soapstones are suited for a considerable range of application. Although so soft, they are among the most indestructible and lasting of rocks, but are too slippery and perhaps of too sombre a color for general structural purposes. At present the chief use of the material in the United States is in the form of thin slabs for sinks and stationary washtubs. At one time it was quite extensively used throughout New England in the manufacture of stoves for heating purposes and to some extent for fire brick, the well-seasoned stone being thoroughly fire-proof. The putting upon the market of unseasoned materials or of material with bad veins, which caused the stone to crack or perhaps fly to fragments when subjected to high temperature, aroused a prejudice against the employment of this material, and the manufacture is stated to have been to a considerable extent discontinued as a consequence. In the manufacture of either stoves or washtubs slabs of considerable size, free from segregation nodules of quartz, pyrite, or other minerals or from dry seams, are essential. As but few of the now known outcrops can furnish material of this nature, the main part of the business of the country is in the hands of but two or three companies. The waste material from the quarries, or the entire output in certain cases, is pulverized and used as a lubricant or white earth, as is the micaceous variety.

13. PYROPHYLLITE; AGALMATOLITE; AND PAGODITE (IN PART).

This is a hydrous silicate of aluminum corresponding to the formula $\text{H}_2\text{O}, \text{Al}_2\text{O}_3, 4\text{SiO}_2$. The analyses given below show the average composition of the material as it occurs in nature:

Locality.	Silica.	Aluminum.	Water.	Remarks.
Westanå, Sweden	65.61	26.09	7.08	With small amounts of iron, magnesia, and lime.
China	66.38	27.95	5.20	
Deep River, North Carolina ...	65.93	29.54	5.40	

The mineral is not known in distinct crystals, but occurs rather in foliated lamellar, massive and compact forms, closely resembling some forms of talc, for which its soapy or greasy feeling renders it very likely to be mistaken, though its hardness (2 to 2.5) is somewhat

greater. The prevailing colors are white or greenish gray to dull red, often mottled.

Occurrence.—The material sometimes occurs, as in the Deep River region (Chatham, Moore, and Orange counties), North Carolina, in compact to schistose masses of beds of considerable extent and purity.

Uses.—The more compact varieties, like that of Deep River (Specimen No. 27665, U.S.N.M.), are used for making slate pencils and tailors' chalk, or French chalk, so called. The still more compact forms, known as agalmatolite (Specimens Nos. 37812, from Sonora, Mexico, and 27133 and 27134, Japan) and pagodite, are used extensively by the Chinese and Japanese for making small images and art objects of various kinds. Dana states, however, that a part of the so-called Chinese agalmatolite is in reality pinitite and a part of steatite. The objects sold by Chinese dealers at the various expositions of late years under the name of jade stone are, however, of agalmatolite.

PINITE: Agalmatolite in part. Composition, a hydrous silicate of alumina and the alkalis. According to Dana,¹ the name is made to include a large number of alteration products of white spodumene, nepheline, feldspar, etc. Professor Heddle has described² a pinitite (agalmatolite) occurring in large lumps of a sea-green color, surrounding crystalline masses of feldspar in the granites of Scotland, and which he regards as alteration products of oligoclase. The composition as given is: Silica, 48.72 per cent; alumina, 31.56 per cent; ferric oxide, 2.43 per cent; magnesia, 1.81 per cent; potash, 9.48 per cent; soda, 0.31 per cent; water, 5.75 per cent.

14. SEPIOLITE; MEERSCHAUM.

This mineral is a hydrous silicate of magnesia, having the composition indicated by the formula $H_4Mg_3Si_3O_{10}$, = silica 60.8 per cent; magnesia, 27.1 per cent; water, 12.1 per cent. The prevailing colors are white or grayish, sometimes with a faint yellowish, reddish, or bluish green tinge. It is sufficiently soft to be impressed by the nail, opaque, with a compact structure, smooth feel, and somewhat clay-like aspect; rarely it shows a fibrous structure. Specimens Nos. 62545, 66861, and 67749 are characteristic. In nature it rarely occurs in a state of absolute purity. The following analyses are quoted from Dana's Mineralogy:

Locality.	SiO ₂ .	MgO.	FeO.	H ₂ O.	CO ₂ .
Turkey	61.17	28.43	0.06	9.83	0.67
Greece	61.30	28.39	0.08	9.74	0.56
Utah (fibrous)	52.97	22.50	<div style="display: inline-block; vertical-align: middle;"> <div style="text-align: center;">CuO.</div> <div style="text-align: center;">0.87</div> </div>	9.90	<div style="display: inline-block; vertical-align: middle;"> <div style="text-align: center;">Hygroscopic H₂O</div> <div style="text-align: center;">8.80</div> </div>

¹System of Mineralogy, 6th ed., p. 621.

²Mineralogical Magazine, IV, p. 215.

The name is from the German words *Meer*, sea, and *Schaum*, foam, in allusion to its appearance.

Mode of occurrence and origin.—According to J. Lawrence Smith,¹ the Asiatic material occurs in the form of nodular masses in alluvial deposits on the plain of Eski-Shehr, and is regarded by him as derived by a process of substitution from magnesium carbonate which is found in the serpentine of the neighboring mountains.

In an article by Dr. E. D. Clarke in the *Cyclopedia of Arts and Sciences* it is stated that the meerschaum of the Crimeria forms a stratum some 2 feet thick beneath a much thicker stratum of marl. Cleveland in his elementary treatise on minerals (1822) states that at Analotia, in Asia Minor, meerschaum occurs in the form of a vein more than 6 feet wide, in compact limestone. At Vallecas, Spain, a very impure form is stated to occur in the form of beds and in such abundance as to be utilized for building material. Aside from the localities above mentioned, sepiolite is known to occur in Greece, at Hrubschitz in Moravia, and in Morocco, in all cases being associated with serpentine, with which it is apparently genetically related.

Uses.—The mineral owes its chief value to its adaptability for smokers' use, being utilized in the manufacture of what are known as meerschaum pipes. At Vallecas, as above noted, the material is said to occur in such abundance as to be utilized as a building stone. In Algeria a soft variety is used in place of soap at the Moorish baths and for washing linen.

According to Kunz,² meerschaum has occasionally been met with in compact masses of smooth, earthy texture in the serpentine quarries of West Nottingham Township, Chester County, Pennsylvania. Only a few pieces were found, but they were of good quality. It also occurs in grayish and yellowish masses in the serpentine in Concord, Delaware County, Pennsylvania. Masses of pure white material, weighing a pound each, have been found in Middletown, in the same county, and of equally good quality at the Cheever Iron Mine, Richmond, Massachusetts, in pieces over an inch across; also in serpentine at New Rochelle, Westchester County, New York. A fibrous variety, in masses of considerable size, has within a few years been found in the Upper Gila River region, New Mexico (Specimen No. 67840, U.S.N.M.).

According to a writer in the *Engineering and Mining Journal*,³ the Eski-Shehr mineral is mined from pits and horizontal galleries in much the same manner as coal. As first brought to the surface it is white, with a yellowish tint, and is covered with red clayey soil. In this condition it is sold to dealers on the spot. Before exporting the

¹ American Journal of Science 1849, VIII, p. 285.

² Gems and Precious Stones, p. 189.

³ Volume LIX, 1895, p. 464.

material is cleaned, dried, and assorted, the drying taking place in the open air, without artificial heat in summer, and requiring from five to six days. The bulk of the material is sent direct to Vienna and Paris.

15. CLAYS.

The term "clay," as commonly used comprises materials of widely diverse origin and mineral and chemical composition, but which have in common the property of plasticity when wet, and usually that of becoming indurated when dried either by natural or artificial means. Of so variable a nature is the material thus classed that no brief definition can be given that is at all satisfactory. One may perhaps describe the clays, as a whole, as heterogeneous aggregates of hydrous and anhydrous aluminous silicates, free quartz, and ever-varying quantities of free iron oxides and calcium and magnesian carbonates, all in a finely comminuted condition.

Origin and mode of occurrence.—The clays are invariably of secondary origin—that is, they result from the decomposition of pre-existing rocks and the accumulation of their less soluble residues, either in place (as residual clays) or through the transporting power of ice and water (drift clays). The fact that silicate of aluminum is so characteristic a constituent of nearly all clays is due to the fact that this substance is one of the most insoluble of natural compounds, and hence when, under the action of atmospheric or subterranean agencies, rocks decompose and their more soluble constituents—as lime, magnesia, potash, soda, or even silica—are removed, the aluminous silicate remains.

The kaolins, which may perhaps be regarded as the simplest of clays, are the product, as a rule, of decomposition in place of feldspathic rocks, as gneisses, granites, and pegmatites. Those of Hockessin, Delaware (Specimens Nos. 63427 to 63430), are mainly of gneissic origin, though from some of the pits the material is in part at least derived from the decomposition of feldspathic conglomerate. In other cases the rock, as in the case of that from Blandford, Massachusetts (Specimens Nos. 68219 and 68221, U.S.N.M.), is a quite pure pegmatite, composed almost wholly of quartz and orthoclase. The samples show the material in various stages of decomposition. In all these cases the material as mined contains particles of free quartz and other substances detrimental to its use as a clay, and which must be removed by washing. It sometimes happens that the natural admixture of silica and undecomposed silicates is of just the right proportions to be utilized after merely grinding and bolting. The so-called "Cornwall stone" (Specimens Nos. 62136 and 62118, U.S.N.M.) is but a granite, very free from mica and ferruginous impurities, and in which the feldspar only has in part decomposed to the condition of kaolin. In some instances the natural conditions are such that running waters have assorted out the

fine clay particles from the coarser impurities and deposited them by themselves, as in the case of that from Florida (Specimen No. 67256, U.S.N.M.). In the majority of cases, however, natural washing has but served to still further contaminate the materials, giving rise to the complex transported clays to be noted later. Many rocks, such as the aluminous limestones, are so impure that on decomposing and the losing of their soluble lime carbonates they leave only very inferior varieties of clay, suitable for brick and tile or pottery making. Such are often highly colored by iron oxides (Specimens Nos. 62564, 62673, 63463, and 63493, U.S.N.M., in Rockweathering series).

The assorting and transporting power of running waters rarely allow the beds of kaolin or of clay to remain in a condition of virgin purity or even in the place of their origin. The minute size and the shape of their constituent particles render them easily transported by rains and running streams, to be deposited again in regularly laminated beds (see Plate 18) when the streams lose their carrying power by flowing into lakes or seas. It is through such agencies that have in times passed been formed the so-called Leda clays (Specimen No. 73036, U.S.N.M.) and the loess. Such may contain a very large proportion of mechanically derived material and proportionately little kaolin.

Speaking of clays of this nature as they exist in Wisconsin, Chamberlain says:

They owe their origin mainly to the mechanical grinding of glacial ice upon strata of limestone, sandstone, and shale, resulting in a comminuted product that now contains from 25 to 50 per cent of carbonates of lime and magnesia. This product of glacial grinding was separated from the mixed stony clays produced by the same action by water either immediately upon its formation or in the lacustrine epoch closely following. The process of separation must have been rapid and comparatively free from the agency of carbonated waters, otherwise the lime and magnesia would have been leached out.

The formation of beds of clay has been confined to no particular period of the earth's history, but has evidently gone on ever since the first rocks were formed and when rock decomposition began. The older beds are as a rule greatly indurated and otherwise altered, and in many instances no longer recognizable as clays at all. Throughout the Appalachian region clay beds of Cambrian and Silurian ages have, by the squeezing and sheering incident to the elevation of this mountain system, become converted into argillites and roofing slates.

Mineral and chemical composition.—Formed thus in a variety of ways, and consisting not infrequently of materials brought from diverse sources, it is easy to comprehend that the substances ordinarily grouped under the name of clays may vary widely in both mineral and chemical composition. It may be said at the outset that the statements so frequently made to the effect that kaolinite or even kaolin is the basis of all clays is not yet well substantiated.

Kaolinite is in itself not properly a clay, nor is it plastic. Further, in many cases it is present only in nonessential quantities. More open to criticism yet, because more concise, is the statement sometimes made that clay is a hydrated silicate of alumina having the formula $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 + 2\text{H}_2\text{O}$. It is doubtful if a clay was ever found which could be reduced to such a formula excepting by a liberal exercise of the imagination. There is scarcely one of the silicate minerals that will not when sufficiently finely comminuted yield a substance possessing those peculiar physical properties of unctuous feel, plasticity, and color, which are the only constant characteristics of the multitudinous and heterogeneous compounds known as clays. Even pure vitreous quartz when rubbed to the condition of an impalpable powder has when wet the plasticity and odor of clay.¹ Daubree so long ago as 1878² pointed out the fact that by the mechanical trituration of feldspars in a revolving cylinder with water an impalpable mud was obtained, which remained many days in suspension, and on drying formed masses so hard as to be broken only with a hammer, resembling the argillites of the coal measures.

The ever varying chemical nature of the materials classed as clays is brought out to some extent by a comparison of the analyses in the table (p. 349), but is even more evident in microscopic and mechanical examinations. Indeed, as stated by Chamberlain:³

While it is convenient and customary to speak of the crude material of brick as clay, that which is really made use of is a mixture of clay and sand, or, in the cream-colored brick, of aluminous clay, calcareous clay or marl, and sand. The mixture is really a loam and but for the appropriation of that term as the designation of a soil, it would doubtless be more generally applied to such mixtures.

Professor Crosby, as noted elsewhere, has shown that the blue-gray brick clays of Cambridge contain only from one-fourth to one-third of their bulk of "true clay," the remainder being finely comminuted material to which he gives the name rock flour.

An examination of certain English fire clays has shown⁴ that they can not properly be considered as mere hydrous silicates of alumina, but are very complex mineral admixtures, among which scales of hydrous micas, grains of feldspar, more rarely quartz and rutile needles greatly preponderate over the kaolin. The Leda clays of Maine, as the writer has noted elsewhere, contain a comparatively small amount

¹ Referring to the odor of clay when a shower of rain first begins to wet a dry, clayey soil, Mr. C. Tomlinson has remarked that it is commonly attributed to alumina, and yet pure alumina gives off no odor when breathed upon or wetted. The fact is, the peculiar odor referred to belongs only to impure clays, and chiefly to those that contain oxide of iron. (Proceedings of the Geological Association, I, p. 242; quoted in Woodward's *Geology of England and Wales*, p. 439.)

² *Geologie Expérimentale*; 1879, p. 251.

³ *Geology of Wisconsin*, I, p. 673.

⁴ W. M. Hutchings, *Geological Magazine*, VII, 1890, p. 264, and VIII, 1891, p. 164.

of kaolin but much free quartz, scales of mica, bits of still fresh feldspar, and more rarely tourmalines and other of the less destructible silicates.

Iron in the hydrated sesquioxide state is found in nearly all clays, even the whitest varieties. More than 1 per cent was found in a siliceous clay from Ohio, although the clay itself was almost of snowy whiteness.

Iron also exists in the form of a silicate and protoxide carbonate, and sometimes as a sulphide in the form of disseminated pyrite. Lime and magnesia are also common constituents, either as free carbonates or as lime-magnesia silicates, and may exercise an important bearing upon the suitability of a clay for any particular purpose, as will be noted later. The clay from which the well-known Milwaukee cream-colored bricks are made contains sometimes as high as 23 per cent carbonate of lime and 17 per cent carbonate of magnesia, together with nearly 5 per cent of iron.

The alkalies, potash and soda, are common constituents in small proportions, and also lithia, the first named being most common as well as most detrimental. It is a fair assumption that these substances are constituent of still undecomposed fragments of feldspar and the micas. To the presence of rutile needles and particles of ilmenite are due the frequent traces of titanitic acid revealed by chemical analysis. The presence of any quartz and undecomposed feldspathic material in a clay can as a rule be detected by the gritty feeling manifested when the material is rubbed between the thumb and fingers. Mica is, however, not readily detected by this means.

The above remarks will explain why a purely chemical analysis of a clay may be of little value for the purpose of ascertaining its suitability for any particular purpose. It is essential that we know not merely the presence or absence of certain elements but also how these elements are combined. Further than this few clays are used in their natural condition, being first purified by washing and usually mixed with other constituents to give them body or fire-resisting properties.

Kinds and classification.—From a geological standpoint the clays may be divided into two general classes, as above noted, (1) residual and (2) transported, the first class including a majority of the kaolin, halloysite, etc., and the second the ordinary brick and potter's clays, the loess, adobe, Leda, and the bedded, alluvial deposits of the Cretaceous, Carboniferous, and other geological periods. Special names, based upon such properties as render them peculiarly adapted to economic purposes, are common. We thus have (1) the kaolin and China clay, (2) potter's clay, (3) pipe clay, (4) fire clay, (5) brick, tile, and terra cotta clays, etc., (6) slip clays, (7) adobe, and (8) fuller's earth. These will be discussed in the order given, though they must necessarily be discussed but briefly, since the subject of clays alone

could be made to far exceed the entire limits of the present volume. The names fat and lean clays are workmen's terms for clays relatively pure and plastic or carrying a large amount of mechanical admixtures, such as quartz sand.

In the Kaolin and China Clays are included a series of clays used in the manufacture of the finer grades of porcelain and china ware and which consist in large proportion of the material kaolin, the name being derived from the Chinese locality Kaoling, from whence have for ages been obtained the materials for the highest grades of Chinese porcelain.

According to Richthofen,¹ however, the material from which the porcelain of King-te-chin is made is not kaolin at all, but a hard greenish rock having somewhat the appearance of jade and which occurs intercalated between beds of clay slate. He says:

This rock is reduced, by stamping, to a white powder, of which the finest portion is ingeniously and repeatedly separated. This is then moulded into small bricks. The Chinese distinguish chiefly two kinds of this material. Either of them is sold in King-te-chin in the shape of bricks, and as either is a white earth, they offer no visible differences. They are made at different places, in the manner described, by pounding hard rock, but the aspect of the rock is nearly alike in both cases. For one of these two kinds of material, the place Kaoling ("high ridge") was in ancient times in high repute; and, though it has lost its prestige since centuries, the Chinese still designate by the name "Kao-ling," the kind of earth which was formerly derived from there, but is now prepared in other places. The application of the name by Berzelius, to porcelain *earth* was made on the erroneous supposition, that the white earth which he received from a member of one of the embassies (I think, Lord Amherst) occurred naturally in this state. The second kind of material bears the name Pe-tun-tse ("white clay").

The following analyses will serve to show the average composition of (I) the natural material from King-te-Chin, such as is used in the manufacture of the finest porcelain; (II) that from the same locality used in the so-called blue Canton ware; (III) that of the English Cornish or Cornwall stone; (IV) washed kaolin from St. Yrieux, France, and (V) washed kaolin from Hockessin, Delaware.²

Constituents.	I.	II.	III.	IV.	V.
Silica	73.55	73.55	73.57	48.68	48.73
Alumina	21.09	18.98	16.47	36.92	37.02
Ferric oxide.....			.27		.79
Lime	2.55	1.58	1.17		.16
Magnesia .....	.15	1.08	.21	.52	.11
Potash.....		.46			.41
Soda.....		2.09	5.84	.58	.04
Combined water	2.62	1.96	2.45	13.13	12.83
Total	99.62	99.70	99.98	99.83	100.09

¹ American Journal of Science, 1871, p. 180.

² Analyses I and II by J. E. Whitfield, Bulletin 27, U. S. Geological Survey; III from Langenbeck's Chemistry of Pottery; IV from Zirkel's Lehrbuch der Petrographie, III, p. 758, and V by George Steiger, U. S. Geological Survey.

Plate 15, figs. 1 and 2, will serve to show the shape and kind of the particles in the mineral kaolinite and in a prepared sample of the Hockessin kaolin, as seen under the microscope.

The name halloysite is given to a white or yellowish material closely simulating kaolin in composition, but occurring in indurated masses, with a greasy feel and luster, and which adheres strongly to the tongue, a property due to its capacity for absorbing moisture.¹ As it is utilized for much the same purpose as is kaolin, it is included here.

Halloysite is described by Gibson² as occurring in a bed some 3 feet in thickness, lying near the base of the Lower Siliceous (L. Carboniferous) formation, a little above or close to the Black Shale (Devonian), in Murphrees Valley, Alabama. This bed has been worked with satisfactory results near Valley Head, in Dekalb County. The present writer has found the material in comparatively small quantities, associated with kaolin, in narrow veins in the decomposing gneissic rock near Stone Mountain, Georgia. A similar occurrence is described near Elgin, Scotland. (Analysis below.) Near Tüffer, Styria, halloysite is described³ as occurring in extensive thick and veinlike agglomerations in porphyry. It is quite pure, and in the form of irregular nodules of various sizes, frequently with a pellucid, steatitelike central nucleus, passing outwardly into a pure white substance, greasy to the touch, in which are occasionally included minute pellucid granules. Outside it passes into an earthy, friable substance. The following analyses show the varying composition of halloysite from (I) Elgin, Scotland, (II) Steinbruck, Styria, and (III) Detroit Mine, Mono Lake, California.

Constituents.	I.	II.	III.
Silica	39.30	40.7	42.91
Alumina	38.52	38.40	38.4
Lime	0.75	0.60	0.6
Magnesia	0.83	1.50	1.5
Ferrie oxide.....	1.42	.....	Trace.
Manganese	0.25	.....	.....
Water	19.34	18.00	18.00
		99.20	

A white chalky halloysite from the pits of the Frio Kaolin Mining Company in Edwards County, Texas (Specimen No. 53253, U.S.N.M.),

¹ This property is characteristic of nearly all clay compounds when they are dry. It is to this same property that many of the so-called "madstone" owe their imaginary virtues. Nearly all the stones of this type examined by the writer have proved to be of indurated clay, halloysite, or a closely related compound. When applied to a fresh wound, such adhere until they become saturated with moisture, when they fall away. Their curative powers are of course wholly imaginary.

² Geological Survey of Alabama. Report on Murphrees Valley, 1893, p. 121.

³ Mineralogical Magazine, II, 1878, p. 264.



Fig. 1.

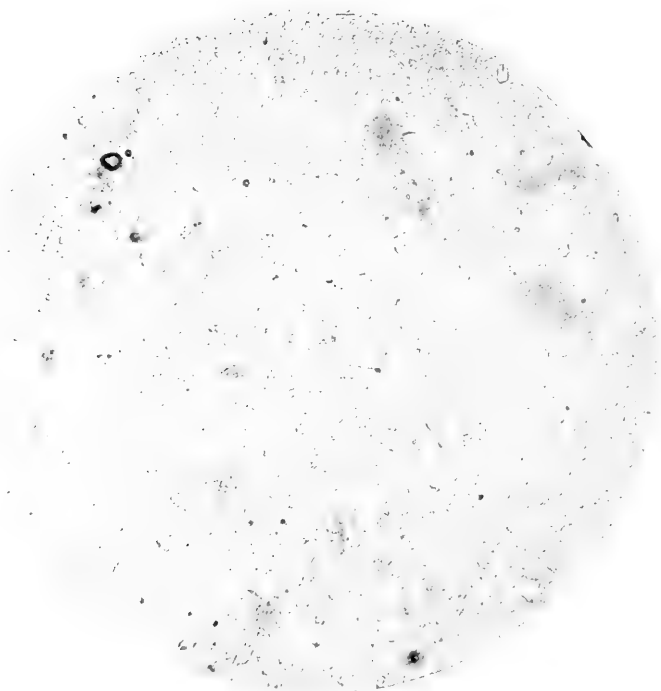


Fig. 2.

MICROSECTIONS SHOWING THE APPEARANCE OF (1) KAOLINITE AND (2) WASHED KAOLIN.

The enlargement is the same in both cases.

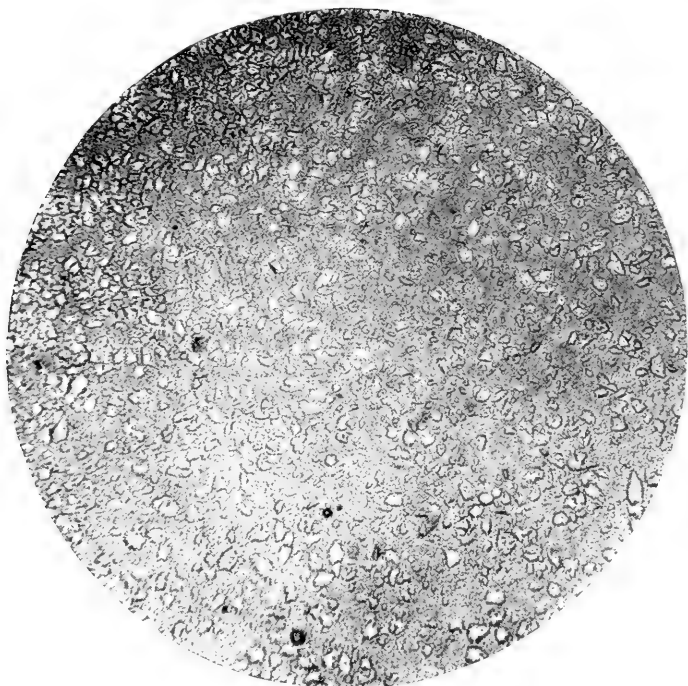


Fig. 1.

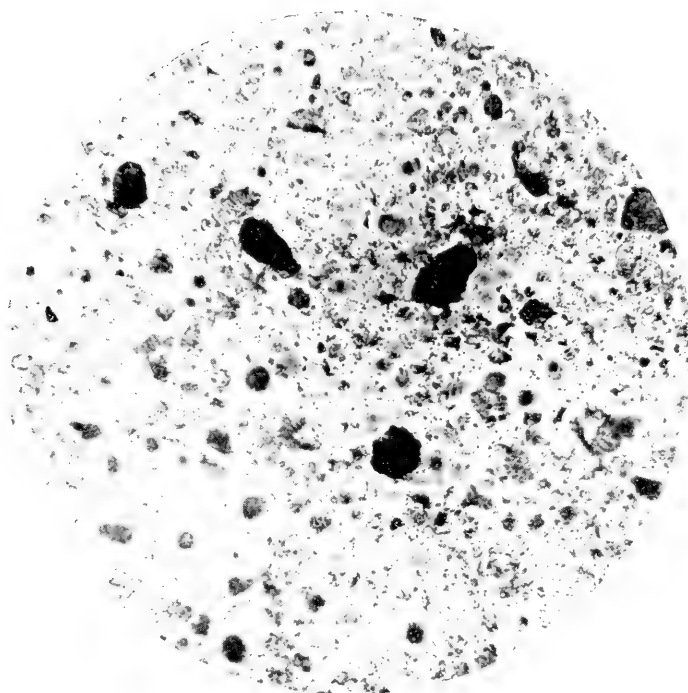


Fig. 2.

MICROSECTIONS SHOWING THE APPEARANCE OF (1) HALLOYSITE AND (2) LEDA CLAY.

The enlargement is the same in both cases.

has the composition given below as shown by analyses made in the laboratory of the department:

Silica.....	45.82
Alumina.....	39.77
Potash.....	.30
Ignition.....	13.38
	<hr/>
	99.27

The material is somewhat variable, corresponding in part to the halloysite described by Dana, and being nonplastic, and in part being plastic to an extraordinary degree. The plastic portions are almost as gritless as starch paste. Its appearance under the microscope is shown in Plate 16, fig. 1, the interspaces of the visible angular particles being occupied by the pasty, almost amorphous material. The particles themselves act very faintly on polarized light, and it is not possible to determine their mineralogical nature.

The name Indianaité has been given by Cox to a variety of halloysite found in Lawrence County, Indiana, and which he regarded as resulting from the decomposition of Archimedes (Lower Carboniferous) limestone. It is represented as forming a stratum from 6 to 10 feet thick, underlying a massive bed of Coal Measure conglomerate 100 feet thick and overlying a bed of limonite 2 to 5 feet thick. The material like kaolin is used in the manufacture of porcelain ware. The composition of this material as given by Dana is as follows: Silica 39 per cent, alumina 36 per cent, water 23.50 per cent, lime and magnesia 0.63 per cent, alkalis 0.54 per cent; 99.67 per cent. (See Specimens, Nos. 29714, 34441, U.S.N.M.)

The potters' and pipe clays belong mainly to what are known geologically as bedded clays, and are as a rule very siliceous compounds, carrying in some instances as much as 50 per cent of free quartz and 6 to 10 per cent of iron oxides and other impurities. They are highly plastic and of a white to blue, gray, or brown color (See Specimens, Nos. 17245, 33975, 20286, 67796, to 67798, from the United States and England) and burn gray, brown, or red. The tables on page 349 will show the varying composition of materials thus classed. The fire clays, so called on account of the refractory nature, differ mainly in the small percentages of lime and the alkalis they carry, and to the absence of which they owe their refractory properties. (Specimens, Nos. 11629, New Jersey; 53179, Maryland; 59258, West Virginia; 68248, California; 53249-53251, South Dakota, etc., are characteristic.)

The bedded clays of the United States reach their maximum development in strata of Cretaceous and Carboniferous ages. To the Cretaceous age belong the celebrated plastic clays of New Jersey and a very large proportion of the brick, tile, and terra cotta clays of Dela-

ware,¹ Maryland, and Virginia. The New Jersey beds are very extensively utilized in Middlesex County and fully described in the State Geological Reports.²

As described, the entire plastic clay formation consists of several members as below, arranged in a descending series:

	Feet.
(1) Dark-colored clay (with beds and laminæ of lignite)	50
(2) Sandy clay, with sand in alternate layers.....	40
(3) Stoneware clay bed	30
(4) Sand and sandy clay (with lignite near the bottom)	50
(5) South Amboy fire-clay bed.....	20
(6) Sandy clay (generally red or yellow)	3
(7) Sand and kaolin	10
(8) Feldspar bed	5
(9) Micaceous sand bed.....	20
(10) Laminated clay and sand.....	30
(11) Pipe clay (top white)	10
(12) Sandy clay (including leaf bed)	5
(13) Woodbridge fire-clay bed	20
(14) Fire-sand bed	15
Raritan clay beds:	
(15) Fire clay.....	15
(16) Sandy clay.....	4
(17) Potters' clay.....	20
Total	347

The following section of the Coal Measure clays at St. Louis, as published in Bulletin No. 3 of the Geological Survey of Missouri, will serve to show the alternating character of these beds, and their varying qualities as indicated by the uses to which they are put.³

- (1) Loess, 20 feet.
- (2) Limestone (Coal Measure), 5 feet.
- (3) Clay, white and yellow, used for sewer-pipe manufacture, called "bastard fire clay," 3 to 4 feet.
- (4) Clay, yellow and red, sold for paint manufacture and for coloring plaster and mortar, called "ochre," 3 feet.
- (5) Clay, gray to white, used for paint manufacture and filling, 1 foot 6 inches.
- (6) Pipe clay, variegated, reddish brown and greenish, called "keel," 12 feet.
- (7) Sandstone.
- (8) Slaty shale.
- (9) Coal.
- (10) Fire clay, becoming sandy toward the base.

When first mined these Coal Measure clays are usually very hard, but on exposure to the weather slack and fall into powder. They are

¹This of course does not include the kaolin deposits of Hockessin, Newcastle County, and similar deposits.

²Report on Clay Deposits of Woodbridge, South Amboy, and other places in New Jersey, 1878.

³Bulletin No. 3, Geological Survey of Missouri, 1890.



Fig. 1.

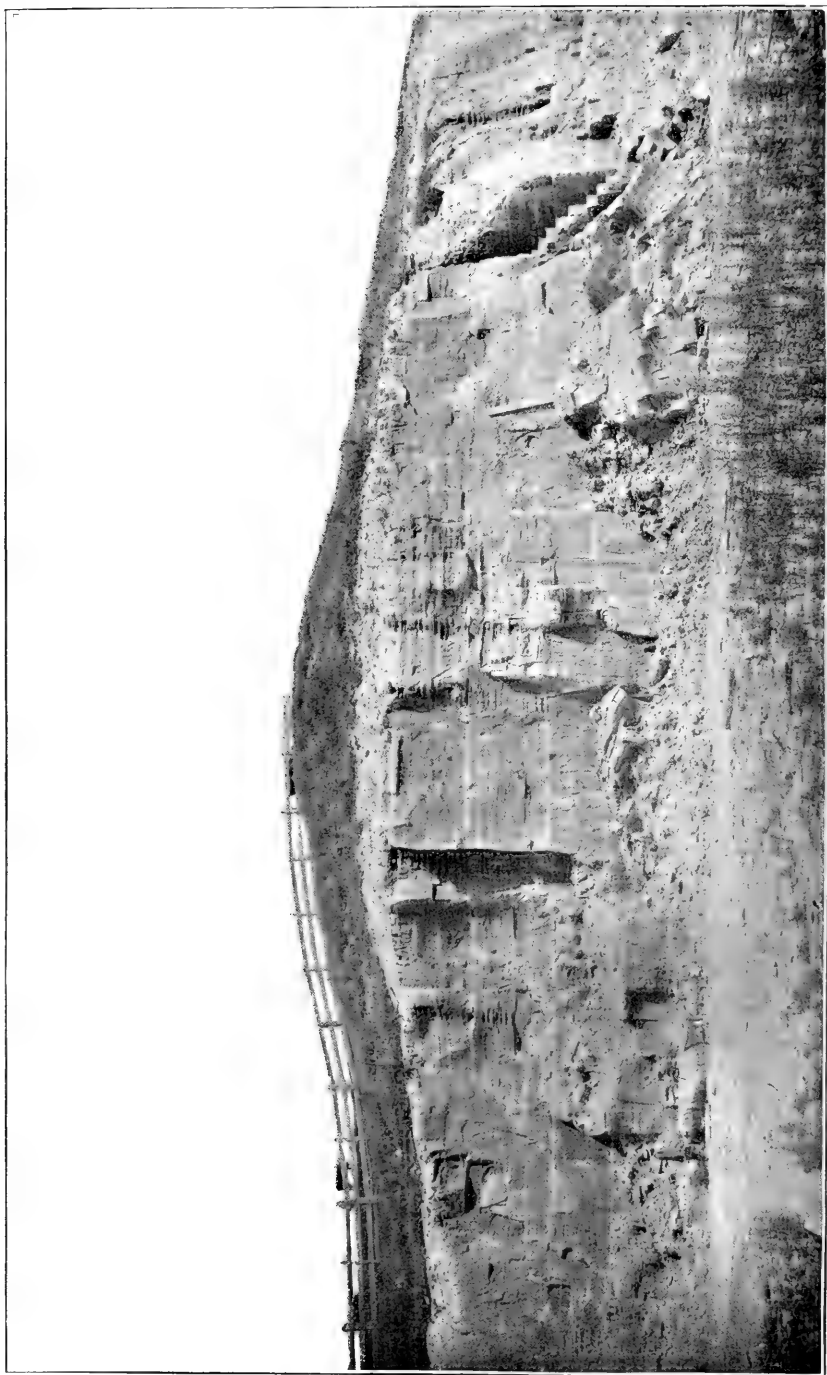


Fig. 2.

MICROSECTIONS SHOWING THE APPEARANCE OF (1) ALBANY COUNTY, WYOMING,
CLAY AND (2) FULLER'S EARTH.

The enlargement is the same in both cases.





LEDA CLAYS, LEWISTON, MAINE.
From a photograph by L. H. Merrill.

as a rule much less fusible than are the glacial or stratified clays, and are used mainly in the manufacture of fire brick, sewer pipe, terra cotta stoneware, as crocks, fruit jars, jugs, etc., glass and gas retorts, smelting pots, etc. Some of these articles are made direct from the natural clays, while others are from a mixture of several clays or of a clay mixed with powdered quartz and feldspar.

For ordinary brick-making purposes a great variety of materials are employed; in some cases residuary deposits, and in others alluvial and sedimentary. Throughout the glacial regions of the United States a fine unctious blue-gray material, laid down in estuaries during the Champlain epoch, the so-called Leda clays, are the main materials used for this purpose. Such are also sometimes used in making the cheaper kinds of pottery. The boulder clays of the glacial regions are also sometimes used when sufficiently homogeneous.

The prevailing colors of the Leda clays are blue-gray or yellowish. They all carry varying amounts of iron, lime, magnesia, and the alkalis, and when burned turn to red of varying tints. They fuse with comparative ease and are used mainly for brick and tile making and for the coarser forms of earthenware, such as flower pots, being as a rule mixed with siliceous sand to counteract shrinkage. The mining of such material is of the simplest kind, and consists merely of scraping away the overlying soil and sand, if such there be, and removing the clay in the form of sidehill cuts or open pits.

Plate 18, facing this page, shows a cut in one of the beds at Lewiston, Maine. The material here is fine and homogeneous, of a blue-gray color, and contains no appreciable grit. It is mixed with siliceous sand and used for making bricks, baking red. An analysis of the material in its air-dry state yielded results as below:

Silica (SiO_2)	56.17
Alumina (Al_2O_3)	24.25
Ferrous oxide (FeO)	3.54
Lime (CaO)	2.09
Magnesia (MgO)	2.57
Potash (K_2O)	4.06
Soda (Na_2O)	2.25
Ignition (H_2O)	4.69

99.62

Under the microscope these clays are seen to be made up of beautifully fresh, angular bits of quartz, feldspar, mica, hornblende, and augite, with more rarely tourmalines, zircons, and other refractory minerals, with a basis of extremely fine undetermined material which may perhaps be kaolin, though the general structure of the clay is such as to suggest it owes its origin mainly to mechanical trituration, rather than chemical decomposition. The appearance of the Lewiston clay under the microscope is shown in Plate 16, fig. 1. (See Specimens

Nos. 73036, 61041, and 61042, of these clays in their natural, mixed, and baked condition.)

One of the most constant distinctions between the so-called clays of glacial and nonglacial origin, are the relatively large amounts, in the first mentioned, of lime carbonate and alkalies and the extremely finely comminuted siliceous material to which the name *rock flour* is commonly given. Prof. W. O. Crosby, has shown that the smooth and plastic bluish-gray brick clays of West Cambridge contain only from one-fourth to one-third their bulk of the clay kaolin, the remainder being largely *rock flour*. [Proceedings of the Boston Society of Natural History, XXV, 1890.]

Leda clays from Beaver County, Pennsylvania, used in the manufacture of terra cotta at New Brighton, are reported¹ as having the following composition:

Silica	46.160	67.780
Alumina	26.976	16.290
Sesquioxide of iron.....	7.214	4.570
Titanic acid .....	.740	.780
Lime	2.210	.600
Magnesia.....	1.520	.727
Alkalies	3.246	2.001
Water	11.220	6.340
	99.286	99.088

Vitrified brick for street pavements are made from fusible clays, sometimes in their natural condition and sometimes mixtures of ground shale and clay. (See Specimens, Nos. 61141, 61142, and 68049, from Evansville, Indiana.)

The following analyses of the materials used by the Onondaga Vitrified Pressed Brick Company show the character of the materials there used:²

Constituents.	Calcareous layer in shale bank.	A green brick: being a mixture of the different shales.	Red shale.	Blue shale.	Clay.
Silica.....	25.40	54.25	52.30	57.79	45.35
Alumina	9.46	16.89	18.85	16.15	12.19
Peroxide of iron.....	2.24	5.81	6.55	5.20	4.41
Lime	22.81	4.34	3.36	2.73	10.99
Magnesia.....	10.39	5.21	4.49	4.67	6.38
Carbonic acid	20.96	4.30	3.04	3.42	7.24
Potash.....	.95	2.95	4.65	4.11	3.26
Soda.....		.83	1.35	1.22	1.14
Water and organic matter.....	7.60	5.01	5.30	4.50	8.90
Oxide of manganese.....			Trace.	Trace.	
Total	99.81	99.59	99.89	99.79	99.86

The name slip clay is given to a readily fusible, impalpably fine clay used for imparting a glaze to earthenware vessels. These clays carry

¹Second Geological Survey of Pennsylvania, Report of Chemical Analyses, p. 257.

²Bulletin of the New York State Museum, III, No. 12, March, 1895. Clay Industries of New York, p. 200.

iron oxides, potash and soda, together with lime and magnesia in such proportions that they vitrify readily, forming thus an impervious glass over those portions of the ware to which they are applied.

The following analyses show (I) the composition of a slip clay used in pottery works in Akron, Ohio, and (II) one from Albany, New York. (Specimen No. 53583, U.S.N.M.):

Constituents.	(I.) *	(II.)
Silica	60.40	58.54
Alumina	10.42	15.41
Iron sesquioxide	5.36	3.19
Lime	9.88	6.30
Magnesia	4.28	3.40
Alkalies	0.87	4.45
Sulphuric acid	0.65	1.10
Phosphoric acid	0.09	.....
Carbonic acid and water	8.05	8.08
Total	100.00	100.47

The Albany clay is stated by Nason¹ to glaze at comparatively low temperatures and to rarely crack or check. It occurs in a stratum 4 to 5 feet thick. It is used very extensively in the United States, and has even been shipped to Germany and France. (See also Specimens Nos. 53582, U.S.N.M., from Brimfield, Ohio; 53580, U.S.N.M., from Rowley, Michigan, and 52985, 52995, U.S.N.M., from Meissen, Saxony.)

The name *adobe* is given to a calcareous clay of a gray-brown or yellowish color, very fine grained and porous, which is sufficiently friable to crumble readily in the fingers, and yet has sufficient coherency to stand for many years in the form of vertical escarpments, without forming appreciable talus slopes. It is in common use throughout Arizona, New Mexico, and Mexico proper for building material, the dry adobe being first mixed with water, pressed in rough rectangular wooden molds some 10 by 18 or more inches and 3 or 4 inches deep, and then dried in the sun. In some cases chopped straw is mixed with it to increase its tenacity. Buildings formed of this material endure for generations and even centuries in these arid climates. The material of the adobe is derived from the waste of the surrounding mountain slopes, the disintegration being mainly mechanical. According to Prof. I. C. Russell it is assorted and spread out over the valley bottoms by ephemeral streams. It consists of a great variety of minerals, among which quartz is conspicuous. The chemical nature of the adobes vary widely, as would naturally be expected, and as is shown in the following analyses from Professor Russell's paper:²

¹Forty-seventh Annual Report of the State Geologist of New York, 1893, p. 468.

²Subaerial Deposits of North America, Geological Magazine, VI, 1889, pp. 289 and 342.

Analyses of adobe.

Constituents.	I, Santa Fe, New Mexico.	II, Fort Win- gate, New Mexico.	III, Humboldt, Nevada.	IV, Salt Lake City, Utah.
SiO ₂	66.69	26.67	44.64	19.24
Al ₂ O ₃	14.16	0.91	13.19	3.26
Fe ₂ O ₃	4.38	0.64	5.12	1.09
MnO	0.09	Trace.	0.13	Trace.
CaO	2.49	36.40	13.91	38.94
MgO	1.28	0.51	2.96	2.75
K ₂ O	1.21	Trace.	1.71	Trace.
Na ₂ O	0.67	Trace.	0.59	Trace.
CO ₂	0.77	25.84	8.55	29.57
P ₂ O ₅	0.29	0.75	0.94	0.23
SO ₃	0.41	0.82	0.64	0.53
Cl	0.34	0.07	0.14	0.11
H ₂ O	4.94	2.26	3.84	1.67
Organic matter	2.00	5.10	3.43	2.96
Total	99.72	99.97	99.79	100.35

The name *loess* is given to certain quaternary surface deposits closely simulating adobe, but concerning the origin of which there is considerable dispute. Deposits in the United States are, according to the best authorities, of subaqueous origin. Clays of this nature are, as a rule, higher in silica than the adobes and correspondingly poorer in alumina. Loess is a common surface deposit throughout the Mississippi Valley, and is in many instances of such consistency as to be utilized for brickmaking.

The analyses given below are from Professor Russell's paper:

Analyses of the loess of the Mississippi Valley.

Constituents.	No. 1.	No. 2.	No. 3.	No. 4.
SiO ₂	72.68	64.61	74.46	60.69
Al ₂ O ₃	12.03	10.64	12.26	7.95
Fe ₂ O ₃	3.53	2.61	3.25	2.61
FeO	0.96	0.51	0.12	0.67
TiO ₂	0.72	0.40	0.14	0.52
P ₂ O ₅	0.23	0.06	0.09	0.13
MnO	0.06	0.05	0.02	0.12
CaO	1.59	5.41	1.69	8.96
MgO	1.11	3.69	1.12	4.56
Na ₂ O	1.68	1.35	1.43	1.17
K ₂ O	2.13	2.06	1.83	1.08
H ₂ O	α 2.50	α 2.05	α 2.70	α 1.14
CO ₂	0.39	6.31	0.49	9.63
SO ₃	0.51	0.11	0.06	0.12
C	0.09	0.13	0.12	0.19
Total	100.21	99.99	99.78	99.54

α Contains H of organic matter, dried at 100° C.

The name fullers' earth (Walkerde, volaorde, terre à foulon, terra da purgatori, etc.) includes a variety of clay of a greenish white, greenish gray, olive and oil green or brownish color, very soft, with a greasy feeling. It falls into powder in water, imparts a milky hue to the liquid, and appears to melt on the tongue like butter. It was formerly used by fullers to take the grease out of cloth; hence the name.

The English beds, according to Geikie¹ occur in Jurassic and Cretaceous formations. Fullers' earth from beds at Nutfield, near Redhill, Surrey, England, is described² as a heavy blue or yellow clay, with a greasy feel and an earthy fracture.

When examined with a microscope it is found to consist of extremely irregular corroded particles of a siliceous mineral which in its least altered state is colorless, but which in nearly every case has undergone a chloritic or talcose alteration whereby the particles are inverted into a faintly yellowish green product almost wholly on polarized light. The particles are of all sizes up to 0.07 mm. The larger portion of the material is made up of particles fairly uniform in size and about the dimensions mentioned. In addition to these are minute colorless fragments down to sizes 0.01 mm. and even smaller.

The minute size of these colorless particles renders a determination of their mineral nature practically impossible. But the outline of the cleavage flakes is evidently suggestive of a soda lime feldspar. The high percentage of silica in the insoluble residue would indicate the presence of a considerable amount of free quartz. This, however, the microscope only partially substantiates, very few of the particles showing the brilliant polarization colors characteristic of this mineral.

When the powder is treated with hydrofluorsilicic acid it yields abundant crystals of potassium and aluminum fluosilicate, together with radiating forms of calcium fluosilicate. The material differs from that last described in that its particles are much larger and more angular in outline and the various elements in a different state of combination. (See Plate 17, fig. 2.)

A substance recently put upon the American market as a fullers' earth (Specimen No. 62737, U.S.N.M., from Enid, Oklahoma), under the trade name of "glacialite," has the following chemical composition, the material being dried at 100° C. before analyzing:

Silica	50.36
Alumina	33.38
Ferric oxide	3.31
Sodium, lithium, potassium oxide .....	.88
Water	12.05
Organic matter	Trace.
Titanium	Trace.
	<hr/> 99.98

¹Text book of Geology. 3d. ed. p. 133.

²Geological Magazine, VI, 1889, p. 47^c

This material when placed in water falls away to a loose flocculent powder, which shows up under the microscope in the form of sharply angular colorless particles, very faintly doubly refracting, without crystal outlines or other physical properties, such as will determine their exact mineral nature. The particles are of all sizes, from the larger flocculent masses, some 0.25 mm. in greatest diameter, down to those too small for measurement. The greater number lie between 0.005 and 0.01 mm., though a very large proportion are even smaller, not exceeding 0.002 mm. These smaller particles are angular in outline and almost perfectly colorless. Their appearance under the microscope is somewhat that of decomposed cherts.

In addition to the faintly doubly refracting particles above mentioned, there are occasional clear, colorless, sharply angular particles of a doubly refracting mineral which can only be referred to quartz. A few yellowish iron-stained particles are suggestive of residual products from decomposition of iron magnesian silicates.

The Gadsden County, Florida, fullers' earth (Specimens Nos. 53254 and 53255, U.S.N.M.) is a light-gray material, often blackened by organic matter, and which shows under the microscope the same greenish, faintly doubly refracting particles as does the English, intermixed with numerous angular particles of quartz. This earth is quite plastic and sticky when wet. A section of the beds at the pits of the Cheesebrough Manufacturing Company, as given in *The Mineral Resources for 1895-96*, is as follows:

Soil.....	inches..	18
Red clay.....	feet	3
Blue clay.....	do.....	3
Fullers' earth.....	do.....	5½
Sandy blue earth.....	do.....	3
Fullers' earth (second bed).....		



VIEW IN KAOLIN PIT, DELAWARE COUNTY, PENNSYLVANIA.

The following table¹ as compiled by Dr. Ries shows the variable character of the material from different sources:

Constituents.	Smectite from Cilly. <i>a</i>	Fullers' earth from Reigate. <i>b</i>	Malthite from Steindörfel. <i>c</i>	Fullers' earth from England. <i>d</i>	Fullers' earth from England. <i>e</i>	Fullers' earth from Gadsden County, Florida. <i>f</i>	Fullers' earth from Decatur County, Georgia. <i>f</i>	Fullers' earth from Fairborn, South Dakota. <i>g</i>	Fullers' earth from southeast of River Junction, Florida. <i>h</i>	Fullers' earth from between Mount Pleasant and Norway, Florida. <i>i</i>	Fullers' earth from near Norway, Florida. <i>j</i>
SiO ₂	51.21	53.00	50.17	44.00	44.00	62.83	67.46	58.72	50.70	58.30	54.60
Al ₂ O ₃	12.25	10.00	10.66	11.00	23.06	10.35	10.08	16.90	21.07	10.63	10.99
Fe ₂ O ₃	2.07	9.75	3.15	10.00	2.00	2.45	2.49	4.00	6.88	6.72	6.61
CaO	2.13	.50	.25	5.00	4.08	2.43	3.14	4.06	4.40	1.71	6.00
MgO	4.89	1.25	.....	2.00	2.00	3.12	4.09	2.56	.30	3.15	3.00
H ₂ O	27.89	24.00	35.83	.....	24.95	7.72	5.61	8.10	9.60	9.05	10.30
Na ₂ O .....	.....	.....	.....	5.00	.....	0.20	.....	} 2.11	.....	.....	.....
K ₂ O .....	.....	.....	.....	.....	.....	0.74	.....		.....	.....	.....
Moisture .....	.....	.....	.....	.....	.....	6.41	6.28	2.30	7.90	9.55	7.45
Total	100.44	98.50	100.06	77.00	100.09	96.25	99.15	98.75	100.85	99.11	98.95

a Pogg. Ann., LXXVII, 1849, p. 591.

b Klaproth. Beitr., Vol. IV, 1807, p. 338.

c Dana, System of Min., 1893, p. 695.

d Geikie, 1893, p. 133.

e Penny Encyclopedia, XI, Dr. Thompson, analyst.

f P. Fireman, analyst.

g E. J. Riederer, analyst.

h Standard Oil Company's property, E. J. Riederer, analyst.

i Howell property, E. J. Riederer, analyst.

j Morgan property, E. J. Riederer, analyst.

Properties of clay.—To what the peculiar properties displayed by the clays are due can not as yet be said to have been fully determined. This is particularly the case with the property of plasticity and that of becoming indurated when dried. “Various explanations have been offered, but none are yet advanced which make clear all points. It has been ascribed to the impurities, to the alumina, to the combined water, and to other causes, against each of which, examples can be cited that seem to set it aside as inadequate. The impurities do not appear to cause the plasticity, for the sand acts unfavorably to it. The alumina is not responsible, or kaolins would be the most plastic of all, while the flint clays of Ohio are many of them approximately pure kaolins, and at the same time eminently non-plastic.”² The combined water exerts some influence it is evident, as its expulsion entails permanent loss of plasticity, but it can not be the sole cause of plasticity, as clays equally hydrated are just as liable to differ in this respect as to agree. No theory is so well received at present as that advanced by Cook. He shows that the microscope reveals a crystalline structure which the eye does not detect, and that this structure varies greatly in degree of perfection in different samples. Some are composed of masses of

¹ Seventeenth Annual Report of the U. S. Geological Survey, 1895–96, p. 880.

² As is also kaolinite, the theoretically pure hydrous silicate of aluminum corresponding to the formula $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$.

hexagonal plates or scales piled up in long bundles or faces and masses of unattached scales nearly perfect. Such clays are always but little plastic, but may become so on mechanical treatment such as grinding and kneading; on re-examination the clay then shows the same elements of structure, but broken and confused, no bundles left intact, scales broken and a homogenous matrix of the crushed material derived from the still crystalline part. Clays are found in all states of this breaking up, from the highly crystalline mass to the homogenous matrix showing no plates at all; and on the degree in which the crystalline structure is retained, its plasticity depends. This theory is certainly plausible, and is supported by the fact that we always subject our clays to secure increased plasticity to mechanical disturbance which has the effect that the microscope reveals. This view harmonizes with more points than any other advanced as yet, and offers a fair solution of the different degrees of plasticity which plastic clays exhibit, but it does not explain, nor attempt to explain, the differences which exist between flint clays and plastic clays, as Professor Cook's examinations were entirely confined to the latter.¹

According to Russian authorities quoted by Ries,² the plasticity is not only due to the interlocking of the clay particles, but varies with the fineness of the grain, the extremely coarse and fine varieties having less plasticity than those of intermediate texture. This view is also held by Drs. Ries and Wheeler.

So far as the compiler's own observations go, plasticity is not dependent wholly upon hydration nor size nor shape of the constituent particles. The glacial (Leda) clays are made up of fresh, sharply angular particles of various minerals and contain less than 5 per cent combined water; yet in their natural condition they are extremely plastic, and scarcely less so when mixed with two-fifths their bulk of ordinary siliceous sand, as is done in the process of brickmaking. The Albany County, Wyoming, clay (Specimen No. 53229, U.S.N.M.), on the other hand, equally or even more plastic and exceedingly pasty, is made up of extremely minute particles of fairly uniform size, scarcely angular, and apparently all of the same mineral nature throughout. This yields some 16 per cent of water, on ignition, as shown in analysis, p. 348. On the whole, the evidence seems to show that the plasticity is due to the manner in which the particles conduct themselves toward moisture, and this is apparently dependent upon the size and shape and the proportional admixture of varying sizes of the constituents rather than upon their chemical composition. The work now being done by Dr. Whitney, of the Agricultural Department, on the relationship of soils to moisture bids fair to throw important light upon this branch of the subject.

¹ Geological Survey of Ohio, *Economic Geology*, V, pp. 651-652.

² Clay Deposits and Clay Industry in North Carolina, Bulletin No. 13, North Carolina Geological Survey, 1897.

The expulsion of the combined water in a clay is nearly always accompanied by a diminution in volume, which varies directly as the water, or the purity of the clay. Pure kaolin shrinks as much as one-fourth of its bulk, it is stated, sometimes even more. The sandy clays used in making sewer-pipe and stoneware shrink from the tempered state from one-ninth to one-sixteenth, usually about one-twelfth. The shrinkage of the raw clay would be very much less, probably not over 3 or 4 per cent.

A clay, when all the water of crystallization is expelled, will not shrink any more at red heat, but with increased heat will shrink more and more up to the moment of fusion. A pure kaolin apparently shrinks when heated a second time, even if the water is all expelled by the first heat, yet it is practically impossible to fuse it. But a good flint clay containing some sand will lose all shrinkage on being once calcined at white heat. Such clay is then used to counteract shrinkage in a body of green clay, as this effect is obtained by mixing in sand or some non-shrinking body. Many clays contain sand enough naturally to shrink little or none on heating, and some are so sandy as to actually expand, though usually at the expense of soundness of structure; for the particles of clay will shrink away from the grains of sand and this renders the structure very friable.

The qualifications of a clay for common pottery and building material are simple, viz., plasticity when wet, and solidity and hardness when burned, but those products involving the highest qualities of clay, refractoriness, require much sharper tests.

The first requisite is purity, at least purity within limits, and though the other points, density, plasticity, and non-shrinkage add greatly to the value of a pure clay, they can in no degree supply its place.

Infusibility in clays rests in the aluminous base and the quartz.

Long and intense heat applied to an intimate mixture of clay and silica is apt to result in a silicate of another ratio of base to acid, and which is likely to be fusible. But the great trouble with free silica in clay, in a fine state of division, is the fact that any fluxing agent readily unites with it, and makes a fluid slag; and in a refractory body the fusing of any one part is the beginning of the end.

The constituents tending to make a clay fusible are iron, the alkalies soda and potash, and lime and magnesia. It is hard to state which is of the most consequence. Of the first two, iron is not so powerful a flux as potash, which is the worst of all the common elements; but the iron is present in larger amounts than potash in most clays, and consequently does as much harm, if not more.

The effect of the iron is detrimental to the appearance of clay ware, and consequently has a direct bearing on the price of goods, while potash shows no more on the surface than on the inside, and when

present in the usual small amounts it produces an incipient vitrification which makes the ware ring like a bell when struck, and is often a help in selling.

The extent to which iron may be present without detriment is a point on which authorities do not agree. The Stourbridge clay of England, acknowledged to be the most refractory clay known, has 2.25 per cent of iron on an average of 100 analyses, with extremes of 1.43 and 3.63. Gros Almerode clay, has 2.12, Coblenz, 2.03, New Castle, 2.32, and yet all these clays are famous. Test mixtures of iron and pure kaolin have been run higher than this and have stood well, but as a general rule it is unsafe to rely for fine qualities on a clay with over 2 per cent of iron, particularly if the other impurities are developed in any amount. It is a well-known principle in chemistry that mixtures of bases are much more active fluxes than an equal amount of any one base; so with iron, its effect shows worse when in presence of other fluxing agents.

The state in which the iron is present makes some difference; if as the sesquioxide, it takes more heat than when in the protoxide state to combine in the clay, for iron will only combine with silica in the protoxide state, and if that state is already developed, it is easier to combine the sand and iron than if in the other oxide.

Sulphide of iron has a bad effect on the clay since its decomposition gives rise to the lower oxide of iron, besides the effect which the sulphur may have.

Silicate of iron is also detrimental, since it melts at a comparatively low temperature. On a piece of ware, iron in the uncombined state imparts a buff or red color; when combination begins and progresses the ware is of a bluish-gray cast, deepening as the fusion of the iron proceeds, and running to glassy black if much iron is present.

Lime and magnesia act as fluxes on clays, but in any but the glacial clays the comparatively small amounts present makes them but little thought of as detrimental. They are probably present as silicates, and as these are readily fusible, their action is evidently unfavorable. When these bases are present as carbonates they combine at a higher temperature than iron or potash. The Milwaukee bricks, as already noted, are full of carbonates of lime and magnesia, and require a very hot burn, but when once the lime and silica combine they destroy the effect of 5 per cent of iron, enough to make the clay perfectly black. A brick of this kind presents an even, fine-grained, vitrified appearance on its fracture.¹

¹They (lime and magnesia) have also the remarkable property of uniting with the iron ingredient to form a light-colored alumina-lime-magnesia-iron silicate, and thus the product is cream-colored instead of red. Mr. Sweet has shown by analysis that the Milwaukee light-colored brick contain even more iron than the Madison red brick. At numerous points in the Lake region and in the Fox River valley cream-

The amount of potash which a clay can contain and keep its fire properties is variously put by different authorities. As with iron, pure kaolin will stand a good deal when no other base is present, but a multiplicity of bases makes fusion easy. Titanic acid is regarded as neutral to fire qualities; the form in which it is present being infusible.

Testing clays.—The statement of the tendencies and comparative power of the dangerous impurities of clay would lead us to believe we could use predictions as to their result in a given clay with some confidence, but the best practice does not yet trust to analysis alone.

The most complete test of a clay now known would be obtained by use of such analysis as has been described, coupled with a fire test made especially to develop such points as the analysis indicates to be weak ones. Fire tests are of two kinds—one is subjecting the clay to absolute heat without the action of any accompaniments, and the other is in putting the clay through the course of treatment for which it is designed to be used. The former develops the absolute quality of the clay as good or bad, the latter proves or disproves the fitness of the clay for the work. The latter is better of course as a business test wherever it is practicable to use it. The former can be made only in a specially adapted furnace. The clay is cut into one-inch cubes with square edges, and is set in a covered crucible resting on a lump of clay of its own kind, so that it touches no foreign object. The heat is then applied, and its effect will vary from fusing the mass to a button to leaving it with edges sharp and not even glazed on the surface. Experience soon renders one proficient in judging of clays by this test.¹

A method of testing the fusibility of clays by comparing them with samples of known composition and fusibility has of late years come into extensive use. These prepared samples, known from their inventor and their shape as Seger's pyramids, consist of mixtures in varying proportions of kaolin and certain fluxes, so prepared that there is a constant difference between their fusing points. When such pyramids, together with the samples to be tested, are placed in a furnace or kiln,

colored brick are made from red clays. In nearly or quite all cases, whatever the original color of the clay, the brick are reddish when partially burned. The explanation seems to be that at a comparatively moderate temperature the iron constituent is deprived of its water and fully oxidized, and is therefore red, while it is only at a relatively high heat that the union with the lime and magnesia takes place, giving rise to the light color. The calcareous and magnesian clays are, therefore, a valuable substitute for true aluminous clays, for they not only bind the mass together more firmly, but give a color which is very generally admired. They have also this practical advantage, that the effects of inadequate burning are made evident in the imperfect development of the cream color, and hence a more carefully burned product is usually secured. It is possible to make a light-colored brick from a clay which usually burns red by adding lime. The amount of lime and magnesia in the Milwaukee brick is about 25 per cent. In the original clays in the form of carbonates they make up about 40 per cent. *Geology of Wisconsin, I, 1873-79, p. 669.*)

¹Geological Survey of Ohio, *Economic Geology*, V, pp. 652-655.

they begin to soften as the temperature is raised, and as it approaches their fusion point the cones bend over until the tip is as low as the base. When this occurs the temperature at which they fuse is considered to be reached.¹

Uses.—Clay when moistened with water is plastic and sufficiently firm to be fashioned into any form desired. It can be shaped by the hands alone; by the hands applied to the clay as it turns with the potter's wheel, or it can be shaped by moulds, presses or tools. When shaped and dried, and then burned in an oven or kiln, it becomes firm and solid, like stone; water will not soften it, it has entirely lost its plastic property, and is permanently fixed in its new forms, and for its designed uses. These singular and interesting properties are possessed by clay alone, and it is to these it owes its chief uses. It is used (1) for making pottery; (2) for making refractory materials; (3) for making building materials; (4) for miscellaneous purposes.

Pottery.—Pure clay worked into shapes and burned, constitutes earthenware. The ware of itself is porous, and will allow water and soluble substances to soak through it. To make it hold liquids, the shaped clay before burning is covered with some substance that in the burning of the ware will melt and form a glass coating or glazing which will protect the ware in its after uses from absorbing liquids, and give it a clean smooth surface. The color of the ware depends on the purity of the clay. Clays containing oxide of iron burn red, the depth of color depending on the amount of the oxide, even a small fraction of 1 per cent being sufficient to give the clay a buff color.

Clay containing oxide of iron in sufficient quantity to make it partially fusible in the heat required to burn it, when made into forms and burned, is called stoneware clay. The heat is carried far enough to fuse the particles together so that the ware is solid and will not allow water to soak through it; and the fusion has not been carried so far as to alter the shapes of the articles burned. The oxide of iron by the fusion has been combined with the clay, and instead of its characteristic red, has given to the ware a bluish or grayish color. Stoneware may be glazed like earthenware, or by putting salt in the kiln, when its vapor comes in contact with the heated ware and makes with it a sufficient glaze.

Clay which is pure white in color and entirely free from oxide of iron, may be intimately mixed with ground feldspar or other minerals which contain potash enough to make them fusible, and the mixture still be plastic so as to be worked into forms for ware. When burned, such a composition retains its pure white color, while it undergoes

¹See Dr. Ries's paper on North Carolina clays, already quoted, and also his numerous contributions on their subject in the volumes of the United States Geological Survey relating to mineral statistics.

fusion sufficient to make a body that will not absorb water. And its surface can be made smooth and clean by a suitable plain or ornamented glaze. Ware of this kind is porcelain or china.

The analyses on page 349, compiled from works believed to be authoritative, show the varying character, so far as chemical composition is concerned, of the clays. In most of the analyses, it will be observed, the silica existing in the form of quartz is given in a separate column from the combined, while in column 4 is given the actual calculated percentage of kaolin which the analyses indicates each sample contains.

Refractory materials.—Modern improvements in metallurgy, and in furnaces for all purposes, are dependent to a great degree on having materials for construction which will stand intense heat without fusing, cracking, or yielding in any way. The two materials to which resort is had in almost all cases, are pure clay, and quartz in the form of sand or rock. They are both infusible at the highest furnace heats. The clay, however, is liable to have in it small quantities of impurities which are fusible, and it shrinks very much when heated to a high temperature. Quartz rocks are very liable to crack to pieces if heated too rapidly, and both the rocks and sand are rapidly melted when in contact with alkalis, earths or metallic oxides, at a high temperature. They do not shrink in heating. Sandstone, or quartz rock, is not as much used as a refractory material as it was formerly. Bricks to resist intense heat are made of clay, of sand, and of a mixture of clay and sand. The different kinds are specially adapted to different uses.

Fire bricks made of clay, or clay and sand, are the ones which have been generally made in the United States. To make these, the clay which stands an intense heat the best, is selected as the plastic material of the brick. This is tempered so that it may not shrink too much or unevenly in burning, by adding to the raw clay a portion of clay which has been burned till it has ceased to shrink and then ground, or a portion of coarse sand, or a quantity of so-called feldspar. These materials are added in the proportions which the experience of the manufacturer has found best. The formula for the mixture is the special property of each manufacturer, and is not made public. The materials, being mixed together and properly wet, are molded in the same way as common bricks are, and after they have dried a little, they are put into a metallic mould and subjected to powerful pressure. They are then taken out, dried, and burned in a kiln at an intense heat.

It does not appear which is the best for tempering, burned and ground clay, or coarse sand, or feldspar. Reputable manufacturers are found who use each of these materials, and make brick that stand fire well. It is of the utmost importance to select the materials care-

fully, and to allow no impurity to get in while handling the clay or working the components together.

Fire bricks intended, in addition to their refractory qualities, to retain their size and form under intense heat without shrinkage, have been made to some extent. The English Dinas bricks are of this kind, and the German and French "silica bricks." The Dinas bricks are of quartz sand or crushed rock, and contain very little alumina and about one per cent of lime. They stand fire remarkably well, the lime being just enough to make the grains of sand stick together when the bricks are intensely heated. In the other "silica bricks," fire clay to the amount of 5 or 10 per cent is mixed with the sand, and this plastic material makes the particles of the sand cohere sufficiently to allow of handling the bricks before burning. They have met the expectation of those who made them, and are extensively used.¹

Under the head of "Miscellaneous uses of clay," p. 317, Cook gives the following, which may well be incorporated entire:

Paper clay.—Clay which is pure white and that also which is discolored and has been washed to bring it to a uniform shade of color, is used by the manufacturers of paper hangings, to give the smooth satin surface to the finished paper. It is used by mixing it up with a thin size, applying it to the surface of the pieces of paper, and then polishing by means of brushes driven by machinery. The finest and most uniformly colored clays only are applicable to this use, and they are selected with great care. Clay is also used to some extent by paper manufacturers, to give body and weight to paper.

Heavy wrapping paper, such as is used by the United States Post-Office Department, must, according to specifications, contain 95 per cent of jute butts and 5 per cent of clay. The cheaper forms of confectionery, particularly such as is sold from carts upon the streets, is very heavily adulterated with this material.

Alum clay.—A large quantity of clay is sold every year to the manufacturers of chemicals, for making alum. A rich clay is needed for this purpose, but those containing lignite or pyrite which renders them inapplicable for refractory materials, do not spoil them for this use. Alum is made by digesting the clay in sulphuric acid, which forms sulphate of alumina, then dissolving out the latter salt from the silica and other impurities, and forming it into alum by the addition of the necessary salt of potash, soda, or ammonia, and crystallizing out the alum.

The white clay of Gay Head and Chilmark, Marthas Vineyard, Massachusetts, was at one time used extensively for alum making, according to Edward Hitchcock.²

As a substitute for sand in making mortar and concrete clay is perhaps the best material to be found. For this purpose the clay is burnt so that it is produced in small irregular pieces that are very hard and durable. These pieces are then ground to a fairly fine powder, which is used to mix with the lime or cement just as sand would be. The

¹ Geological Survey of New Jersey, Report on Clay Deposits, pp. 307-312.

² American Journal of Science, XXII, 1832, p. 37.

result is a very strong mortar, in some cases stronger than when sand is employed.¹

The so-called gumbo clays, sticky, tough, and dark-colored clays of the Chariton River region, Missouri, are hard burned and used for railroad ballast and macadam.

Under the names of *Rock Soap* and *Mineral Soap* there have from time to time been described varieties of clay which, owing to their soapy feeling, are suggestive of soap, and which in a few instances have been actually used in the preparation of this material.

A rock soap from Ventura County, California, has been described by Prof. G. H. Koenig as a mixture of sandy and clayey or soapy material in the proportion of 45 per cent of the first and 55 per cent of the second. The chemical composition of the material and of the two portions is given below:

Constituents.	Crude material.	Sandy portion.	Soapy portion.
Silica	67.55	69.40	73.10
Alumina and iron.....	12.97	13.50	14.10
Lime	0.77	0.30	} Not determined.
Magnesia.....	0.85	Trace.	
Potash.....	1.43	} 4.55	
Soda.....	3.63		
Water	13.67			12.25
			6.70

Nearly all the silica is reported as being in a soluble or opalescent state and the alumina as either a hydrate or very basic silicate. It is said² that at one time the material was made into a variety of useful articles, as "salt water soap," scrubbing and toilet soap, tooth powder, etc.

A somewhat similar material from Elk County, Nevada, has been used for like purposes, and put upon the market under the name of San-too-gah-choi mineral soap. This clay is of a drab color, with a slight pinkish tint, a pronounced soapy feeling and slight alkaline reaction when moistened and placed upon test paper. An analysis by Packard in the laboratory of the U. S. National Museum yielded:

Silica	48.80
Alumina	18.57
Iron oxides	3.88
Lime	1.07
Magnesia	2.52
Soda	2.32
Potash	1.12
Ignition	21.13
Total	99.41

¹The Worlds Progress, February, 1893.

²Sixth Annual Report of the State Mineralogist of California, 1886, Pt. 1, p. 132.

Mention may be made here also of the material sold in the shops under the name of Bon Ami and used for cleansing glass and other like substances. This under the microscope shows abundant minute sharply angular particles, consisting of partially decomposed feldspar mixed with a completely amorphous mineral which may be opalescent silica or possibly a very finely comminuted pumice. An analysis by Packard in the laboratory of the Department yielded:

Silica.....	59.86
Alumina.....	18.74
Magnesia.....	0.34
Potash.....	10.70
Soda.....	3.51
Ignition.....	7.67
Total.....	100.82

Alcohol extracts 7.43 per cent, and water 0.244 per cent in addition, the extract having a soapy appearance and the odor of some essential oil.

A soapy clay occurring near Rock Creek station, in Albany County, Wyoming, has been shipped in considerable quantities during the past few years to New York, Philadelphia, and Chicago, but the use to which it was put remains a secret. It is stated¹ that at first the material was sold at the rate of \$25 a ton, but that the price has now dropped to \$5 a ton. Analyses are given as below. The chief physical characteristic of this clay, aside from its soapy feeling, is its enormous absorptive power, the absorption being attended naturally with an increase in bulk amounting to several times that of the original mass.² Plate 17, fig. 11 shows the extreme fineness and homogeneity of this clay as seen under the microscope.

Constituents.	I. Rock Creek.	II. Crook County.	III. Weston County.	IV. Natrona County.
SiO ₂	59.78	61.08	63.25	65.24
Al ₂ O ₃	15.10	17.12	12.62	15.88
Fe ₂ O ₃	2.40	3.17	3.70	3.12
MgO.....	4.14	1.82	3.70	} 5.34
CaO.....	0.73	2.69	4.12	
Na ₂ O, K ₂ O.....	(a)	b 0.20	.....	(a)
SO.....	(a)	0.88	1.53	(a)
H ₂ O.....	16.26	.....	.....	9.17
Specific gravity.....	.....	.....	2.132	.....

a No estimate.

b NaO.

¹ Engineering and Mining Journal, LXIII, 1897, p. 600; LXVI, 1898, p. 491.

² A small plug of this clay fitted to accurately occupy a space of 20 cubic centimeters in the bottom of a conical measuring flask, and kept saturated with water for two days, swelled to a bulk of 160 cubic centimeters. The absorption was so complete that none of the water ran off when the flask was inverted, and the condition of the clay resembled that of flour or starch paste.

Composition of clays.

Name of company and location.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	Authority.
	Combined silica (SiO ₂).	Alumina (Al ₂ O ₃).	Combined water (H ₂ O).	Percent of the kaolin base.	Quartz (free SiO ₂).	Titanic acid (TiO ₂).	Total sandy material.	Sesquioxide of iron (Fe ₂ O ₃).	Lime (CaO).	Magnesia (MgO).	Potash (K ₂ O).	Soda (Na ₂ O).	Total deleterious impurity.	Molsture.	Sum total.	
<i>China clays.</i>																
Kaolin (washed), Hockessin, New-castle County, Delaware.	40.72	34.10	12.35	87.17	6.50			2.49		0.39	1.64	0.27	4.79	1.35	99.81	
China clay, Redruth, Cornwall, England.	28.40	34.11	7.20	59.71	37.80	0.20	38.00	0.79			0.96		1.75	0.70	100.16	Report on Clay Deposits, Geological Survey of New Jersey.
China clay, from Huron, Lawrence County, Indiana.	40.10	36.35	22.60	99.05	0.40	0.00	0.40	0.15		0.13	0.14		0.42		99.87	Do.
China clay, St. Yrieux, France....	48.37	34.95	12.62					1.26				2.40				
<i>Potters' clays.</i>																
Brumage's stoneware clay, Roseville, Ohio.	25.60	19.08	5.57	50.25	43.73	0.29	44.02	1.26	0.60	0.63	2.14	0.02	4.65	0.94	99.86	Geol. Survey of Ohio, Vol. V.
Allen's stoneware clay, Roseville, Ohio.	28.61	23.01	8.03	59.65	34.79	0.35	35.11	1.50	0.41	0.62	1.26	Tr. Li ₂ O.	3.81	1.97	100.57	Do.
Walker's stoneware clay, Roseville, Ohio.	69.79	19.31	5.08	94.18	With clay.								By diff.	0.94	100.00	Do.
Uniontown stoneware clay, Perry County, Ohio.	29.35	23.05	7.39	59.79	35.85	0.55	36.40	0.99	0.58	0.58	1.45	Tr. Li ₂ O.	3.60	1.11	100.90	Do.
Myers, Atchison & Co., North Springfield, Ohio, stoneware.	72.10	19.38	5.13	96.61					1.38	0.23			1.61	1.12	99.34	Do.
Do	68.2	22.61	5.56	96.41					0.99	0.11			1.10	1.00	98.51	Do.
Do	69.0	21.37	6.00	96.42					1.70	0.21			1.91	1.00	99.33	Do.
East Liverpool, Ohio (yellow-ware clay).	42.2	24.12	7.77	74.17	18.02	1.20	19.22	1.46	0.59	0.68	2.42	Tr.	5.15	0.86	99.40	Do.

Composition of clays—Continued.

Name of company and location.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	Authority.
	Combined silica (SiO ₂).	Alumina (Al ₂ O ₃).	Combined water (H ₂ O).	Per cent of the kaolin base.	Quartz (free SiO ₂).	Titanic acid (TiO ₂).	Total sandy material.	Sesquioxide of iron (Fe ₂ O ₃).	Lime (CaO).	Magnesia (MgO).	Potash (K ₂ O).	Soda (Na ₂ O). Lithia (Li ₂ O).	Total deleterious impurity.	Moisture.	Sum total.	
<i>Potters' clays—Continued.</i>																
H. Cutter & Sons, Woodbridge, New Jersey.	43.90	38.24	14.10	96.24	1.10	1.30	2.40	0.96	0.00	0.11	0.15	0.00	1.22	0.70	100.56	Report on Clay Deposits, Geol. Survey of New Jersey.
Blue Ball clay, Pennsylvania.	44.55	39.00	13.66	97.21		1.70		1.44	0.02	0.07	0.53		2.06		100.98	Geol. Survey of Ohio, Vol. V.
<i>Pipe clay.</i>																
N. U. Walker, Walker's Station, Ohio (sewer pipe).	39.03	27.88	8.87	75.08	15.50	1.26	16.76	2.41	0.42	0.68	3.31	0.12	6.94	0.76	99.54	Geol. Survey of Ohio, Vol. V.
Bolivar clay, Island Siding, Ohio (ft for pipe).	35.73	28.69	9.67	74.09	16.07	0.72	16.79	2.77	0.77	1.41	2.57	0.25	7.77	1.72	100.37	Do.
W. H. Evans, Waynesburg, Ohio (drain pipe).	16.20	15.89	7.07	39.16	52.69	0.16	52.85	2.86	0.59	0.66	2.23	0.29	6.61	1.03	99.65	Do.
A. O. Jones, Columbus, Ohio (drain tile).	14.50	12.63	7.30	34.43	56.80		56.80	5.07	1.05				6.12		99.35	Do.
Whitmore, Robinson & Co., Akron, Ohio (kaolinite slip clay).	60.40	10.42	H ₂ SO ₄ 0.65.	H ₃ PO ₄ 0.09.	CO ₂ + H ₂ O 8.05.			5.36	9.88	4.28		0.87	20.39		100.00	Do.
<i>Fire clay.</i>																
C. E. Holden, Mineral Point, Ohio.	35.39	31.84	11.68	78.91	17.13	1.68	18.81	0.67	0.50	0.19	0.59	0.00	1.95	0.69	100.36	Geol. Survey of Ohio, Vol. V.
Scioto Fire Brick Co., Sciotoville, Ohio.	43.78	40.82	13.77	97.97				With Al ₂ O ₃ .						0.82	98.79	Do.
Do.	52.56	34.80	10.50	97.80	With clay.			1.00		1.20			2.20		100.00	Do.
Wassall Fire Clay Co., Columbus, Ohio.	60.77	25.74	9.46	95.97	With clay.			1.61	0.89	0.63	1.20		4.83		100.30	Do.

Island Fire Clay Co., near Steubenville, Ohio.	29.22	24.97	8.90	63.09	31.34	1.30	32.64	1.66	0.63	0.40	0.28	Tr.	2.97	1.69	100.39	Do.
Ballou clay, Zanesville, Ohio	31.07	26.47	9.96	67.50	27.71	0.94	28.65	1.22	0.59	0.32	0.99	Tr. Ld.	3.12	1.04	100.31	Do.
Etna Fire Brick Co., Oakhill, Ohio.	63.12	26.20	10.72	100.05	With clay.	.....	.....	.....	This is a plastic clay.	.....	.....	.....	.....	.....	100.05	Do.
B. Ellison, south-southwest of Bonhamtown, New Jersey.	17.90	15.50	4.90	38.30	57.35	1.60	58.95	1.20	.....	.....	0.17	.....	1.37	1.30	99.92	Do.
<i>Brick clay</i>																
Milwaukee brick clay, Wisconsin.	38.22	9.75	1.85	49.82	.....	CaO	FeO	2.84	CaCO ₃	MgCO ₃	2.16	0.65	49.07	0.95	99.84	Geol. Survey of Ohio, Vol. V.
Mount Savage, Maryland	39.90	30.08	7.00	77.58	16.90	3.24	1.16	1.67	23.20	15.83	.....	.....	3.97	0.90	100.50	Report on Clay Deposits, Geol. Survey of New Jersey.
Newcastle, England	55.50	27.75	10.57	93.78	.....	.....	.....	2.01	0.67	0.75	2.19	0.44	6.06	.....	99.84	Geol. Survey of Ohio, Vol. V.
Sayre & Fisher, front brick clay, Sayreville, New Jersey.	28.30	27.42	6.60	62.32	27.80	1.00	28.80	2.68	.....	0.18	2.71	.....	5.57	2.90	99.59	Report on Clay Deposits, Geol. Survey of New Jersey.

The bibliography of clays is very extensive, and but a few references are given here. The reader is referred particularly to Branner's Bibliography of Clays and the Ceramic Arts,¹ and to the papers of Dr. H. Ries in the reports on the Mineral Resources of the United States, published annually by the U. S. Geological Survey.

S. W. JOHNSON, JOHN M. BLAKE. On Kaolinite and Pholerite.

American Journal of Science, XLIII, 1867, p. 351.

J. C. SMOCK. The Fire Clays and associated Plastic Clays, Kaolins, Feldspars, and Fire Sands of New Jersey.

Transactions of the American Institute of Mining Engineers, VI, 1877, p. 177.

GEORGE H. COOK. Report on the Clay Deposits of Woodbridge, South Amboy, and other places in New Jersey.

Geological Survey of New Jersey, 1878.

RICHARD C. HILLS. Kaolinite, from Red Mountain, Colorado.

American Journal of Science, XXVII, 1884, p. 472. See also Bulletin No. 20, U. S. Geological Survey, 1885, p. 97.

J. P. LESLEY. Some general considerations respecting the origin and distribution of the Delaware and Chester kaolin deposits.

Annual Report Geological Survey of Pennsylvania, 1885, p. 571.

J. H. COLLINS. On the Nature and Origin of Clays: The Composition of Kaolinite.

Mineralogical Magazine, VII, December, 1887, p. 205.

J. FRANCIS WILLIAMS, R. N. BRACKET. Newtonite and Rectorite—two new minerals of the Kaolinite Group.

American Journal of Science, XLII, 1892, p. 11.

EDWARD ORTON. The Clays of Ohio, Their Origin, Composition, and Varieties.

Report of the Geological Survey of Ohio, VII, 1893, pp. 45-68.

EDWARD ORTON, jr. The Clay Working Industries of Ohio.

Report of the Geological Survey of Ohio, VII, 1893, pp. 69-254.

H. O. HOFMAN, C. D. DEMOND. Some Experiments for Determining the Refractoriness of Fire Clays.

Transactions of the American Institute of Mining Engineers, XXIV, 1894, p. 42.

W. MAYNARD HUTCHINGS. Notes on the Composition of Clays, Slates, etc., and on some Points in their Contact-Metamorphism.

The Geological Magazine, I, 1894, p. 36.

H. JOCHUM. The Relation between Composition and Refractory Characters in Fire Clays.

Minutes of Proceedings of the Institution of Civil Engineers, CXX, 1894-95, p. 431.

J. A. HOLMES. Notes on the Kaolin and Clay Deposits of North Carolina.

Transactions of the American Institute of Mining Engineers, XXV, 1895, p. 929.

HEINRICH RIES. Clay Industries of New York.

Bulletin No. 12 of the New York State Museum, III, March, 1895, pp. 100-262.

JOHN CASPER BRANNER. Bibliography of Clays and the Ceramic Arts.

Bulletin No. 143, U. S. Geological Survey, 1896.

W. S. BLATCHLEY. A Preliminary Report on the Clays and Clay Industries of the Coal and Coal-Bearing Counties of Indiana.

The School of Mines Quarterly, XVIII, 1896, p. 65.

W. MAYNARD HUTCHINGS. Clays, Shales, and Slates.

The Geological Magazine, III, 1896, p. 309.

CHAS. F. MABERY, OTIS T. FLOOZ. Composition of American Kaolins.

Journal of the American Chemical Society, XVIII, 1896, p. 909.

¹ Bulletin No. 143, U. S. Geological Survey, 1896.

- CHAS. F. MABERY, OTIS T. FLOOZ. Clay, Bricks, Pottery, etc.
Thirteenth Report of the California State Mineralogist, 1896, p. 612.
- THOMAS C. HOPKINS. Clays and Clay Industries of Pennsylvania.
Appendix to the Annual Report of the Pennsylvania State College for 1897.
- J. NELSON NEVIUS. Kaolin in Vermont.
Engineering and Mining Journal, LXIV, 1897, p. 189.
- HEINRICH RIES. The Clays and Clay-Working Industry of Colorado.
Transactions of the American Institute of Mining Engineers, XXVII, 1897, p. 336.
- H. A. WHEELER. Clay Deposits.
Missouri Geological Survey, XI.
- W. W. CLENNENIN. Clays of Louisiana.
Engineering and Mining Journal, LXVI, 1898, p. 456.
- M. H. CRUMP. The Clays and Building Stones of Kentucky.
Engineering and Mining Journal, LXVI, 1898, p. 190.
- W. C. KNIGHT. Bentonite. [A New Clay.]
Engineering and Mining Journal, LXVI, 1898, p. 491.
- The Building Stones and Clays of Wyoming.
Engineering and Mining Journal, LXVI, 1898, p. 546.
- HEINRICH RIES. Physical Tests of New York Shales.
School of Mines Quarterly, XIX, 1898, p. 192.
- The Ultimate and the Rational Analysis of Clays and Their Relative Advantages.
Transactions of the American Institute of Mining Engineers, XXVIII, 1898, p. 160.
- EUGENE A. SMITH. The Clay Resources of Alabama and the Industries Dependent upon Them.
Engineering and Mining Journal, LXVI, 1898, p. 369.
- J. E. TODD. The Clay and Stone Resources of South Dakota.
Engineering and Mining Journal, LXVI, 1898, p. 371.

VII. NIOBATES AND TANTALATES.

1. COLUMBITE AND TANTALITE.

These are columbates and tantalates of iron and manganese, columbite representing the nearly pure columbate and tantalite the nearly pure tantalate. Both are likely to carry varying quantities of iron and manganese. The analyses given below will serve to show the varying composition, No. I being columbite from Greenland, No. II from Haddam, Connecticut, and Nos. III and IV from the Black Hills of South Dakota:

Constituents.	I.	II.	III.	IV.
Columbium pentoxide	77.97	51.53	54.09	29.78
Tantalum pentoxide		28.55	18.20	53.28
Iron protoxide	17.33	13.54	11.21	6.11
Manganese protoxide	3.28	4.55	7.07	10.40

With traces of tin, wolfram, lime, magnesia, etc.

The mineral is of an iron black, grayish or brownish color, opaque, often with a bluish iridescence, dark red to black streak, specific gravity varying from 5.3 to 7.3 and hardness of 6. Insoluble in acids.

Occurrence.—The mineral occurs in granitic and feldspathic veins in the form of crystals, crystalline granules, and cleavable masses. In the United States it has been found in greater or less abundance in nearly all the States bordering along the Appalachian Mountain system (Specimen No. 63478, from Portland, Connecticut), in the Black Hills of South Dakota, and also in California and Colorado. It has also been found in Italy, Bavaria, Finland, Greenland, and western South America.

Uses.—The material is used only in the preparation of salts of columbium and tantalum, and as but a small quantity of these salts are used, the mineral is in but little demand, except as mineralogical specimens.

2. YTTROTANTALITE.

This name is given to a mineral closely related to samarskite (see below), but carrying smaller percentages of uranium and lacking in didymium and lanthanum. It is essentially a tantalate of yttrium with small amounts of other of the rarer earths. (Specimen No. 60926, U.S.N.M.) In appearance it is distinguished from samarskite only with difficulty. Pyrochlore, fergusonite, æschynite, euxenite, etc., are closely related compounds, the commercial uses of which have not yet been demonstrated.

3. SAMARSKITE.

Composition as given below. When crystallized, in the form of rectangular prisms, but occurring more commonly massive and in flattened granules. Cleavage, imperfect; fracture conchoidal; brittle. Hardness, 5 to 6; specific gravity, 5.6 to 5.8. Luster, vitreous to resinous. Color, velvet black. (Specimen No. 62772, U.S.N.M.)

Constituents.	I.	II.	III.	IV.
Columbic oxide	54.81	54.96	55.13	37.20
Tantallic oxide				18.60
Tungstic and stannic oxides		0.16	0.31	0.08
Uranic oxide	17.03	9.91	10.96	12.46
Ferrous oxide	14.07	14.02	11.74	10.90
Manganous oxide		0.91	1.53	0.75
Cerous oxide, etc	3.95	5.17	4.24	4.25
Yttria	11.11	12.84	14.49	14.45
Magnesia			Trace.	
Lime		0.52		0.55
Loss by ignition	0.24	0.66	0.72	1.12
Insoluble		1.25		
	101.21	100.40	99.12	100.36

Localities and mode of occurrence.—The only localities of importance in the United States are the Wiseman Mica Mine and Grassy Creek Mine, in Mitchell (Specimen No. 62772, U.S.N.M.) and in McDowell

counties, North Carolina. The mineral has also been found in the form of black grains and pebbles, sometimes weighing one-fourth of an ounce, in the gold-bearing sands of Rutherford County. At the Wiseman Mine large masses, one weighing upwards of 20 pounds, were found some years ago. The analyses quoted above were made from material from this mine.¹

Uses.—See under Monazite, p. 383.

4. WOLFRAMITE AND HÜBNERITE.

Composition, a tungstate of manganese, and iron. The proportion of the iron and manganese are quite variable, the tungsten remaining nearly constant. The name hübnerite is given to the variety containing very little iron, but consisting essentially of tungsten and manganese. The following table shows the range in composition:

Locality.	WO ₃ .	FeO.	MnO.	CaO.	MgO.
Wolframite:					
Adun-Chalon.....	75.55	21.31	2.37	0.26	0.51
Monroe, Connecticut	75.47	9.53	14.26	.....	.....
Hübnerite:					
Bonita, New Mexico.....	76.33	3.82	19.72	0.13	Trace.
Nye County, Nevada	74.88	0.56	23.87	0.14	0.08

Wolframite is dark reddish brown to black in color, with a resinous luster; has a hardness of about 5, a specific gravity of 7.55, and a pronounced tendency to cleave with flat, even surfaces. Its great weight, color, and cleavage tendencies are strongly marked characteristics, and the mineral once identified is as a rule easily recognized.

Occurrence.—The mineral is found in veins associated with tin ore (cassiterite), and also with quartz, pyrite, galena, sphalerite, etc. The chief known localities in the United States are Monroe and Trumbull, Connecticut; Blue Hill Bay, Maine; Rockbridge County, Virginia (Specimen No. 65206, U.S.N.M.); the Mammoth district, Nye and Lander counties, Nevada (Specimens Nos. 15755, 5653, U.S.N.M.); Black Hills, S. Dakota (Hübnerite) (Specimen No. 53461, U.S.N.M.); Bonita and White Oaks, Lincoln County, New Mexico; Falls County, Texas (Specimen No. 62766, U.S.N.M.); Russellville, Arizona (Specimen No. 53223, U.S.N.M.). The foreign localities are the tin regions of Bohemia, Saxony (Specimen No. 67752, U.S.N.M.), and Cornwall and Devonshire (Specimens Nos. 67460, 67753, 67787, and 67788, U.S.N.M.), England; also Australia (Specimens Nos. 60978, 60967, U.S.N.M.) and Bolivia and Peru, South America. For uses, see under Scheelite, p. 356.

¹See the Minerals of North Carolina, Bulletin 74, U. S. Geological Survey, 1891.

5. SCHEELITE.

This is calcium tungstate, consisting when pure of some 80.6 per cent tungsten trioxide (WO_3) and 19.4 per cent lime; usually, however, carrying from 1 to 8 per cent of molybdic oxide (MoO_3). The mineral is white and translucent, and yellow and brownish in color, with a hardness of 4.5-5, gravity 6, and a tendency to cleave into octahedral forms. The occurrence is similar to that of wolframite, but the mineral is less common.

Uses.—The tungstates have been used mainly in the manufacture of tungstic acid, but the metal tungsten is coming into use as an alloy in making steel. Recently attempts have been made in France to utilize the material in porcelain glazes, but thus far without much success. There is at present no regular source of supply in America.

BIBLIOGRAPHY.

J. PHILLIP. Tungsten Bronzes.

Journal of the Society of Chemical Industry, I, 1882, p. 152.

—— The Use of Wolfram or Tungsten.

Iron Age, XXXIX, 1887, p. 33.

T. A. RICKARD. Tungsten.

Engineering and Mining Journal, LIII, 1892, p. 448.

—— Wolfram Ore.

Iron Age, XL, 1892, p. 229.

ADOLF GURLT. On a Remarkable Deposit of Wolfram Ore in the United States.

Transactions of the American Institute Mining Engineers, XXII, 1893, p. 236.

See also Engineering and Mining Journal, LVI, 1893, p. 216.

F. CREMER. The Place of Tungsten in the Industries.

Iron Age, LVI, 1895, p. 536.

HENRI MOISSAN. Researches on Tungsten.

Minutes of the Proceedings of the Institution of Civil Engineers, CXXVI, 1895-96, p. 481.

R. HELMHACKER. Wolfram Ore.

Engineering and Mining Journal, LXII, 1896, p. 153.

Prof. BODENBENDER. Wolfram in the Sierra de Cordoba, Argentine Republic.

Transactions of the North of England Institute of Mining and Mechanical Engineers, XLV, Pt. 3, March, 1896, p. 59.

VIII. PHOSPHATES.

1. APATITE; ROCK PHOSPHATE; GUANO; ETC.

Phosphorus is one of the most widespread of the elements, and is apparently indispensable to both animal and vegetable life. In nature it occurs in various compounds, by far the more common being the phosphates of calcium and aluminum, such as are commercially used as fertilizers. These in various conditions of impurity occur under

several forms, some distinct and well defined, others illy defined and passing by insensible gradations into one another, but all classed under the general term of phosphates. Their origin and general physical properties are quite variable, and any attempt at classifying must be more or less arbitrary. For our present purposes it is sufficient that we treat them under the heads of mineral phosphates and rock phosphates, as has been done by Dr. Penrose.¹ These two classes are then subdivided as below:

- | | | |
|---|--------------------------------------|---------------------|
| (I) Mineral phosphates ² --- | { Apatites ---- | { Fluor apatites, |
| | { Phosphorite. | { Chlor apatites. |
| | { Amorphous nodular phosphates loose | |
| | { or cemented into conglomerates. | |
| (II) Rock phosphates ---- | { Phosphatic limestones. | |
| | { Guanoses ---- | { Soluble guanoses. |
| | { Bone beds. | { Leached guanoses. |

APATITE.—Under the name of apatite is included a mineral composed essentially of phosphate of lime, though nearly always carrying small amounts of fluorine or chlorine, thereby giving rise to the varieties *fluor-apatite* and *chlor-apatite*. The mineral crystallizes in the hexagonal system, forming well-defined six-sided elongated prisms of a green, yellow, rose, or reddish color, or sometimes quite colorless. (Specimens, Nos. 62128, 62129, U.S.N.M., from Renfrew, Canada.) It also occurs as a crystalline granular rock mass. (Specimens, Nos. 62137, 62148, 65111, U.S.N.M.) The hardness is 4.5 to 5; specific gravity, 3.23; luster, vitreous. Apatite in the form of minute crystals is an almost universal constituent of eruptive rocks of all kinds and all ages. It is also found in sedimentary and metamorphic rocks as a constituent of veins of various kinds, and is a common accompaniment of beds of magnetic iron ore. It is only when occurring segregated in veins and pockets, either in distinct crystals or as massive

¹ Bulletin No. 46 of the U. S. Geological Survey.

²Fuchs (Notes Sur la Constitution des Gites Phosphate de Chaux) divides the natural phosphates into three classes. In the first the phosphatic material is concentrated in sedimentary beds; in the second it is disseminated throughout eruptive rocks, and in the third it constitutes entirely or partially the material filling veins and pockets. That found in sedimentary beds occurs in rounded and concretionary masses called nodules. In eruptive and metamorphic rocks the phosphate occurs in the crystalline form of apatite, sometimes isolated or grouped in aggregates. In veins the phosphate occurs massive and in pockets, crystalline, but not in distinct crystals; rather as globular and radiating masses. To such the name phosphorite is given. The three varieties show a like variation in solubility, the amorphous phosphates being soluble in citrate or oxalate of ammonia to the extent of 30 to 50 per cent; the phosphorites to the extent of only 15 to 30 per cent, and the apatite scarcely at all. The amorphous phosphates alone have proven of value for direct application to soils, the other varieties needing previous treatment to render them soluble.

crystalline aggregates, as in Canada and Norway, that the material has any great economic value. The average composition of the apatites, as given in the latest edition of Dana's Mineralogy, is as follows:

Variety.	P ₂ O ₅	CaO	F.	Cl.	
Chlor-apatite	41.0	53.8	.....	6.8	or Ca ₃ P ₂ O ₈ 89.4 + CaCl, 10.6.
Fluor-apatite	42.3	55.5	3.8	.....	or Ca ₃ P ₂ O ₈ 92.25 + CaF ₂ 7.75.

The name *phosphorite* covers a material of the same composition as apatite, but occurring in massive concretionary and mammillary forms. (Specimens No. 37147, U.S.N.M., from Spain and 66741, U.S.N.M., from Florida). The name was first used by Kirwan in describing the phosphates of Estremadura, Spain, which occur in veins and pockety masses in Silurian schists, as noted later.

ROCK PHOSPHATE.—The general name of rock phosphate is given to deposits having no definite composition but consisting of amorphous mixtures of phosphatic and other mineral matter in indefinite proportions. Here would be included the amorphous nodular phosphates like those of our Southern Atlantic States (Specimens Nos. 34322, 44244, 66737, U.S.N.M.), phosphatic limestones and marls (Specimens Nos. 62718, U.S.N.M., Africa, and 62723 Utah), guano (Specimen No. 69281, U.S.N.M.), and bone bed deposits (Specimens Nos. 66581, 67332, U.S.N.M.). These are so variable in character that no satisfactory description of them as a whole can be given. The name *coprolite* is given to a nodular phosphate such as occurs among the Carboniferous beds of the Firth of Forth in Scotland, and which is regarded as the fossilized excrement of vertebrate animals. (Specimen No. 62731, U.S.N.M.) Phosphatic limestones and marl, as the names denote, are simply ordinary limestones and marls containing an appreciable amount of lime in the form of phosphate. Such are rarely sufficiently rich to be of value except in the immediate vicinity, owing to cost of transportation. Guano is the name given to the accumulations of sea-fowl excretions, such as occur in quantities only in rainless regions, as the western coast of South America. The most noted deposits are on small islands off the coast of Peru. The material is of a white-gray and yellowish color, friable, and contains some 20 or more per cent of phosphate of lime, 10 to 12 per cent of organic matter, 30 per cent ammonia salts, and 20 per cent of water. Through prolonged exposure to the leaching action of meteoric waters, like deposits in the West India Islands have lost all their ammonia salts and other soluble constituents and become converted into insoluble phosphates, or leached guanos like those of the Navassa Islands. (Specimen No. 73243, U.S.N.M., to be noted later; and also specimens from the Grand Connetables, French Guiana, Nos. 73069 to 73075, U.S.N.M., and Redonda Nos. 53147 to 53152, U.S.N.M.)

Origin and occurrence.—The origin of the various forms of phos-

phatic deposits has been a subject of much speculation. Their occurrence under diverse conditions renders it certain that not all can be traced to a common source, but are the result of different agencies acting under the same or different conditions. By many, all forms are regarded as being phosphatic materials from animal life, and owing their present diversity of form to the varying conditions to which they were at the time of formation or have since been subjected. This, however, as long since pointed out, is an uncalled-for hypothesis, since phosphatic matter must have existed prior to the introduction of animal life, and there is no reason to suppose it may not, under proper conditions, have been brought into combination as phosphate of lime without the intervention of life in any of its forms. The almost universal presence of apatite in small and widely disseminated forms in eruptive rocks of all kinds and all ages would seem to declare its independence of animal origin as completely as the pyroxenic, feldspathic, or quartzose constituents with which it is there associated. The occurrence of certain of the Canadian apatites as noted later, in veins and pockets, sometimes with a banded or concretionary structure and blending gradually into the country rock, is regarded by some as strongly suggestive of an origin by deposition from solution, that is, by a process of segregation of phosphates from the surrounding rock contemporaneously with their metamorphism and crystallization.

Dr. Ells, of the Canadian survey, would regard those occurring in close juxtaposition with eruptive pyroxenites as due to combination of the phosphoric acid brought up in vapors along the line of contact with the calcareous materials in the already softened gneisses. This explanation as well as others will perhaps be better understood in the part of this work relating to localities. On the other hand, the presence of apatite in crystalline form associated with beds of iron ore, as in northern New York, has been regarded by Prof. W. P. Blake and others as indicative of an organic and sedimentary origin for both minerals. The Norwegian apatite from its association with an eruptive rock (gabbro) has been regarded as itself of eruptive origin.

The phosphorites, like the apatites, occur in commercial quantities mainly among the older rocks, and in pockets and veins so situated as to lead to the conclusion that they are secondary products derived by a process of segregation from the inclosing material. Davies regards the Bordeaux phosphorites occurring in the Jurassic limestones of southern France as the result of phosphatic matter deposited on the rocky floor of an Eocene ocean, from water largely impregnated with it. Others have considered them as geyserine ejections, or due to infiltration of water charged with phosphatic matter derived from the bones in the overlying clays. Stanier, on the other hand, regards the phosphorites of Portugal as due to segregation of phosphatic matter from the surrounding granite, the solvent being meteoric waters. These

deposits are regarded as superficial and limited to those portions of the rock affected by surface waters.

The origin of the amorphous, nodular, and massive rock phosphates can, as a rule, be traced more directly to organic agencies. All things considered, it seems most probable that the phosphatic matter itself was contained in the numerous animal remains, which, in the shape of phosphatic limestones, marls, and guanos, have accumulated under favorable conditions to form deposits of very considerable thickness. Throughout these beds the phosphatic matter would, in most cases, be disseminated in amounts too sparing to be of economic value, but it has since their deposition been concentrated by a leaching out by percolating waters of the more soluble carbonate of lime. Thus H. Lösne, in writing of the nodular phosphates occurring in pockety masses in clay near Doullens (France), argues that the nodules as well as the clay itself are due to the decalcification of preexisting chalk by percolating meteoric waters.

In this connection it is instructive to note that phosphatic nodules, in size rarely exceeding 4 to 6 cm., were dredged up during the *Challenger* expedition from depths of from 98 to 1,900 fathoms on the Agulhas Banks, south of the Cape of Good Hope. These are rounded and very irregular capricious forms, sometimes angular and have exteriorly a glazed appearance, due to a thin coating of oxides of iron and manganese. The nodules yield from 19.96 to 23.54 per cent P_2O_5 . In those from deep water there are found an abundance of calcareous organic remains, especially of rhizopods. The phosphate penetrates the shell in every part, and replaces the original carbonate of lime.

The nodules are most abundant apparently where there are great and rapid changes of temperature due to alternating warm and cold oceanic currents, as off the Cape of Good Hope and eastern coast of North America. Under such conditions, together with perhaps altered degrees of salinity, marine organisms would be killed in great numbers, and by the accumulation of their remains would, it is believed, furnish the necessary phosphatic matter for these nodules. It seems probable that the Cretaceous and Tertiary deposits in various parts of the world may have formed under similar conditions.

Hughes has described¹ phosphatic coralline limestones on the islands of Barbuda and Aruba (West Indies), as having undoubtedly originated through a replacement of their original carbonic by phosphoric acid, the latter acid being derived from the overlying guano. The phosphatic guano has, however, now completely disappeared through the leaching and erosive action of water, leaving the coral rock itself containing 70 to 80 per cent phosphate of lime.

Hayes² regards the Tennessee black phosphates (Specimens Nos.

¹Quarterly Journal of the Geological Society of London, XLI, 1885, p. 80.

²Sixteenth Annual Report of the U. S. Geological Survey, 1894-95, Pt. 4, p. 620; Seventeenth Annual Report U. S. Geological Survey, 1895-96, Pt. 2, p. 22.

62574 and 62781, U.S.N.M.) as due to the slow accumulation on sea bottoms of phosphatic organisms (*Lingulæ*), from which the carbonate of lime was gradually removed by the leaching action of carbonated waters, leaving the less soluble phosphate behind. The white bedded phosphates of Perry County (Specimen No. 52060, U.S.N.M.), in the same State, are regarded as a product of secondary replacement—that is, as due to phosphate of lime in solution, replacing the carbonate of lime of preexisting limestones, as in the case noted above. The source of the phosphoric acid, whether from the overlying Carboniferous limestones or from the older Devonian and Silurian rocks, is not, however, in this case apparent.

Teall has shown¹ that some phosphatic rocks from Clipperton Atoll, in the northern Pacific, are trachytes in which phosphoric acid has replaced the original silica. The replacement he regards as having been effected through the agency of alkaline (principally ammonium) phosphate which has leached down from overlying guano. A microscopic examination of the rock in thin sections showed that the replacing process began with the interstitial matter, then extended to the feldspar microlites, and lastly the porphyritic sanidin crystals. The gradual change in the relative proportion of silica and phosphoric acid, as shown by analyses of more or less altered samples, is shown below, No. I being that of the unaltered rock and II and III of the altered forms:

Constituents.	I.	II.	III.
SiO ₂	54.0	43.7	2.8
P ₂ O ₅	8.4	17.0	38.5
Loss on ignition.....	3.8	12.3	23.0

From a comparison of these rocks with those of Redonda, in the Spanish West Indies, it is concluded that the latter phosphates have likewise resulted from a similar replacement in andesitic rocks. (Specimens Nos. 53148 to 53152, U.S.N.M.) In this connection reference is made to the work of M. A. Gautier,² in which he describes the formation of aluminous phosphates in caves through the action of the ammonium phosphate arising from decomposing organic matter on the clay of the floor of caverns. (See under Occurrences.)

The guanos, as noted elsewhere, owe their origin mainly to the accumulations of sea-fowl excretions. Such deposits when unleached, are relatively poor in phosphatic matter and rich in salts of ammonia. Where, however, subjected to the leaching action of rains the more soluble constituents are carried away, leaving the less soluble phosphates, together with impurities, in the shape of alumina, silica, and iron oxides to form the so-called leached guanos of the West India Islands. As stated in the descriptions of localities, guano deposits are

¹ Quarterly Journal of the Geological Society of London, LIV, 1898, p. 230.

² Formation des Phosphates Naturels d'Alumina et de Fer, Comptes Rendus de l'Academie des Sciences, Paris, CXVI, 1893, p. 1491.

not infrequently of a thickness such as to cause their origin as above stated to seem well-nigh incredible were there not sufficient data acquired within historic times to demonstrate its accuracy beyond dispute. Thus it is said¹ that in the year 1840 a vessel loaded with guano on the island of Ichabo, on the east coast of Africa. During the excavations which were necessary the crew exhumed the dead body of a Portuguese sailor, who, according to the headboard on which his name and date of burial had been carved with a knife, had been interred fifty-two years previously. The top of this headboard projected 2 feet above the original surface, but had been covered by exactly 7 feet of subsequent deposit of guano. That is to say, the deposition was going on at the rate of a little over an inch and a half yearly.

LOCALITIES OF PHOSPHATES.

Canada.—According to Dr. Ells, of the Canadian Survey,² the discovery of apatite in the Laurentian rocks of eastern Canada was first made in the vicinity of the Lievre by Lieutenant Ingall in 1829, though it was not until early in 1860 that actual mining was begun. The mineral occurs in the form of well-defined crystals in a matrix of coarsely crystalline calcite (Specimen No. 67942, U.S.N.M.) and in vein-like and pockety granular masses along the line of contact between eruptive pyroxenites and Laurentian gneisses. The first form is the predominant one for Ontario only, the second for Quebec. From a series of openings made at the North Star Mine, in the region north of Ottawa, it appears that the massive coarsely crystalline granular apatite follows a somewhat regular course in the pyroxenite near the gneiss, but occurs principally in a series of large bunches or chimneys connected with each other by smaller strings or leaders. Sometimes these pockety bunches of ore are of irregular shape and yield hundreds of tons, but present none of the characteristics of veins, either in the presence of hanging or foot walls, while many of the masses of apatite appear to be completely isolated in the mass of pyroxene, though possibly there may have been a connection through small fissures with other deposits. The lack of any connection between these massive apatites and the regularly stratified gneiss is evident, and their occurrence in the pyroxene is further evidence in support of the view that these workable deposits are not of organic origin, but confined entirely to igneous rocks. In certain cases where a supposed true-vein structure has been found, such structure can be explained by noticing that the deposits of phosphates occur, for the most part at least, near the line of contact between the pyroxene and the gneiss.

By far the greater part of the Canadian apatite thus far mined has been from the Ottawa district of Quebec, where it is mined or quarried mainly from open cuts and shafts. The principal fields lie in

¹ R. Ridgway, *Science*, XXI, 1893, p. 360.

² The Canadian Mining and Mechanical Review, March, 1893.

Ottawa County, Province of Quebec (Specimen No. 62157, U.S.N.M.) and Leeds, Lanark (Specimens Nos. 62136, 62137, U.S.N.M.), Frontenac (Specimen No. 62148, U.S.N.M.), Addington, and Renfrew (Specimen No. 62130, U.S.N.M.) counties, Province of Ontario. The first consists of a belt running from near the Ottawa River on the south for over 60 miles in a northerly direction through Buckingham, Portland, Templeton, Wakefield, Denholm, Bowman, Hincks, and other townships to the northward have an average width of 15 to 25 miles. The second belt runs from about 15 miles north of the St. Lawrence River in a northerly direction to the Ottawa River, a distance of about 100 miles, and varies from 50 to 75 miles in breadth.

Davies gives the following table as showing the average composition of the Canadian phosphates:

Constituents.	I.	II.	III.	IV.	V.	VI.
Moisture, water of combination, and loss on ignition.	0.62	0.10	0.11	1.09	0.89	1.83
Phosphoric acid.....	33.51	41.54	37.68	30.84	32.53	31.87
Lime.....	46.14	54.74	51.04	42.72	44.26	43.62
Oxide of iron, alumina, fluorine, etc	7.83	3.03	6.88	13.32	12.15	9.28
Insoluble siliceous matter	11.90	0.59	4.29	12.03	10.17	13.50
	100.00	100.00	100.00	100.00	100.00	100.10
Equal to tribasic phosphate of lime	73.15	90.68	82.25	67.32	71.01	69.35

Norway.—The principal apatite fields lie along the coast in the southern portion of the peninsula between Langesund and Arendal. The material occurs in crystals and crystalline granular aggregates of a white, yellow, greenish, or red color in veins and pockets embedded in the mass of an eruptive gabbro, near the line of contact of the gabbro and adjacent rocks, in the country rock itself in the immediate vicinity of the gabbro, and in coarse pegmatitic veins which are cut by the gabbro. The largest veins are in the mass of the gabbro itself or near the line of contact. Where the apatite occurs in the gabbro the latter is as a rule altered into a hornblende scapolite rock. The principal associated minerals are quartz, mica, tourmaline, scapolite, feldspars, rutile, and magnetic and titanite iron and sulphides of iron and copper. The country rock is gneiss, schist, and granite. The mineral belongs to the variety called fluor apatite, as shown by the following analysis from Dr. Penrose's Bulletin:

Apatite from Arendal.

Phosphoric acid (P_2O_5) ⁽¹⁾	42.229
Fluorine ⁽²⁾	3.415
Chlorine ⁽³⁾	0.512
Lime (CaO)	49.96
Calcium	3.884
	100.000

¹ Equal 92.189 per cent tribasic phosphate. ³ Equal 0.801 per cent chloride of calcium.

² Equal 7.01 per cent fluoride of calcium.

The Norway apatites have been mined according to Penrose since 1854, the earliest workings being at Kragerö. According to Davies, however, the discovery of deposits that could be profitably worked dates only from 1871. The distribution of the material is very uncertain and irregular, and the value of the deposits can not be foretold with any great approximation to accuracy. Specimen No. 65122, U.S.N.M., is characteristic. The large specimen on floor of hall, weighing nearly 2 tons, shows well the massive character of the material.

A second locality of phosphates but recently described, and which seems to occur under somewhat similar conditions, exists in the Gellivara Mountains, in Norrland.

Nodular phosphatic deposits are described by Penrose¹ as being found at intervals all along the Atlantic coast of the United States, from North Carolina down to the southern extremity of Florida. The North Carolina deposits occur principally in the counties of Sampson, Duplin, Pender, Onslow, Columbus, and New Hanover, all in the southeastern part of the State. The deposits are of two kinds, (1) a nodular form overlying the Eocene marls and consisting of phosphate nodules, sharks' teeth (Specimen No. 73643, U.S.N.M.), and bones as embedded in a sandy or marly matrix, and (2) as a conglomerate of phosphate pebbles, sharks' teeth, bones, and quartz pebbles, all well rounded and cemented together along with grains of green sand in a calcareous matrix. (Specimen No. 44244, U.S.N.M.)

The beds of the first variety usually overlies strata of shell marl, though this is sometimes replaced by a pale green indurated sand. The two following sections will serve to illustrate their mode of occurrence:

SAMPSON COUNTY.

- (1) Soil, sand or clay, 5 to 10 feet.
- (2) Shell marl, 5 to 10 feet.
- (3) Bed with phosphate nodules, 1 to 3 feet.
- (4) Sea green, sandy marl, 2 to 4 feet.
- (5) Ferruginous hardpan, 6 to 12 inches.
- (6) Interstratified lignites and sands as in (4).

DUPLIN COUNTY.

- (1) Sandy soil, 1 to 10 feet.
- (2) Nodule bed, 1 to 2 feet.
- (3) Shell marl.

The nodules as described are of a lead gray color, varying in size from that of a man's fist to masses weighing several hundred pounds. In texture they vary from close compact and homogeneous masses to coarse-grained and highly siliceous rocks distinguished by considerable quantities of sand and quartz pebbles sometimes the size of a chestnut. Occasionally the nodules, which as a rule are of an oval flattened form,

¹Bulletin 46 of the U. S. Geological Survey, 1888.

contain Tertiary shells (Specimens Nos. 44244 and 34318, U.S.N.M.). The second or conglomerate variety occurs mainly in New Hanover and Pender counties, the beds in some instances being 6 feet in thickness, though usually much less. The following section, taken like those above from Dr. Penrose's Bulletin, shows their position and association as displayed at Castle Hayne, New Hanover County.

- (1) White sand, 0 to 3 feet.
- (2) Brown and red ferruginous sandy clay, or clayey sand, 1 to 3 feet.
- (3) Green clay, 6 to 12 inches.
- (4) Dark brown indurated peat, 3 to 12 inches.
- (5) White calcareous marl, 0 to 2 feet.
- (6) White shell rock, 0 to 14 inches.
- (7) Phosphatic conglomerate, 1 to 3 feet.
- (8) Gray marl containing smaller nodules than the overlying beds, $2\frac{1}{2}$ to $4\frac{1}{2}$ feet.
- (9) Light-colored, calcareous marl, containing nodules which are smaller than those in the overlying beds, which grow fewer and smaller at a depth. Many shells.

The phosphatic nodules in this conglomerate are kidney and egg shaped as sometimes make up as much as three-fourths the contents of a bed; usually, however, the proportion is smaller, and sometimes there are none at all. The mass as a whole does not contain more than 10 to 20 per cent phosphate of lime, but it is said to have been successfully used as a fertilizer. The individual may be richer in phosphatic matter on the outer surface than toward the center.

Aside from the phosphatic layer as described above, phosphatic nodules are found in large quantities in the beds of rivers of these districts, where they have accumulated through the washing action of flowing water, the finer sand clay and gravel having been carried away. Such phosphates naturally do not differ materially from those on land except that they are darker in color and sometimes more siliceous.

The deposits of South Carolina, though of low grade compared with some others, are now more generally used than any other known phosphate. The output of the mines, which is yearly increasing, is shipped to the North, South, and East by sea and to the West by rail. This popularity is due not only to the cheapness of the phosphate (\$5 to \$6 a ton in 1886), but to the many good qualities of the low-grade acid phosphate made from it. The fact that the nodule bed extends, at an accessible depth, over many miles of country, the easy approach for large vessels up to the very mines, the abundance of water, fuel, and labor, and a climate that permits mining operations to be carried on throughout the whole year, all combine to make the South Carolina phosphates the cheapest and consequently the most productive source of supply of this material. Specimens Nos. 34317 and 34318, 34321 to 34324, and 34326 to 34328, U.S.N.M. are characteristic.

Phosphates in the form of nodules and phosphatic marls and green-sands occur in Alabama in both the Tertiary and Cretaceous formations. Their geographical distribution is therefore limited to areas

south of the outcrops of the lowest Cretaceous beds which stretch in a curve from the northwest corner of the State across near Fayette, Courthouse, Tuscaloosa, Centerville, and Wetumpka, to Columbus, Georgia. As all the Cretaceous and Tertiary beds have a dip toward the Gulf of from 25 to 40 feet to the mile, the phosphate-bearing strata appear at the surface only in a comparatively narrow belt along the line above indicated and are to be found only at gradually increasing depths below at points to the southward.

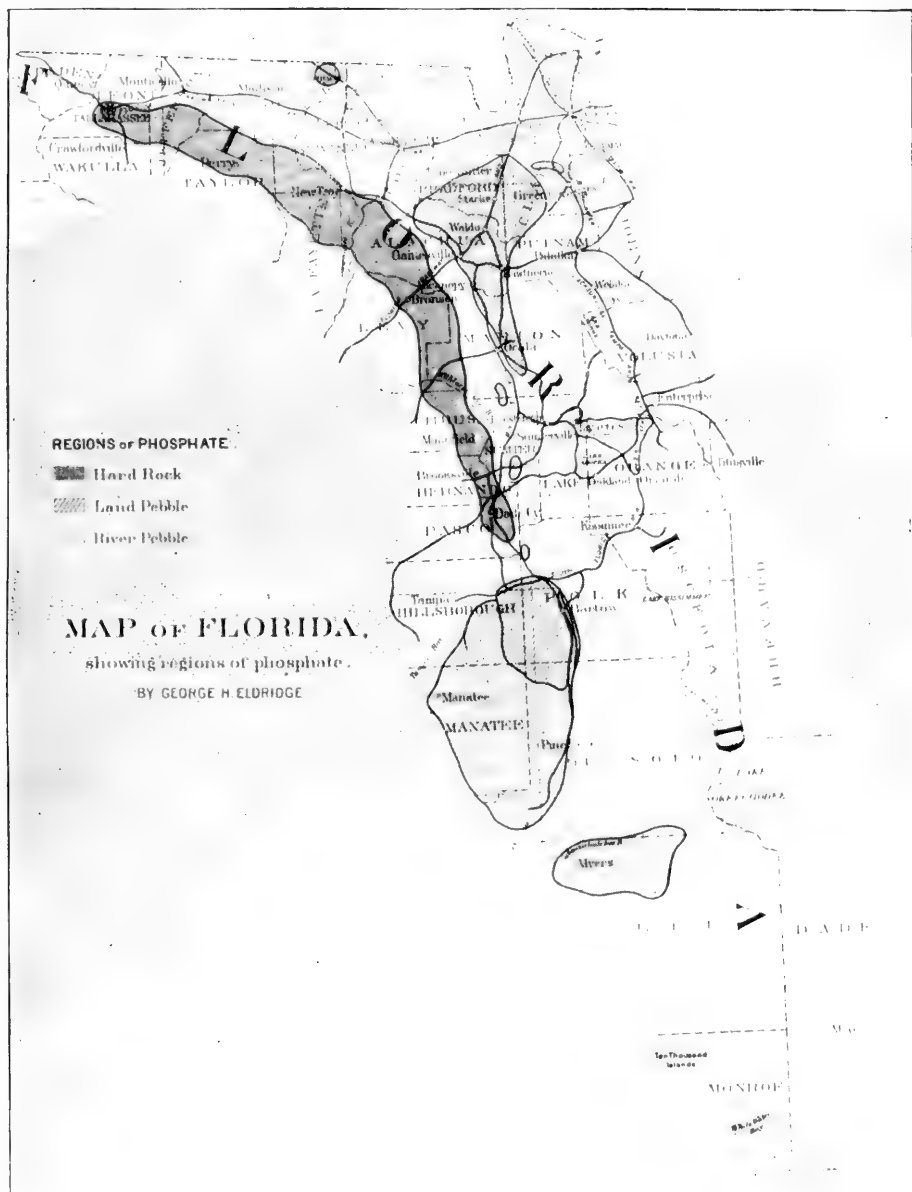
Phosphatic nodules and marls of the Tertiary occur in four different horizons: The Black Bluffs and Nantehala groups of the Lignitic; in the white limestone, and in eastern Alabama, at Ozark, in strata of the Claiborne group. Selected nodules run as high as 27 per cent of phosphoric acid, and marls as high as 6.7 per cent. The Tertiary is not, however, regarded by Professor Smith as a promising source of commercial phosphates in the State. In the Cretaceous the phosphates occur in the transition beds both above and below the so-called Rotten Limestone existing as nodules, shell casts, phosphatic limestones, marls, and greensands. The nodules have essentially the characteristics of those of South Carolina.

The principal phosphate region of Florida, as known to-day, comprises an area extending from west of the Apalachicola River eastward and southward to nearly 50 miles south of Caloosahatchee River, as shown on the accompanying map.¹ According to Mr. Eldridge, the deposits comprise four distinct and widely different classes of commercial phosphates, each having a peculiar genesis, a peculiar form of deposit, and chemical and physical properties such as readily distinguish it from any of the others.

According to their predominant characteristics or modes of occurrence, these classes have come to be known as hard-rock phosphates, soft phosphate, land pebble or matrix rock, and river pebble. With the exception of the soft phosphates, they underlie distinct regions, each class being separate or but slightly commingling with one another. The type of the hard-rock phosphate, as described by Mr. Eldridge, is a hard, massive, close-textured homogeneous, light-gray rock, showing large and small irregular cavities, which are usually lined with secondary mammillary incrustations of phosphate of lime (Specimens Nos. 66737, 66741, U.S.N.M.), the general appearance being that of the calcareous deposits of the preglacial hot springs of the Yellowstone National Park.

There are numerous variations in color and physical characteristics from this type, but which can best be comprehended by a study of the collection. This type carries some 36.65 per cent phosphoric anhydride (P_2O_5). The deposits of the hard-rock phosphate lie in Eocene and Miocene strata, occurring in the first named as a boulder

¹ Preliminary sketch of Phosphates of Florida, by George H. Eldridge.



MAP SHOWING PHOSPHATE REGIONS OF FLORIDA
After George H. Eldridge.

deposit in a soft matrix of phosphatic sands, clays, and other material, resulting from the disintegration of the hard rock and constituting the soft phosphates. The deposits underlie sands of from 10 to 20 feet in thickness, and have been penetrated to a depth of 60 feet. The phosphate deposit proper is white, the bowlders of rounded and irregular outline, varying in diameter from 2 or 3 inches to 10 feet. None of the hard-rock deposits of the Eocene originated in the positions they now occupy. The Miocene hard-rock phosphates, on the other hand, lie in regular bedded deposits in situ, as well as in bowlders. The beds lie horizontal but a few feet below the surface, being covered only by superficial sand. The beds as a rule are but from 4 feet to 5 feet thick. The name soft rock, or soft phosphate, as above indicated, is given to the softer material associated with the hard rock, which in part results from the disintegration of the last named. It is also applied somewhat loosely to any variety not distinctly hard. It therefore varies greatly in color, chemical and physical characteristics, and rarely carries more than 20 to 25 per cent of P_2O_5 (Specimens Nos. 67304, 67319, 67293, 67296, 67297, U.S.N.M.).

The name land-pebble phosphate includes pebble from deposits consisting of either earthy material carrying fossil remains, grains of quartz, and pisolitic grains of lime phosphate, or else of a material resembling in texture and other characteristics the hard-rock phosphate. The individual pebbles vary in size up to that of the English walnut, are normally white, but when subjected to percolating water become dark gray or nearly black. The exteriors are quite smooth and glossy, colors and textures uniform, and average some 30 to 35 per cent P_2O_5 (Specimen No. 61070, U.S.N.M.).

The river-pebble varieties differ from the last mainly in mode of occurrence, being found, as the name would indicate, in the beds of streams, where presumably they have accumulated through the washing away of finer and lighter materials. They are most abundant in the Peace, Caloosahatchee, Alafia, and other rivers entering the Gulf south of Tampa and Hillsborough bays, though the Withlacoochee, Aucilla, and rivers of the western part of the State, carry also a mixture of pebbles, hard-rock fragments, and bones derived from the various strata through which they have cut their channels. The pebbles of the Western rivers show a very uniform composition, and range from 25 to 30 per cent phosphoric anhydride (P_2O_5), or about 65 per cent of phosphate of lime, the impurities being mainly siliceous matter, carbonate of lime, alumina, and iron oxides (Specimens Nos. 67299, 67298, 67355, U.S.N.M.).

Phosphates the mineralogical nature of which does not seem to be as yet accurately made out occur in the Devonian Shales of Middle Tennessee. They are thus described by Professor Safford:¹

¹Engineering and Mining Journal, LVII, April 21, 1894, p. 366.

There are two distinct beds of the phosphates, one above a stratum known as the black shale; the other below the shale. The one above is a bed or layer of concretionary masses, balls, and kidney and knee-shaped forms from the size of walnuts to that of a man's head (Specimen No. 52059 from Hickman County). These are sometimes loosely disposed in a greenish or bluish shale, and sometimes tightly packed together like so many cannon balls in a layer 8 or 10 inches thick. Ordinarily the layer has less thickness, often, in fact, being represented by only a few scattered concretions. But, thick or thin, it may be said to be universally present, its kidneys serving to indicate the place of the black shale and the underlying bed when these are concealed by débris or soil.

The other phosphate, that underlying the shale, and the more important of the two, is, in its best presentations, a well-defined, continuous stratum of dark-bluish or bluish-black—rarely grayish—rock, with fine or coarse grain. Its regularly stratified character and its dark color make it look like a bed of stone coal.

The geographical distribution and general geology of these phosphates has been worked out in considerable detail by C. W. Hayes, to whose papers reference has been already made (p. 360). According to this authority the phosphates occur in four distinct varieties: (1) Black nodular phosphate; (2) black bedded phosphate; (3) white breccia phosphate, and (4) white bedded phosphate. The first two of these are of Devonian age, the third is a secondary and comparatively recent deposit, while the fourth, perhaps also of secondary origin, is interbedded with rocks of Carboniferous age. The black nodular variety contains from 60 to 70 per cent of phosphate of lime, and is found in commercial quantities only in the region of the black bedded phosphate in western middle Tennessee. The black bedded variety, which is the only one that has thus far proved of commercial importance, is confined, so far as at present known, "to an oval area southwest of Nashville, having Centerville about in its center." It also covers portions of Hickman, Williamson, Maury, Lewis, Wayne, Perry, and Decatur counties.

Sections showing the relation of the phosphates to the adjacent formations are given in Dr. Hayes's paper. The beds vary in thickness from a fraction of 1 to 8 or 10 feet, the average run of the rock being about 50 per cent phosphate of lime. The white bedded and white breccia phosphates are limited to small areas in Perry County. Their contents of phosphoric acid (P_2O_5) is low, varying from 14 to 15 per cent, and as yet their value for other than local purposes is to be determined. (See especially Specimens Nos. 52058, 52060, 52061, U.S.N.M.)

England.—Deposits of phosphates sufficiently concentrated for commercial purposes lie near the upper limit of Cambro-Silurian strata in North Wales. According to Davies, the phosphatic material occurs

in the form of nodular concretions of a size varying from that of an egg to a cocoanut, closely packed together and cemented by a black slaty matrix. The concretions have often a black highly polished appearance, due to the presence of graphite, but owing to the presence of oxidizing pyrite they sometimes become rusty brown. The concretions carry from 60 to 69 per cent of phosphate of lime; the matrix is also phosphatic. The phosphate beds are highly tilted and are overlaid by gray shales with fossilized echinoderms and underlaid by dark crystalline limestone, which also contains from 15 to 20 per cent of phosphatic material. Davies regards the deposit as an old sea bottom "on which the phosphatic matter of Cretaceous and Molluscan life was precipitated and stored during a long period, while certain marine plants may also have contributed their share of phosphatic matter. He thinks it also as possible that, as in the Laurentian deposits, the water of the sea may have contained phosphatic matter in solution, to be deposited independently of organic agencies.

These phosphated beds are mined at Berwin, where an average production over a space of 360 fathoms was 2 tons 10 hundredweight of phosphate per fathom, of an average strength of 46 per cent.

The nodules average from 45 to 55 per cent of phosphate of lime.

Amorphous nodular phosphates also occur in both the Upper and Lower Greensands of the Cretaceous and in Tertiary deposits. Those of the upper beds have been mined in Cambridgeshire and Bedfordshire. The phosphatic material occurs in the form of shell casts, fossils, and nodules, of a black or dark-brown color, of varying hardness, embedded in a sand consisting of siliceous and calcareous matter as well as phosphatic and glauconitic grains. The average composition shows from 40 to 50 per cent of phosphate of lime. The thickness of the nodule-bearing bed is rarely over a foot. The nodules of the Lower Greensands differ from those of the Upper in many details, the more important being their lower percentages of phosphate of lime (from 40 to 50 per cent). They occur in a bed of siliceous sand which itself is not phosphatic. The Tertiary phosphates reach their best development in the county of Suffolk, where they are found at the base of the Coralline and Red Crag groups and immediately overlying the London clays. The beds consist of a "mass of phosphatic nodules and shell casts, siliceous pebbles, teeth of cretaceans and sharks, and many mammal bones, besides occasional fragments of Lower Greensand chert, granite, and chalk flints." The nodules vary in both quality and quantity. They are at times of a compact and brittle nature, while at others they are tough and siliceous. They average about 53 per cent phosphate of lime and 13 per cent phosphate of iron.

France.—Phosphates of the nodular type occur in beds of Cretaceous age in the provinces of Ardennes and Meuse, and to a less extent in others in northern France; in the department of Cote d'Or, and along

the Rhone at Bellegarde, Seyssel, and Grenoble. As in England, the phosphatic nodules of the northern area, such as are of commercial importance, occur in both the Upper and Lower Greensands. They resemble in a general way the English phosphates, but are described as soft and porous and easily disintegrating when exposed to the air. Those of the Upper Greensand average some 55 per cent of phosphate of lime.

More recently deposits have been described by M. J. Gosselet,¹ near Fresnoy-le-Grand, in the north of France. The phosphatic material occurs in a zone of gray chalk some 6 feet in thickness ($1\frac{1}{2}$ to 2 meters), and is in the form of concretionary nodules forming a sort of conglomerate in the lower part of the bed. A portion of the chalk is also phosphatic. Phosphatic material (of the type of phosphorites) is found in fissures and pockets in the upper portion of limestones of Middle Jurassic (Oxfordian) age, in the departments of Tarn-et-Garonne, Aveyron, and Zoti, France.

The deposits are of two kinds. The first occurring in irregular cavities or pockets never over a few yards long, and the second in the form of elongated leads with the sides nearly vertical. These are generally shallow, and thin out very rapidly at a short distance below the surface.

The nodules or concretions are of a white or gray color, waxy luster, and opal-like appearance, and occur in the form of tubercular or kidney shaped masses embedded in ferruginous clay in the clefts of the limestone, or in geodic, fibrous, and radiating forms.

The material of this region is known commercially as Bordeaux phosphate, being shipped mainly from Bordeaux. They average from 70 to 75 per cent phosphate of lime, the impurities being mainly iron oxides and siliceous matter.

Gautier² describes deposits of phosphates estimated to the amount of 120,000 to 300,000 tons on the floors of the Grotte de Minerve, near the village of Minerve on the northeast flank of the Pyrenees, in Aude, France. The cave proper is in nummulitic limestone of Eocene age, the floors being formed by Devonian rocks. The filling material consists of cave earth and bone breccia below which are the aggregates of concretionary phosphorites and other phosphatic compounds of lime and alumina, the more interesting being *Brushite*, a hydrous tribasic calcium phosphate hitherto known only as a secondary incrustation on guano from the West India islands, and *Minervite*, a new species having the formula $\text{Al}_2\text{O}_3 \cdot \text{P}_2\text{O}_5 \cdot 7\text{H}_2\text{O}$, a hydrous aluminum phosphate, existing in the form of a white plastic clay-like mass filling a vein from a few inches to 2 or more feet in thickness.

Germany.—According to Davies, the principal phosphate regions of

¹ Annales de la Société Géologique du Nord., XXI, 1893, p. 149.

² Annals des Mines, V, 1894, p. 5.

North Germany occupy an irregular area bounded on the northeast by the town of Weilburg, on the northwest by the Westerwald, on the east by the Taunus Mountains, and on the south by the town of Dietz. The phosphorite occurs in the form of irregular nodular masses of all sizes up to masses of several tons weight, embedded in clay which rests upon Devonian limestone and is overlaid by another stratum of clay. The phosphate-bearing clay varies in thickness from 6 inches to 10 feet. With the phosphate nodules are not infrequently associated deposits of manganese and hematite. Davies regards the deposits as of early Tertiary age. The color of the freshly mined material varies from pale buff to dark brown, varying in specific gravity from 1.9 to 2.8, the quality deteriorating with the increase in gravity. Selected samples of the staple nodules yielded as high as 92 per cent phosphate of lime; but the average is much lower, being but about 50 to 60 per cent phosphate of lime. (Specimens Nos. 66827, 66828, U.S.N.M., from Gleisenberg and Heckholzhausen.)

Belgium.—Nodular phosphates belonging to the Upper Cretaceous formations occur in the province of Hainaut, where they form the basis of an extensive industry. The nodules, which are generally of a brown color and vary in size from the fraction of 1 to 4 or 5 inches in diameter, lie in a coarse-grained, friable rock called the brown or gray chalk, which itself immediately underlies what is known as the Cipley conglomerate. The phosphate-bearing bed is sometimes nearly 100 feet in thickness, but is richest in the upper 10 feet, where it is estimated the phosphatic pebbles constitute some 75 per cent of its bulk. Below this the bed grows gradually poorer, passing by gradations into the white chalk below.

The overlying conglomerate also carries phosphate nodules, which carry from 25 to 50 per cent phosphate of lime. Owing to the hardness of the inclosing rock they are less mined than those in the beds beneath. The mining of phosphates is carried on extensively near the town of Mons, on the lands of the communes of Cuesmes, Ciply, Mesvin, Nouvelles, Spiennes, St. Symphorien, and Hyon. The annual output has gradually increased from between 3,000 and 4,000 tons in 1887 to 85,000 tons in 1894. Other phosphatic deposits are described¹ as occurring in the provinces of Antwerp and Liege.

Spain.—Important deposits of phosphorites occur between Logrosan and Cáceres, in Estremadura Province. The deposits are in the form of pockets and veins in slates and schists supposed to be of Silurian age; at times a vein is found at the line of contact between the slate and granite. The veins vary in thickness from 1 to several feet, the largest being some 20 feet and extending for over 2 miles. This is by

¹ Annales de la Société Géologique de Belgique, XVII, 1890, p. 185.

far the largest of its kind known. As described by Penrose, the "Logrosan phosphate has a subcrystalline structure; some specimens are fibrous and radiating and often resemble feathers. [See Specimen No. 44277, U.S.N.M.]. It is soft and chalky to the touch, easily broken, but difficult to grind into a fine powder. An examination under the microscope exhibits conchoidal figures, interrupted with spherical grains, devoid of color and opaque. (Shepard.)

"The highest-grade material is rosy white or yellowish white in color, soft, concentric, often brilliantly radiated, with a mammillary or conchoidal surface. Red spots from iron and beautiful dendrites of manganese are not infrequent. The poorer qualities are milky white, vitreous, hard, and, though free from limestone, contain considerable silica."

In the Cáceres district the phosphorites occur not in veins but rather in pockety masses in veins of quartz and dark-colored limestone, which are found cutting both the granite and slate. (Specimens Nos. 37147, 63779, 63780, U.S.N.M.)

The following analyses from Dr. Penrose's paper show about the average composition of these phosphorites:

Logrosan, by Professor Daubeny.

Silica.....	1.70
Protoxide of iron.....	3.15
Fluoride of lime.....	14.00
Phosphate of lime.....	81.15

Cáceres, by Bobierre and Friedel.

Insoluble siliceous matter.....	21.05
Water expelled at a red heat.....	3.00
Tribasic phosphate of lime.....	72.10
Loss, iron oxides, etc.....	3.85

Portugal.—Phosphorites occur in Silurian and Devonian rocks under similar conditions to those of Spain in Estremadura, Alemetjo, and Beira provinces, and which need, therefore, no further notice here. Stanier,¹ however, describes a variety found in pockety and short vein-like masses which are worthy of a passing notice. These occur not in schists and sedimentary rocks but in massive granites. They are found mainly in the superficial portions, where the granite has weathered away to a coarse sand, and in short gashlike veins and pockets of slight width and extent. The phosphatic material is described as of a milk-white color, opaque, and showing when broken open a palmately radiating structure, like hoarfrost upon a window pane. As a rule the masses when found are enveloped in a thin coating of kaolin-like material supposed to be derived by decomposition from the feld-

¹Les Phosphorites du Portugal, Annales de la Société Géologique de Belgique, XVII, 1890, p. 223.

spar of the granites. They are mined only from open cuts and in the superficial more or less decomposed portions of the rock, to which they are believed to be mainly limited, having originated, as elsewhere indicated, through a segregation of the phosphatic material dissolved by meteoric waters from the surrounding granite and subsequently depositing it in preexisting fissures. The percentage of tricalcic phosphate is given as varying between 60 and 80 per cent.

Italy.—Phosphatic deposits consisting of coprolites, bones, etc., imbedded in a porous Tertiary limestone occur between Gallipoli and Otranto, Cape Leuca, west of the Gulf of Taranto, on the Italian coast. There are two beds having a thickness of $19\frac{1}{2}$ and $31\frac{1}{2}$ inches, respectively, and which have been traced for a distance of some 160 yards. Analyses show them to be of low grade, rarely carrying as high as 10 per cent P_2O_5 .

Tunis.—Phosphatic nodules in the form of cylindrical coprolites and clustered aggregates have been found in Tertiary strata covering considerable areas in the region south of Tunis. The coprolite nodules are stated to carry as high as 70 per cent of calcium phosphate, and the clustered aggregate some 52 per cent.

Russia.—Rich phosphate deposits of Cretaceous age occur in the governments of Smolensk, Orlov, Kursk, and Voronez, between the rivers Dnieper and the Don in European Russia. The deposits lie mostly in a sandy marl, underlying white chalk and overlying greensands, which also carry beds of from 6 to 12 inches thickness of phosphatic nodules. The nodules are dark, often nearly black, in color and are intermixed with gray, brown, and yellow sands. The depth of the beds below the surface is variable. Yermolow¹ divides the deposits into two groups, the first presenting the form of separate nodules, rounded or kidney-shaped, of variable size, and black, brown, gray, or green in color. The second is in form of an agglomeration of large nodules cemented together into a sort of flag, which used to be quarried for road purposes. The nodules in this agglomerate are richer in phosphoric acid when most dense and of a deep black color, the sandy varieties being comparatively poor. The cement carrying the nodules contains numerous fossil bones, shells, corals, etc., which are also phosphatic. The samples yield about 30 to 60 per cent phosphate of lime. Other deposits occur south of Saratov, on the Volga (Specimen No. 52067, U.S.N.M.); at Tambov and Spask, where the overlying rock is a greensand in place of the chalk; Moscow; east of Novgorod, on the Msta; at Kiev, on the Dnieper; Kamenetz, Podolsk, on the Dniester, and at Grodno, on the Niemen.

*Maltese Islands.*²—Nodular phosphates occur in Miocene beds on the

¹ Recherches sur les Gisements de Phosphate de Chaux Fossil en Russie.

² J. H. Cooke, The Phosphate Beds of the Maltese Island. Engineering and Mining Journal, LIV, 1892, p. 200.

islands of Malta, Gozo, and Comino, of the Maltese group in the Mediterranean Sea. The bed containing the nodules is in what is known as the Globigerina limestone, which underlies an upper coralline limestone, greensands, and blue clays, and overlies the lower coralline limestone. Upper and lower beds all carry phosphoric acid in small amounts. There are four seams of nodules, the first varying in different localities from 9 to 15 inches in thickness. The second is more constant in character, averaging some 2 feet in thickness and consisting of an aggregate of irregularly shaped nodules, intermixed with which are considerable quantities of the phosphatized remains of mollusks, corallines, echinoderms, crustaceans, sharks, whales, etc., the whole being firmly bound together by an interstitial cement, composed of foraminiferal and other calcareous matter similar to that of which the overlying beds are made up. The third seam is the poorest of the lot and consists of two or more thin layers of nodules, none of which exceeds 3 inches in thickness. Between this and the fourth and lowest seam, which is the most important of all, is a bed of rock some 50 to 80 feet in thickness. The seam averages some $3\frac{1}{2}$ feet in thickness. The nodules are of a dark-chocolate color embedded in a calcareous matrix, from which they are freed by calcination. The composition of I, the nodules, and II, the average composition of nodules and interstitial cement, is given below, from analyses by Drs. Murray and Blake:

Constituents.	I.	II.
Sulphate of lime	2.26	1.97
Carbonate of lime	47.14	51.12
Phosphate of lime.....	38.34	31.66
Alumina (Al_2O_3)	5.98	10.59
Oxide of iron (Fe_2O_3)	Trace.	a 3.83
Residue	6.08	b 0.87
Total.....	99.80	100.00

a Silica.

b Moisture.

GUANO, SOLUBLE AND LEACHED.—The largest and best-known deposits of unleached guanos are found on the mainland and small islands off the coasts of Peru and Bolivia, where abundant animal life and lack of rainfall have contributed to their formation and preservation. These deposits are described as consisting mainly of the evacuations of sea fowl and marine animals, such as flamingoes, divers, penguins, and sea lions. Mixed with these deposits are naturally more or less bone and animal matter furnished by the dead bodies of both birds and mammals. The deposits vary indefinitely in extent and thickness, but have attained in places a depth of upward of 100 feet. As a rule they are more compact beneath than at the surface, but

may be readily removed by pick and shovel. The first deposits to be worked are stated by Penrose to have been those of the Chincha Islands, off the Peruvian coast. These were practically exhausted as early as 1872. Other islands which have been worked and completely if not entirely stripped are those of Macabi, Guañape, Ballestas, Lobos, Foca, Pabellon de Pica, Tortuga, and Huanillos.

A mean of 21 analyses of Macabi Island guano, by Barral, as quoted by Penrose,¹ showed:

Nitrogen.....	10.90
Phosphates.....	27.60
Potash.....	2 to 3

Other analyses are given in the following table:

Constituents.	Angamos, coast of Bolivia, white guano.	Bolivian.	Los Patos.	Island of Elide, coast of California.
Organic matter.....	70.21 to 52.92	23.00	32.45	27.37 to 34.50
Containing nitrogen....	20.09 14.38	3.38	5.92	1.34 6.98
Equivalent in ammonia..	24.36 17.44	4.10	7.18	1.62 8.46
Total phosphates.....	13.30 20.95	48.60	34.81	28.00 31.00
Constituents.	Îlot de Pe- dro-Bey, coast of Cuba.	Mexican coast.	Galapa- gos, Ecuador.	Falkland Islands.
Organic matter.....	6.16	13.05 to 18.00	.....	17.35 to 28.68
Containing nitrogen....	0.28	0.21 3.45	0.7	0.56 2.26
Equivalent in ammonia..	0.34	0.26 4.19	0.85	0.68 2.74
Total phosphates.....	48.52	8.00 25.00	60.30	21.46 25.62

^aContaining sometimes very considerable quantities of phosphates of alumina and the oxide of iron.

Aside from on the islands, guano is found all along the coast of the Chilean province of Tarapaca, from Carmarones Bay to the mouth of the river Loa, there being scarcely a prominence or rock on the shore that does not contain some guano. According to the Journal of the Society of Chemical Industry,² the deposits have been known from a very early date. The aborigines of the valleys and gullies of Tarapaca, Mamina, Huatacondo, Camina, and Quisma were acquainted with the fertilizing qualities of guano, and they conveyed it from the coast to their farms on the backs of llamas.

The southern beds vary so much in aspect and color that it frequently requires an experienced eye to make them out. Many of the deposits are covered with immense layers of sand, while others are buried beneath a solid layer of conglomerate. Guano is also frequently found in the fissures and gullies which descend to the sea-

¹ Bulletin No. 46 of the United States Geological Survey.

² Volume VI, 1887, p. 228.

shore. The richest and largest beds are at Pabellon de Pica, Punta de Lobos, Huanillos, and Chipana.

Aside from the localities above mentioned, guano is found on the islands Itschabo, Possession, Pamora, and Halifax, off the Namagua coast of South Africa. The material is described as forming a grayish brown powder, free from large lumps, and possessing a faint ammoniacal odor. It carries from 8 to 14 per cent of nitrogen and 8 to 12 per cent of phosphoric acid.¹

The West India Islands.—Phosphates belonging to the class of leached guanos occur in considerable abundance on several of the islands of the West Indies group, the principal localities being Sombrero, Navassa, Turk, St. Martin, Aruba, Curaçao, Orchillas, Arenas, Roncador, Swan, Cat or Guanahani, Redonda, the Pedro and Morant Keys, and the reefs of Los Monges and Aves in Maracaibo Gulf. These, as would naturally be expected from their mode of origin, vary greatly, not merely in appearances, but in chemical composition as well. That of Sombrero is described² as occurring in two forms—one a granular, porous, and friable mass of a white, pink, green, blue, or yellow color (Specimen No. 44275, U.S.N.M.); the other as a dense, massive, and homogeneous deposit of a white or yellow color. Many bones occur. The phosphate carries from 70 to 75 per cent phosphate of lime. An analysis as given by Davies³ is as follows:

Moisture and water of combination.....	8.92
Phosphoric acid ⁴	31.73
Lime	45.69
Carbonic acid ⁵	5.99
Oxide of iron and alumina	7.07
Insoluble siliceous matter.....	.60
	<hr/>
	100.00

The Nevassa phosphate is described by D'Invilliers⁶ as occurring (1) in the form of a gray phosphate confined to the lower levels of the island, and (2) a red variety occupying the oval flat of the interior. The gray is the better variety, as shown by the analyses below, though both are aluminous, and difficult of manipulation on that account. Both varieties occur in cavities and fissures in the surface of the hard gray, white, or blue limestone, of which the island is mainly composed. These cavities or pockets are rarely more than 4 or 5 yards wide on the surface, and frequently much smaller, and of depths varying from 5 to 25 feet. The deposits, so far as explored, are wholly superficial.

¹ Journal of the Society of Chemical Industry, I, 1882, p. 29.

² R. F. Penrose, Bulletin No. 46 of the U. S. Geological Society.

³ D. C. Davies, Earthy and Other Minerals, p. 178.

⁴ Equal to tribasic phosphate of lime, 69.27 per cent.

⁵ Equal to carbonate of lime, 13.61 per cent.

⁶ Bulletin of the Geological Society of America, II, 1891, p. 75-89.

Experimental shafts sunk to a depth of 250 feet have failed to bring to light any deeper lying beds.

Analysis of gray Navassa phosphate.

Water, at 100 C	2.33
Organic matter and water of combination	7.63
Lime	34.22
Magnesia .....	.51
Sesquioxide of iron and alumina	15.77
Potash and soda .....	.86
Phosphoric acid	31.34
Sulphuric acid .....	.28
Chlorine .....	.15
Carbonic acid	1.84
Silica	4.53
Bone phosphate	68.46
Bone phosphate (dry basis)	70.09

Analysis of red Navassa phosphate.

Loss on ignition	14.223
Lime	23.090
Magnesia	Trace.
Sesquioxide of iron	9.796
Alumina	18.425
Phosphoric acid	29.779
Sulphuric acid	1.160
Carbonic acid (by difference)	3.527
Bone phosphate	65.037

Specimens Nos. 10247, 73245-73248, U.S.N.M., show the variable character of the phosphate rock, and Nos. 73242, 73243, U.S.N.M., the associated coral work.

The Aruba phosphate is described as a hard, massive variety of a white to dark-brown color. The underlying corals of this island are sometimes found phosphatized. An analysis given by Davies¹ is as follows:

	Per cent.
Moisture	8.50
Water of combination	4.15
Phosphoric acid ²	28.47
Lime	34.07
Magnesia .....	.45
Carbonic acid ³	2.30
Oxide of iron	4.49
Alumina	9.48
Sulphuric acid	1.81
Insoluble siliceous matter	6.28
	100.00

¹D. C. Davies, *Earthy and Other Minerals*, p. 177.

²Equal to tribasic phosphate of lime, 62.15 per cent.

³Equal to carbonate of lime, 5.22 per cent.

The Pedro Keys, Redonda, Alta Vela, and some others differ in carrying larger percentages of alumina and iron oxides, necessitating special methods of preparation.

Deposits of leached guano of considerable extent have existed on several islands of the Polynesian Archipelago, in the Pacific Ocean, the better known being those of Bakers, Howland, Jarvis, Malders, Birmie, Phoenix, and Enderbury islands. The deposits are described¹ as varying from 6 inches to several feet in thickness, of a whitish-brown or red color, pulverulent when dry, sometimes in the form of fine powder and again in coarse grains. Though closely compacted, the material can as a rule be readily removed by pick and shovel. The purest varieties are those lying on the unaltered coral limestones, of which the islands are mainly composed. Those lying upon gypsum have become contaminated with sulphate of lime. In places the deposits are covered with a thin crust due to the action of atmospheric agencies. On Jarvis Island a considerable share of the deposit is covered by material of this crust-like character. Such on analysis are found to contain less water and a corresponding higher percentage of lime and phosphoric acid than the loosely compacted material, being indeed, as shown by Mr. Hague, a nearly pure diphosphate of lime. The following analyses show the general character of these guanos from Bakers Island, No. I being freshly deposited and consisting of the dung of the frigate bird (*Pelicanus aquilus*). No. II is a light-colored variety from a deep part of the deposit, and No. III dark guano from a shallow part.

Analyses of guano.

Constituents.	I.	II.	III.
Moisture expelled at 212° F.....	10.40	2.92	1.82
Loss by ignition.....	36.88	8.32	8.50
Insoluble in HCl (unconsumed by ignition).....	0.78		
Lime.....	22.41	42.74	42.34
Magnesia.....	1.46	2.54	2.75
Sulphuric acid.....	2.36	1.30	1.24
Phosphoric acid.....	21.27	39.70	40.14
Carbonic acid, chlorine and alkalis, undetermined.....	4.44	2.48	3.21
Total.....	100.00	100.00	100.00
Soluble in water remaining after ignition.....	3.63		

BAT GUANO.—The dry atmosphere of caves preserves indefinitely the fecal matter of bats and such other animals as may frequent them. Such under favorable conditions may accumulate in sufficient quantities to become of economic importance, being gathered and used as a fertilizer under the name of bat guano. The usual form of the

¹J. D. Hague, American Journal of Science, XXXIV, 1862, p. 224.

entrances to caves is, however, such as to make the process of removal tedious and expensive.

Bat guano is, as a rule, dark in color, of a glossy, almost mucilaginous appearance, and quite hard (Specimen No. 53358, U.S.N.M., from Goshen caves, Juab County, Utah). Its composition is shown in the following analysis of a sample from the Wyandotte caves¹ in southern Indiana :

Loss at red heat	44.10
Organic matter	4.90
Ammonia	4.25
Silica	6.13
Alumina	14.30
Ferric oxide	1.20
Lime	7.95
Magnesia	1.11
Sulphuric acid	5.21
Carbonic acid	3.77
Phosphoric acid	1.21
Chloride of alkalies and loss	5.82
	<hr/> 100.00

According to the reports of the State geologist, the caves in the Silurian strata in Burnet County, Texas, are in many instances enormously rich in bat guano. The following description of one of these caves is taken from the report for 1889:

The bat cave in the northwest corner of Burnet County is worked by a Georgia company, and I learn from the men there that about 157 tons of the material had been shipped up to December 20, 1889. The shipments are made by wagon to Lampasas, Texas, and from there by rail to Georgia and other parts of the United States. The cave is situated about 8 miles from Bluffton, going north up Beaver Creek. Near Lacy Branch, a tributary of Beaver Creek, about 2 miles north of Silver Mine Creek, there is a fault on the west side of Beaver Creek, in a branch which is called "Bat Cave Hollow." Proceeding from this point in a northwest direction for about 2 miles we reach the bat cave, on top of a higher chert bed. The way from Beaver Creek to the cave is constantly ascending, first over Silurian limestone for about 1 mile, when the chert formation appears. On the top of a chert hill there is an opening of about 10 feet in diameter, extending perpendicularly downward for 30 feet, where, at the north side of this opening, there is an entrance to the cave. The cave has not been measured, but I estimate its length from north to south to be about 600 yards, with as much if not more space in the opposite direction. The top of the cave, as well as its sides, is solid chert, such as occurs in all the chert beds in San Saba and all the neighboring counties. The guano bed in the heart of the cave has been burned, leaving the ashes at places 26 feet deep, and not less than 18 feet at others. The ash is not brought up, and the supply of guano is taken from the surrounding portions and sides of the cave. As I understand, there are some leaders to the cave that have not yet been explored, there being plenty of material near the heart of the cave for all present requirements. Five men were employed in digging and bringing out the guano by means of a rail track to the surface, where it is deposited upon a large platform erected for that purpose.

¹Geology of Indiana, 1878, p. 163.

Muntz and Marciano¹ have called attention to the extensive deposits of guano, sometimes amounting to millions of tons, in caves in Venezuela and other parts of South America.

According to them the deposits consists not merely of the excreta of the birds and bats which frequent the caves, but also of the dead bodies of these and other animals. The excreta were found to consist almost wholly of the remains of insects. Through the agency of bacteria, nitrification takes place, whereby the organic nitrogen is converted in nitric acid which combines with the lime from the bones or the carbonate of lime in the soils to form nitrates, as described on page 391.

Uses.—The phosphates of the classes thus far described are used wholly for fertilizer purposes. In their natural condition they exist in the form known to chemists as tribasic phosphates—that is a compound in which three atoms of a base mineral, usually calcium, are combined with one of phosphoric anhydride (P_2O_5). Thus the common tribasic phosphate of lime has the formula $(CaO)_3 P_2O_5$ (= 45.81 parts by weight P_2O_5 and 54.19 CaO). Other bases, as alumina, iron, or magnesia, may partially replace the lime, but the phosphate is always deteriorated thereby. This is particularly the case when aluminum and iron are the replacing constituents. Although when finely ground the tricalcic phosphates are of value for fertilizers, it is customary to first submit them to chemical treatment in order to render them more readily soluble.

This treatment consists, as a rule, in converting them into a superphosphate by treatment with sulphuric acid whereby a portion of the base becomes converted into sulphates and the anhydrous and insoluble tribasic phosphate into a hydrous and soluble monobasic form of the formula $CaO \cdot (H_2O)_2 \cdot P_2O_5$. There are other reactions than those above given, but the process is one too complicated for discussion here, and the reader is referred to especial treatise on the subject.

BIBLIOGRAPHY.

- R. A. F. PENROSE, JR. Nature and Origin of Deposits of Phosphate of Lime. Bulletin No. 46, U. S. Geological Survey, 1888, pp. 143. Gives a bibliography, up to date, of publication. The following have appeared since:
- W. H. ADAMS. List of Commercial Phosphates.
Transactions of the American Institute of Mining Engineers, XVIII, 1889, p. 649.
- JOHN D. FROSSARD. About some Apatite Deposits of Ontario.
Engineering and Mining Journal, VIII, 1889, p. 194.
- PAUL LEVY. Des phosphates de chaux. De leurs principaux gisements en France et a l'étranger des gisements récemment découvertes. Utilisation en agriculture; assimilation par les plants.
Annales des Sciences Géologiques, XX, 1889, p. 78.

¹Comptes Rendus de l'Académie des Sciences, Paris, 1885, p. 65.

THEODOR DELMAR. Das Phosphoritlager von Steinbach und allgemeine Gesichtspunkte über Phosphorite.

Vierteljahrsschrift der Naturforschenden Gesellschaft in Zurich, 1890, p. 182.

HENRI LASNE. Sur les Terrains phosphatés des environs de Doullens. Etage Séonien et Terrains superposés.

Bulletin de la Société Géologique de France, XVIII, 1890, p. 441.

Idem, XX, 1892, p. 211.

Idem, XXII, 1894, p. 345.

ALBERT R. LEDOUX. The Phosphate Beds of Florida.

Engineering and Mining Journal, XLIX, 1890, p. 175.

HJALMAR LUNDBOHM. Apatitförekämster I Gellivare Malmberg och Kringliggande Trakt.

Sveriges Geologiska Undersökning, ser. C, 1890, pp. 48.

X. STAINIER. Les dépôts phosphates des environs de Thuillies.

Annales de la Société Géologique Belgique, XVII, 1890, p. LXVI.

———. Les Phosphorites du Portugal.

Idem., p. 223.

WALTER B. M. DAVIDSON. Suggestions as to the origin and deposition of Florida phosphates.

Engineering and Mining Journal, LI, 1891, p. 628.

EDWARD V. D'INVILLIERS. Phosphate Deposits of the Island of Navassa.

Bulletin of the Geological Society of America, II, 1891, p. 75.

N. DE MARCY. Remarques sur les Gîtes de Phosphate de Chaux de la Picardie.

Bulletin de la Société Géologique de France, XIX, 1891, p. 854.

EUGENE A. SMITH. Phosphates and Marls of Alabama.

Bulletin No. 2, Geological Survey of Alabama, 1892.

W. DE L. BENEDICT. Mining, Washing, and Calcining South Carolina Land Phosphate.

Engineering and Mining Journal, LIII, 1892, p. 349.

JOHN H. COOKE. The Phosphate Beds of the Maltese Islands.

Engineering and Mining Journal, LIV, 1892, p. 200.

WALTER B. M. DAVIDSON. The Present Formation of Phosphatic Concretions in Deep-Sea Deposits.

Engineering and Mining Journal, LIII, 1892, p. 499.

D. C. DAVIES. Phosphate of Lime.

Chaps. VII, VIII, IX, X, pp. 109-180, of A Treatise on Earthy and other Minerals and Mining, 3d ed., revised by E. Henry Davies, London, Crosby, Lockwood & Son, 1892.

HJALMAR LUNDBOHM. Apatitförekämster I Norrbottens Malmberg.

Sveriges Geologiska Undersökning, ser. C, 1892, p. 38.

N. A. PRATT. Florida Phosphates; The Origin of the Boulder Phosphates of the Withlacoochee River District.

Engineering and Mining Journal, LIII, 1892, p. 380.

FRANCIS WYATT. Phosphates of America.

New York, 4th ed., 1892.

W. P. BLAKE. Association of Apatite with Beds of Magnetite.

Transactions American Institute Mining Engineers, XXI, 1893, p. 159.

———. Contribution to the Early History of the Industry of Phosphate of Lime in the United States.

Idem., p. 157.

A. GAUTIER. Sur des phosphates en roche d'origine animale et sur un nouveau de phosphorites.

Comptes Rendus, CXVI, 1893, pp. 928 and 1022.

- A. GAUTIER. Sur la genèse des phosphates naturels, et en Particulier de ceux qui ont emprunté leur phosphore aux êtres organisés.
Comptes Rendus, CXVI, 1893, p. 1271.
- J. GOSSELET. Note sur les gîtes du Phosphate de Chaux de Templeux-Bellicourt et de Buire.
Société Géologique du Nord, XXI, 1893, p. 2.
- . Note sur les gîtes de Phosphate de Chaux des environs de Fresnoy-le-Grand.
Idem., p. 149.
- THOMAS M. CHATARD. Phosphate Chemistry as it concerns the Miner.
Transactions of the American Institute Mining Engineers, XXI, 1893, p. 160.
- GEO. H. ELDRIDGE. A Preliminary Sketch of the Phosphates of Florida.
Transactions of the American Institute Mining Engineers, XXI, 1893, p. 196.
- CHARLES HELSON. Notes sur la nature et le gisement du phosphate de chaux naturel dans les départements du Tarn-et-Garonne et du Tarn.
Société Géologique du Nord, XXI, 1893, p. 246.
- WALTER B. M. DAVIDSON. Notes on the Geological Origin of Phosphate of Lime in the United States and Canada.
Transactions of the American Institute Mining Engineers, XXI, 1893, p. 139.
- WILLIAM B. PHILLIPS. A List of Minerals containing at least one per cent of Phosphoric Acid.
Transactions of the American Institute Mining Engineers, XXI, 1893, p. 188.
- H. B. SMALL. The Phosphate Mines of Canada.
Transactions of the American Institute Mining Engineers, XXI, 1893, p. 774.
- JOHN STEWART. Laurentian Low-Grade Phosphate Ores.
Transactions of the American Institute Mining Engineers, XXI, 1893, p. 176.
- CARROLL D. WRIGHT. The Phosphate Industry of the United States.
Sixth Special Report of the Commissioner of Labor, 1893. Washington: Government Printing Office.
- M. BLAYAC. Description Géologique de la Région des Phosphates du dyr et du Kouif Près Tebéssa.
Annales des Mines, VI, 1894, p. 319.
- . Note sur les Lambeaux Suessoniens a Phosphate de Chaux de Bordj Redir et du Djebel Mzeita.
Idem., p. 331.
- EUGENE A. SMITH. The Phosphates and Marls of the State. Report on the Geology of the Costal Plain of Alabama, 1894, pp. 449-525.
- A. GAUTIER. Sur un Gisement de Phosphates de Chaux et d'Alumine contenant des espèces rares ou nouvelles et sur la Genèse des Phosphates et Nitrates naturels.
Annales des Mines, V, 1894, p. 5.
- THOMAS C. MEADOWS and LYTLE BROWN. The Phosphates of Tennessee.
Engineering and Mining Journal, LVIII, 1894, p. 365.
- WILLIAM B. PHILLIPS. The Phosphate Rocks of Tennessee.
Engineering and Mining Journal, LVII, 1894, p. 417.
- DAVID LEVAT. Étude sur l'industrie des Phosphates et Superphosphates. (Tunisie-Floride-scoires basiques.)
Annales des Mines, VII, 1895, p. 135.
- J. M. SAFFORD. Tennessee Phosphate Rocks.
Report of the Commissioner of Agriculture, Nashville, Tennessee, 1895, p. 16.
- CHARLES WILLARD HAYES. The Tennessee Phosphates.
Extract from the Seventeenth Annual Report of the U. S. Geological Survey, 1895-96. Pt. 2, Economic Geology and Hydrography. Washington: Government Printing Office. 1896.
- M. BADOUSEAU. Sur les gisements de chaux phosphates de l'Estremadure.
Bulletin de la Société Centrale Agriculture de France, XXXVIII.

2. MONAZITE.

Composition, a phosphate of cerium metals of the general formula (Ce, La, Di) PO₄. Actual analyses as given by Dana yielded results as below:

Constituents.	I.	II.
Phosphoric anhydride (P ₂ O ₅)	29.28	27.55
Cerium sesquioxide (Ce ₂ O ₃)	31.38	29.20
Lanthanum sesquioxide (La ₂ O ₃)	30.88	26.26
Didymium sesquioxide (Di ₂ O ₃)		
Yttrium sesquioxide (Y ₂ O ₃)		3.82
Iron sesquioxide (Fe ₂ O ₃)		1.13
Silica (SiO ₂)	1.40	1.86
Thorina (ThO ₂)	6.49	9.57
Lime (CaO)		0.69
Ignition	0.20	0.52
Total	99.63	100.60

I Burke County, North Carolina.

II Arendal, Norway.

The crystals are commonly minute, often flattened; not uncommonly in form of small cruciform twins. The mineral also occurs in coarse masses yielding angular fragments. Hardness, 5 to 5.5; specific gravity, 4.9 to 5.3. Color, hyacinth-red to brown and yellowish, subtransparent to translucent.

Localities and mode of occurrence.—The common form of occurrence of the mineral is that of minute crystals or crystalline granules disseminated throughout the mass of gneissoid rocks. Owing to their small size they have been very generally overlooked, and it is only where, through the decomposition of the inclosing rock and the concentration of these and the accompanying heavy minerals—as magnetite, garnet, etc.—in the form of sand, that it becomes sufficiently conspicuous to be evident. Prof. O. Derby was the first to point out the widespread occurrence of the mineral as a rock constituent, he having obtained it in numerous and hitherto unsuspected localities by washing the débris from decomposed gneisses of Brazil. Although widespread as a rock constituent and of interest from a mineralogical and petrographical standpoint, only the localities mentioned below have thus far yielded the mineral in commercial quantities.

North Carolina.—The mineral is found in considerable quantities in the form of small brown, greenish, or yellow-brown granules, often rounded by water action, in the gold-bearing sands of Rutherford, Polk, Alexander, Burke, and McDowell counties, and also in the neighborhood of Crowders Mountain, Gaston County, and at Todds Branch, in Mecklenburg County, where it occurs associated with zircons and an occasional diamond. Fine crystals over an inch in length have been found in Mitchell County, and large cleavable masses, sometimes 3 or

4 inches across and of a yellowish-brown color, at Mars Hill, in Madison County. From the gold-bearing sands at Brindleton, Burke County, some 15 tons of sand, containing from 60 to 92 per cent of small crystals, had been obtained prior to 1891.

According to Mr. H. B. Nitze¹ the commercially economical deposits of monazite are those occurring in the placer sands of the streams and adjoining bottoms and in the beach sands along the seashore. The geographical areas over which such workable deposits have been found up to the present time are quite limited in number and extent. In the United States the placer deposits of North and South Carolina stand alone. This area includes between 1,600 and 2,000 square miles, situated in Burke, McDowell, Rutherford, Cleveland, and Polk counties, North Carolina, and the northern part of Spartanburg County, South Carolina. The principal deposits of this region are found along the waters of Silver, South Muddy, and North Muddy creeks, and Henrys and Jacobs Forks of the Catawba River in McDowell and Burke counties; the Second Broad River in McDowell and Rutherford counties; and the First Broad River in Rutherford and Cleveland counties, North Carolina, and Spartanburg County, South Carolina. These streams have their sources in the South Mountains, an eastern outlier of the Blue Ridge. The country rock is granitic biotite gneiss and dioritic hornblende gneiss, intersected nearly at right angles to the schistosity by a parallel system of small auriferous quartz veins, striking about N. 70° E., and dipping steeply to the N.W. Most of the stream deposits of this region have been worked for placer gold. The existence of monazite in commercial quantities here was first established by Mr. W. E. Hidden, in 1879. The thickness of these stream gravel deposits is from 1 to 2 feet, and the width of the mountain streams in which they occur is seldom over 12 feet. The percentage of monazite in the original sand is very variable, from an infinitesimal quantity up to 1 or 2 per cent. The deposits are naturally richer near the headwaters of the streams.

Brazil.—As above noted, the original source of the Brazilian monazite were gneisses from which the mineral has been liberated by decomposition. The particular localities examined by Professor Derby are in the provinces of Minas Geraes, Rio de Janeiro, and São Paulo. The most extensive accumulation thus far reported is in the form of considerable patches on the sea beach near the little town of Alcobaca in the southern part of the province of Bahia, though it has been also found on other sea beaches and in river sands. Nitze writes that

Sacks filled with this sand were shipped to New York in 1885, the deposit having been taken for tin ore. Its true character was, however, soon recognized, and since then a number of tons have been shipped in the natural state, without any further

¹Sixteenth Annual Report U. S. Geological Survey, 1894-95, pt. 4, p. 685.

concentration or treatment, as ballast, mainly to the European markets. It is reported to contain 3 to 4 per cent thoria. * * * Monazite has also been found in the gold and diamond placers of the provinces of Bahia (Salabro and Caravellas), Minas Geraes (Diamantia), Rio de Janeiro, and São Paulo. It has been found in the river sands of Buenos Ayres, Argentine Republic, and also in the gold placers of Rio Chico, at Antioquia, in the United States of Colombia.

In the Ural Mountains of Russia monazite is found in the Bakakui placers of the Sanarka River. The placer gold mines of Siberia are reported to be rich in monazite, which is rafted down the Lena and the Yenesei rivers to the Arctic Ocean, and thence to European ports.

Economic deposits of monazite are also reported to exist in the pegmatic dikes of Southern Norway. It is picked by the miners while sorting feldspar at the mines. It is not known to exist in placer deposits. The annual output is stated to be not more than 1 ton, which is shipped mainly to Germany.

Methods of extraction.—The monazite is won by washing the sand and gravel in sluice boxes exactly after the manner that placer gold is worked. The sluice boxes are about 8 feet long by 20 inches wide by 20 inches deep. Two men work at a box, the one charging the gravel on a perforated plate fixed in the upper end of the box, the other one working the contents up and down with a gravel fork or perforated shovel in order to float off the lighter sands. These boxes are cleaned out at the end of the day's work, the washed and concentrated monazite being collected and dried. Magnetite, if present, is eliminated from the dried sand by treatment with a large magnet. Many of the heavy minerals, such as zircon, menaccanite, rutile, brookite, corundum, garnet, etc., can not be completely eliminated. The commercially prepared sand, therefore, after washing thoroughly and treating with a magnet, is not *pure* monazite. A cleaned sand containing from 65 to 70 per cent monazite is considered of good quality. From 20 to 35 pounds of cleaned monazite sand per hand, that is, from 40 to 70 pounds to the box, is considered a good day's work. The price of labor is 75 cents per day.

But very few regular mining operations are carried on in the region. As a rule each farmer mines his own monazite deposit and sells the product to local buyers, often at some country store in exchange for merchandise.

At the present time the monazite in the stream beds has been practically exhausted, with few exceptions, and the majority of the workings are in the gravel deposits of the adjoining bottoms. These deposits are mined by sinking pits about 8 feet square to the bed rock and raising the gravel by hand labor to a sluice box at the mouth of the pit. The overlay is thrown away excepting in cases where it contains any sandy or gritty material. The pits are carried forward in parallel lines, separated by narrow belts of tailing dumps, similar to the methods pursued in placer gold mining.

At the Blanton and Lattimore mines on Hickory Creek, 2 miles northeast of Shelby, Cleveland County, North Carolina, the bottom is 300 to 400 feet wide, and has been partially worked for a distance of one-fourth of a mile along the creek. The overlay is from 3 to 4 feet and the gravel bed from 1 to 2 feet thick. The methods of mining and cleaning are much more systematic in Spartanburg County, South Carolina, than in North Carolina regions. Although the raw material contains on an average fully as much garnet, rutile, titanite iron ore, etc., as that in the North Carolina mines, a much better finished product is obtained, and more economically, by making several grades. Two boxes are used in washing the gravel, one below the other. The gravel is charged on a perforated plate at the head of the upper box, and the clean-up from this box is so thoroughly washed as to give a high grade sand, often up to 85 per cent pure. The tailings discharge directly into the lower box, where they are rewashed, giving a second grade sand. At times the material passes through as many as five washing treatments in the sluice boxes. Even after these grades are obtained as clear as possible by washing, the material, after being thor-

oughly dried, is further cleaned by pouring from a cup, or a small spout in a bin, in a fine, steady stream from a height of about 4 feet, on a level platform; the lighter quartz and black sand with the fine-grained monazite (tailings) falls on the periphery of the conical pile and is constantly brushed aside with hand brushes; these tailings are afterwards rewashed. Instead of pouring and brushing, the material is sometimes treated in a winnowing machine similar to that used in separating chaff from wheat.

Although the best grade of sand is as high as 85 per cent pure, its quantitative proportion is small as compared with the second and other inferior grades, and there is always considerable loss of monazite in the various tailings. It is impossible to conduct this washing process without loss of monazite, and equally impossible to make a perfect separation of the garnet, rutile, titanite iron ore, etc., even in the best grades. The additional cost of such rewashing and rehandling must also be taken into consideration.

If the material washed contains gold, the same will be collected with the monazite in concentrating. It may frequently pay to separate it, which can easily be accomplished by treating the whole mass over again in a riffle box with quicksilver.

It has been shown that the monazite occurs as an accessory constituent of the country rock, and that the latter is decomposed to considerable depths, sometimes as much as 100 feet. On account of the minute percentage of monazite in the mother rock, it is usually impracticable to economically work the same in place, by such a process as hydraulicking and sluicing, for instance. However, even hillside mining has been resorted to. Such is the case at the Phifer mine, in Cleveland County, North Carolina, 2 miles northeast of Shelby. The country rock is a coarse mica (muscovite and biotite) gneiss, and the small monazite crystals may at times be distinctly seen, unaided by a magnifying glass, in this rock. It is very little decomposed and still quite hard, and the material that is mined for monazite is the overlying soil and subsoil, which is from 4 to 6 feet thick. This is loaded on wheelbarrows and transported to the sluice boxes below the water race. The yield is fairly good, and the product very clean, though the cost of working * * * must be considerably in excess of that of bottom mining. Where the rock contains sufficient gold, as it sometimes does, to be operated as a gold mine, there is no reason why the monazite can not be saved as a valuable by-product.¹

The following localities are represented in the Museum collections:

Specimen No. 53107, U.S.N.M. Prado, Bahia, Brazil. Monazite-bearing sand from the bed of a small stream near the beach.

Specimen No. 53108, U.S.N.M. Monazite sand, Prado, Bahia, Brazil. Natural concentrate of beach; represents the condition in which much of the material is shipped.

Specimen No. 53109, U.S.N.M. Monazite sand, Prado, Bahia, Brazil. The natural concentrate of the beach still further concentrated in the batea.

Specimen No. 53110, U.S.N.M. Monazite sandstone, Prado, Bahia, Brazil. A small bit of loosely coherent sandstone, composed largely of monazite particles. Of Quaternary (?) age, and presumably the source of much of the sand on the beach.

Specimen No. 62568, U.S.N.M. Monazite sand, with magnetic iron and other impurities. Henderson County, North Carolina.

Specimen No. 63343, U.S.N.M. Monazite sand from near Shelby, Cleveland County, North Carolina.

Specimen No. 63496, U.S.N.M. Monazite sand, concentrated, from Abbeville, South Carolina.

¹Sixteenth Annual Report U. S. Geological Survey, 1894-95, Pt. 4, pp. 686-687.

Uses.—The rare elements cerium, zirconium, thorium, yttrium, lanthanum, etc., which are as a rule associated with each other in the minerals cerite, zircon, monazite, samarskite, etc., as described, find their commercial use not in the form of metals, but as oxides only; and it is only since the introduction of the Welsbach incandescent system of lighting that their use in this form has assumed any commercial importance.

This Welsbach light consists of a cap or hood to gas or other burners, to increase their illuminating powers. The cap is made of cotton or other suitable material, impregnated with the oxides in proportions 60 per cent zirconia, 20 per cent yttria, and 20 per cent lanthanum. The fabric is strengthened and supported with fine platinum wire and suspended in the flame. On igniting in the flame the fabric is quickly reduced to ash, the cotton being burnt away and the earthy matter still retaining the form of a cap or hood.¹

The drawback to the use of these oxides has been, it is said,² the great difficulty in obtaining them in a pure condition. Several methods have been used, but usually with poor results, especially when the mineral contains iron.

The demand for the minerals of this group being so limited there is no regular market price. The Mineral Industry for 1893 quotes zircon at 10 cents a pound, monazite 25 cents, and samarskite 50 cents. It is stated that 1 ton of zircon will yield sufficient zirconia for half a million Welsbach burners.

BIBLIOGRAPHY.

See paper on Monazite, by H. B. C. Nitze, in Mineral Resources of the United States, Part. 4, of the Sixteenth Annual Report U. S. Geological Survey, 1894-95, pp. 667-693. This contains a very satisfactory bibliography down to date of publication. Also see *Les Terres Rares Mineralogie-Propriétés Analyse*, by P. Truchot. Carré et Naud. Paris, 1898.

3. VANADINITE.

This is a vanadate and chloride of lead of the formula $(\text{PbCl})\text{Pb}_4\text{V}_3\text{O}_{12}$, = Vanadium pentoxide 19.4 per cent; lead protoxide 78.7 per cent; chlorine 2.5. In nature often more or less impure through the presence of arsenic and traces of iron, manganese, zinc, and lime. Color deep red to brown and straw-yellow, resinous luster; translucent to opaque. Hardness 2.75 to 3. Gravity 6.66 to 7.23. When a drop of nitric acid is applied to a particle of a crystal there is soon formed a yellow coating of vanadic oxide. This reaction is quite characteristic and furnishes an easy and convenient means of determination.

Localities and mode of occurrence.—Occurs in prismatic crystals with smooth faces and sharp edges; crystals sometimes cavernous at the top,

¹ Journal of the Society of Chemical Industry, V, 1886, p. 522.

² Mineral Resources of the United States, 1885, p. 393.

as in Specimen No. 61135, U.S.N.M. Also common in parallel grouped and rounded forms and globular incrustations. Dana gives the following relative to the known localities:

This mineral was first discovered at Zimapan in Mexico, by Del Rio. Later obtained among some of the old workings at Wanlockhead in Dumfriesshire, where it occurs in small globular masses, on calamine, and also in small hexagonal crystals; also at Berezov in the Ural, with pyromorphite; and near Kappel in Carinthia, in crystals; at Udenäs, Böhle, Sweden; in the Sierra de Córdoba, Argentine Republic; South Africa.

In the United States it occurs sparingly with wulfenite and pyromorphite as a coating on limestone, near Sing Sing, New York. In Arizona it is found at the Hamburg, Melissa, and other mines in Yuma County, in brilliant deep red crystals; Vulture, Phoenix, and other mines in Maricopa County; at the Black Prince mine; also the Mammoth gold mine, near Oracle, Pinal County, and in brown barrel-shaped crystals in the Humbug district, Yavapai County. In New Mexico it is found at Lake Valley, Sierra County (endlicheite); and the Mimbres mines near Georgetown [Specimen No. 67844, U.S.N.M.].

The characteristic mode of occurrence at the Mimbres Mine, above noted, is associated with descloizite in the form of small hopper-shaped crystals and drusy or botryoidal and globular masses coating the siliceous residues of the limestone in the irregular cavities with which the stone abounds. The color of these coatings varies from beautiful ruby red to light ochreous yellow. The mineral is here nearly always associated with descloizites as noted below.

Uses.—See under descloizite.

4. DESCLOIZITE.

This is a vanadate of lead and zinc of the formula $4(\text{PbZn})\text{O} \cdot \text{V}_2\text{O}_5 \cdot \text{H}_2\text{O}$ = vanadium pentoxide 22.7 per cent; lead protoxide 55.4 per cent; zinc oxide 19.7 per cent; water 2.2 per cent. The published analyses show also small amounts of arsenic, copper, iron, manganese and phosphorus. Color, red to brown; luster, greasy; no cleavage; fracture small conchoidal to uneven. Occurs in small prismatic or pyramidal crystals and in fibrous, mamillated or massive forms. Often associated with and pseudomorphous after vanadinite.

Localities and mode of occurrence.—Dana gives the following relative to occurrence:

Occurs in small crystals, 1 to 2 millimeters thick, clustered on a siliceous and ferruginous gangue from South America, at the Venus Mine and other points in the Sierra de Córdoba, Argentine Republic, associated with acicular green pyromorphite, vanadinite, etc. At Kappel, in Carinthia, in small clove-brown rhombic octahedrons.

* * * * *

Sparingly at the Wheatley Mine, Phoenixville, Pennsylvania, as a thin crystalline crust on wulfenite, quartz, and a ferruginous clay. Abundant at the Sierra Grande Mine, Lake Valley, Sierra County, New Mexico, in red to nearly black crystals, pyramidal and prismatic in habit, associated with vanadinite, iodyrite, etc.; at the Mimbres and other mines, near Georgetown, New Mexico, in stalactitic crystalline

aggregates [Specimen No. 67844, U.S.N.M.]. In Arizona near Tombstone, in Yavapai County, in brownish olive-green crystals; at the Mammoth Gold Mine, near Oracle, Pinal County, in orange-red to brownish red crystals with vanadinite and wulfenite.

A vanadinite, probably identical with descloizite, occurs at the Mayflower Mine, Bald Mountain district, in Beaverhead County, Montana; it is in an impure earthy form of a dull yellow to pale orange color. See further under Carnotite, p. 404.

Vanadium is also found in small quantities in certain Swedish iron ores; in the cupriferous schists of Mansfeld, Saxony; in cupriferous sands of Cheshire, England, and Perm, Russia; in coals from various localities; in beauxite and in clay near Paris. As stated by Fuchs and De Launey,¹ vanadium has been shown to exist in extremely small proportions in primordial rocks, from which it became concentrated in the clays on their breaking up. Certain oolitic iron ores (limonites) at Mafenay, Saone et Loire, France, contain the substance in such proportions that the slag from their smelting have become commercial sources of supply, some 60,000 kilograms of vanadic acid being manufactured annually from them.

The following referring to the occurrence and value of vanadates in the United States is of sufficient interest to bear reproduction here:

The lead vanadates are frequently found in association with lead ores, as, for instance, in the deposits at Leadville, whence some very handsome specimens were formerly obtained. The most important occurrence of lead vanadates in the United States, however, is probably in Arizona, where it has been reported in the ores of several mines, among others those of the Castle Dome district, the Crowned King mine in the Bradshaw Mountains, and the Mammoth gold mines at Mammoth, in Pinal County. The last-mentioned mines are probably the only ones in the United States from which vanadium minerals have been won on an industrial scale. The vanadium minerals, of which nearly all the known varieties occurred, the dechenite and descloizite predominating, were found in the upper levels of the mine, forming about 1 per cent of the ore on the average, though within limited areas they formed from 3 to 4 per cent. In the lower levels they occurred less abundantly, only an occasional pocket and a small quantity of disseminated crystals being found. The red crystals, according to an analysis by the late Dr. F. A. Genth, contained chlorine, 2.43 per cent; lead, 7.08 per cent; lead oxide, 69.98 per cent; ferric oxide, 0.48 per cent; vanadic acid, 17.15 per cent; arsenic acid, 3.06 per cent, and phosphoric acid, 0.29 per cent. In milling the ore (gold) the vanadium minerals collected in riffles, placed about 18 inches apart in the sluices. The material thus obtained was worked over by hand in a sort of buddle, and the resulting concentrates were sold to the Kalion Chemical Company, of Gray's Ferry Road, Philadelphia. The total quantity of concentrates obtained in this manner did not exceed 6 tons. An average sample of the lot, analyzed by Dr. Genth, gave the following results: Vanadic acid, 15.40 per cent; molybdic acid, 3.35 per cent; arsenic acid, 1.50 per cent; carbonic acid, 0.90 per cent; chlorine, 0.48 per cent; oxide of lead, 56.80 per cent; oxide of zinc, 10.70 per cent; oxide of copper, 0.95 per cent; oxide of iron, 0.35 per cent; soluble silica, 0.60 per cent; insoluble matter, 5.29 per cent. The value of the gold and silver contents of the concentrates was about \$140 per ton. The price realized on this first lot was 12.5 cents per pound, or \$250 per ton, on board the cars at Tucson.

The vanadic salts manufactured from this lot of concentrates were said to have

¹ *Traité des Gîtes Minéraux*, II, p. 95.

been the first produced on a commercial scale in the United States, and owing to the limited market for the same the price dropped over 50 per cent.

Frue vanners were then introduced into the mill, and the product obtained from them, amounting to about 1 ton per 100 tons of ore crushed, contained from 5 to 6 per cent vanadic acid and \$40 to \$80 per ton in gold and silver. The Kalion Chemical Company offered to buy this product according to the following sliding scale: With the market price of ammonium vanadate \$5 per pound, \$100 per ton for the concentrates; vanadate of ammonium \$4.50 per pound, concentrates \$92; vanadate of ammonium \$4 per pound, concentrates \$82; vanadate of ammonium \$3.50 per pound, concentrates \$72; vanadate of ammonium \$3 per pound, concentrates \$64. Only a few tons of these concentrates were shipped to Philadelphia, the remainder being sold to the Denver smelters for their gold, silver, and lead value.¹

Uses.—The only uses thus far developed for the mineral are as a source for vanadium salts used as a pigment for porcelain; in the manufacture of ink and in textile dyeing and printing, both vanadate of ammonium and vanadic oxide being used for the latter purpose, producing an intense black color with a slight greenish cast.

5. AMBLYGONITE.

This is a fluo-phosphate of aluminum and lithium, of the formula Li (Al F) P O_4 . Analysis of a sample from Paris, Maine, as given by Dana, shows: Phosphoric acid, 48.31 per cent; alumina, 33.68 per cent; lithia, 9.82 per cent; soda, 0.34 per cent; potash, 0.03 per cent; water, 4.89 per cent; fluorine, 4.82 per cent; hardness, 6; specific gravity, 3.01 to 3.09. Luster vitreous to greasy, color white to pale greenish, bluish, yellowish to brownish, streak white. On casual inspection the mineral somewhat resembles potash feldspar (orthoclase), but when finely pulverized is soluble in sulphuric acid, and less readily so in hydrochloric acid. The Hebron variety, when pulverized and moistened with sulphuric acid, gives the characteristic lithia red color to the flame.

Mode of occurrence.—Amblygonite occurs in the form of coarse crystals, or compact and columnar forms in pegmatic veins associated with lepidolite, tourmalines, and other minerals so characteristic of this class of veins. In the United States it occurs at Hebron (Specimen No. 62576, U.S.N.M.); Mount Mica, in Paris (Specimen No. 53694, U.S.N.M.); Auburn and Peru, Maine, at the latter place associated with spodumene, petalite, and lepidolite. In Saxony the mineral is found at Chursdorf and Arnsdorf, near Penig, and near Geier. Also found at Arendal, Norway, and at Montebbras and Creuze, France.

Uses.—Since 1886 the mineral has been utilized as a source of lithia salts, in place of the lithia mica. The chief commercial source is at present Montebbras, France, where it occurs in a coarse granitic vein yielding also cassiterite and kaolin in commercial quantities.

¹ The Mineral Industry, II, 1893, p. 574.

6. TRIPHYLITE AND LITHIOPHILITE.

These are names given to phosphates of iron, manganese, and lithium, and which pass into one another by insensible gradations through variations in the proportional amounts of manganese protoxide, the triphylite containing from 10 to 20 per cent of this oxide, while the lithiophilite contains twice that amount. The comparative composition of extreme types is shown below:

Name.	P ₂ O ₅ .	FeO.	MnO.	Li ₂ O.	Na ₂ O.	H ₂ O.
Triphylite	43.18	36.21	8.96	8.15	0.26	0.87
Lithiophilite	44.67	4.02	40.86	8.63	0.14	0.82

Triphylite is a gray to blue-gray mineral in crystals and coarsely cleavable masses of a hardness of 4.5 to 5 of Dana's scale, and specific gravity of 3.42 to 3.56.

Lithiophilite differs mainly in color—aside from composition as above noted—being of a pink to clove-brown hue. Both minerals may undergo a darkening in color, becoming almost black through a higher oxidation and hydration of the manganese protoxide. This feature is best shown in the lithiophilite from Branchville, Connecticut. (Specimen No. 62583, U.S.N.M.)

Occurrence.—These minerals occur chiefly in granitic veins, associated with spodumene and other lithia bearing minerals, as at the localities above mentioned. Peru, Hebron, and Norway, Maine; Keityö, Finland, etc.

IX. NITRATES.

There are three compounds of nitric acid and a base occurring in nature in such quantities and of sufficient economic importance to merit attention here. These are (1) the true niter or potassium nitrate (KNO₃), (2) soda niter or sodium nitrate (NaNO₃), and (3) nitrocalcite, a calcium nitrate (CaN₂O₆). All are readily soluble in water, and hence found in any quantity only in arid regions or where protected, as in the dry parts of caves.

1. NITER, POTASSIUM NITRATE.

Composition KNO₃, =nitric anhydride, 53.5 per cent; potash, 46.5 per cent. Hardness, 2; specific gravity, 2.1; color, white, subtransparent. Readily soluble in water. Taste, saline and cooling. Deflagrates vividly when thrown on burning coals and colors the flame violet.

The mineral occurs in nature mainly in the form of acicular crystals and efflorescences on the surface or walls of rocks and scattered in the loose soil of limestone caves and similar dry and protected places.

It is also found in certain soils of tropical countries, as noted under origin. In the United States it has been found in caves of the Southern States, as those of Madison County, Kentucky, but never in commercial qualities. The chief commercial source of the salt has been the artificial nitrates of France, Germany, Sweden, and other European countries. It is also prepared artificially from soda niter.

2. SODA NITER.

Nitrate of sodium, NaNO_3 . This in its pure state is a white or colorless salt, but in nature brown or bright lemon yellow (See Specimens in jar, No. 67278, U.S.N.M.), of a slight saline taste, but with a peculiar cooling sensation when placed upon the tongue. It is by far the most common of the nitrates, and indeed the only one of the natural salts of any great commercial value, owing to the comparative rarity of the others. Though found to a slight extent in caves and protected places, the commercial supply is drawn almost wholly from the desert regions of the Pacific coast of South America and particularly from Chile, the chief deposits being found in the provinces of Tarapaca and Antofagasta.

According to the Journal of the Society of Chemical Industry:¹

The total area of the province of Tarapaca is 16,789½ square miles, and it is divided naturally into five distinct and well-defined zones. The first of these zones commences on the shores of the Pacific and has an average width, west to east, of 18 miles. It is formed, in the first place, of the beach; and, in the second, of the coast range, which attains an altitude varying from 1,125 to 5,800 feet above the sea level. This zone may be denominated the guano and mining zone. * * * This belt as it advances eastward becomes more and more depressed and terminates in a series of pampas (open plains), having an elevation of 3,500 to 3,800 feet above the sea level. Nearly all these pampas contain vast beds of salts, sulphate of soda, and sulphate of lime. They are known locally by the name of "salares." In some parts of the desert of Atacama the beds of nitrate of soda are found under these salares deposits, but in Tarapaca the caliche (nitrate earth) is found only under a bed of conglomerate known as "costra." * * *

The second zone—the nitrate zone—commences on the edge of the Camarones Gully and extends southward to the desert of Atacama. Up to 1858 it was believed that the nitrate beds did not extend southward beyond the Loa Gully, but in that year beds were discovered in what was then the Bolivian littoral. Explorations which were effected in 1872 proved that the nitrate beds extended northward beyond the Camarones Gully and that they reached as far as the Chaca Gully and even as far as the Azapa Valley, in the province of Alrica. * * * The quantity and quality of the caliche varies very considerably in different parts of the zone, but the dimensions of the nitrate area may be set down at 120 geographical miles in length north to south, and 2 geographical miles in width east to west. It is estimated that the beds contain the enormous quantity of 1,980,630,502 quintals of niter, and it is stated that with the present export duty which is equal to 27 pence per quintal, the deposits will yield a revenue of £230,809,474.

¹ Volume VI, 1887, pp. 228, 229.

It is elsewhere stated that the point on the slope of the mountains where the deposits of caliche are found is some 500 or 600 feet higher than the valley, but that the material diminishes in quantity and richness as the valley is approached and disappears entirely at the bottom.

An examination of the workings of these beds discloses the following conditions:

(1) That the surface to the depth of 8 or 10 inches is covered with a layer of fine, loose sand.

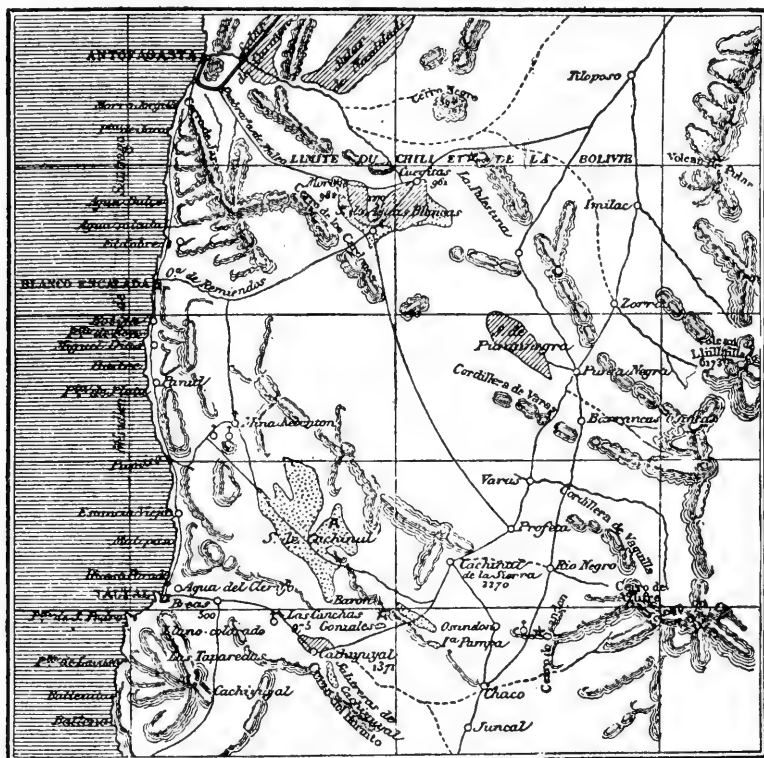


Fig. 12.

MAP OF NITRATE REGION, CHILE.

After Fuchs and De Launay.

(2) That underneath the sand is a conglomerate of amorphous porphyry, feldspar, chloride of sodium, magnesia, gypsum, etc., cemented by the sulphate of lime into a hard, compact mass to a depth of 6 to 10 feet, called the "costra" or crust.

(3) That below this crust the caliche, or impure nitrate, is found, presenting to the view a variety of colors—yellowish-white, orange, bluish-gray, etc.

The nitrate deposit is quarried by blasting with a coarse-grained powder, of which as much as 150 pounds are sometimes used at a single blast. Neither dynamite nor nitroglycerine is used, as it would shatter and pulverize the caliche so as to occasion a serious loss.

After being brought to the surface the caliche is carefully assorted by experts, broken into pieces double the size of an orange, and carted to the refinery establishment, situated on the pampas or on the sea-coast, or carried to Iquique, Pisagua, Patillos, and Antofagasta by rail, all of these places having connection, by narrow-gauge railways, with the nitrate deposits and which, consequently, are rapidly becoming the chief centers of nitrate production and export.

According to the reports of Consul-General Walker, the southern limit of the nitrate fields is in Antofagasta province, latitude $25^{\circ} 45' S.$, and the northern in latitude $19^{\circ} 12' S.$, its extreme north and south length being some 260 geographical miles and its average width some $2\frac{1}{2}$ miles.

This narrow strip of nitrate lands stretches along the eastern slope of the coast range of barren, verdureless mountains which wall in the Pacific Ocean from the northern limit of Peru to the Straits of Magellan, upon which, for more than 2,000 miles, no rain ever falls and upon which there is no living vegetation. Some of the peaks reach an altitude of 4,000 or 5,000 feet above the sea level, but the usual height of the range is about 2,000. The average distance from the coast to the nitrate beds is about 14 miles, but many of them are not more than 10 miles.

The accompanying map, p. 393, from Fuchs and De Launays, *Traité des Gîtes Minéraux*, will serve to show the geographic position of the deposits.

Specimen No. 62111, U.S.N.M., show the varying character of the material as mined.

3. NITRO-CALCITE.

Nitro-calcite, or calcium nitrate, $\text{CaN}_2\text{O}_6 + n\text{H}_2\text{O}$, is not uncommon as a silky efflorescence on the floors and walls of dry limestone caverns and may be extracted in considerable quantities from their residual clays by a process of leaching. During the war of 1812 the clays upon the floors of Mammoth Cave, Kentucky, were systematically leached and the dissolved nitrate obtained by evaporation and crystallization. The wooden tanks and log pipes for conducting the water are still in a remarkable state of preservation, owing to the dry air of the cavern.

The nitrous earths of Wyandotte Cave in southern Indiana, and doubtless of other localities, were similarly treated during these times of temporary stringency. (See Specimens Nos. 68165, 68166, U.S.N.M. in cave exhibit.)

According to the reports of the State geologist¹ this earth, in its air-dry condition, has the following composition:

Loss at red heat.....	16.50
Silica.....	20.60
Ferrie oxide.....	6.03
Manganic oxide.....	0.75
Alumina.....	20.40
Lime.....	8.06
Magnesia.....	4.58
Carbonic acid.....	10.38
Sulphuric acid.....	6.55
Phosphoric acid.....	2.43
Nitric acid.....	3.50
Chlorides of alkalis and loss.....	0.32
	<hr/>
	100.10

The researches of Muntz and Marceno² have shown that the soils as well as the earth from the floor of caves, in Venezuela and other portions of South America may be rich in calcium nitrate to an extent quite unknown in other countries.

Origin.—The source of the nitrates, both of caves and of the Chilean pampas has been a subject of considerable discussion. There appears little doubt but the deposits in caves and those disseminated in soils are due to the nitrifying agencies of bacteria acting upon organic matter whereby the organic nitrogen is converted into nitric acid which immediately combines with the most available bases, be they of lime, soda, or potash. The accumulation of the niter in caves is probably due, as suggested by W. H. Hess (see Bibliography), to the retention by the clay of the nitrates brought in from the surface by percolating waters.

In other words, the caves serve merely as receptacles, or store-houses, for nitrates which had their origin in the surface soil. The Chilean nitrate beds are considered by Muntz and Marceno as having a very similar origin. The material being soluble is gradually leached out from the soils in which it originated and drained into inclosed salt marshes or inland seas where a double decomposition takes place between the sodium chloride and calcium nitrate, whereby sodium nitrate and calcium chloride are produced. That such a double decomposition may take place has been shown by actual experiment.

This is not widely different from the view taken also by W. Newton.³

After discussing briefly theories previously advanced including Darwin's theory of derivation from decomposing seaweeds accumulated on old sea beaches, and the even less plausible one of its derivation from guano, he goes on to show that the plain of Tamarugal

¹ Geological Report of Indiana, 1878, p. 163.

² Comptes Rendus de l'Academie des Sciences, CI, Paris, 1885, p. 1265.

³ Geological Magazine, III, 1896, p. 339.

within which the deposits lie, is covered by an alluvial soil rich in organic matter. This organic matter under the now well-known action of bacteria, aided by the prevailing high temperatures of the region, gives rise to nitrates, which owing to the absence of rains for long periods, accumulates to an extent impossible under less favorable circumstances. Mountain floods which occur at periods of seven or eight years, swamp the plain, bringing in solution the nitrate drained from the soils of the surrounding slope, and to accumulate in the lower levels. On the evaporation of the water this is again deposited. The occurrence of the nitrate so far up the slope of the hills is regarded by Newton as due to the tendency of the nitrate salt, in saturated solutions, to creep up, as in experiment it may be seen to creep up and over the sides of a saucer or other shallow dish in which the evaporation is progressing.

BIBLIOGRAPHY.

- M. A. MUNTZ. Recherches sur la formation des gisements de nitrate de soude.
Comptes Rendus de l'Academie des Sciences, CI, 1885, p. 1265.
- ROBERT HARVEY. Machinery for the Manufacture of Nitrate of Soda.
Journal of the Society of Chemical Industry, IV, 1885, p. 744.
- RALPH ABERCROMBY. Nitrate of Soda, and the Nitrate Country.
Nature, XL, 1889, p. 186.
- . The Nitrate Deposits and Trade of Chile.
Engineering and Mining Journal, L, August 9, 1890, p. 164.
- NICOLAS RUSCHE. Die Saltpetrewüste in Chile.
Vom Fels zum Meer, pt. 4, 1891-2.
- G. M. HUNTER. The Santa Isabel Nitrate Works, Toco, Chile.
Transactions of the Institute of Engineers and Shipbuilders of Scotland, XXXVI, p. 57.
- WILLIAM NEWTON. The Origin of Nitrate in Chile.
The Geological Magazine, III, 1896, p. 339.
- W. H. HESS. The Origin of Nitrates in Caves.
Journal of Geology, VIII, No. 2, 1900, p. 129.

X. BORATES.

Of the ten or more species of natural borates but three, or possibly four, are commercial sources of borax, and need consideration here. These are, (1) borax or tincal; (2) ulexite, or boronatocalcite; (3) priceite, colemanite, or pandermite, and (4) boracite, or stassfurtite. Sassolite, or native boric acid, occurs chiefly in solution. The intimate association of these minerals renders it advisable to treat of their origin and mode of extraction in common, after giving the composition and general physical characters of each by itself.

1. BORAX OR TINCAL; BORATE OF SODA.

Composition $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$, = boron trioxide, 36.6 per cent; soda, 16.2 per cent; water, 47.2 per cent. Color, white to grayish, and sometimes greenish; translucent to opaque. It crystallizes in short,

stout prisms, belonging to the monoclinic system (Specimen No. 15514, U.S.N.M.) Hardness, 2 to 2.5; specific gravity, 1.7. Readily soluble in water; taste sweetish alkaline.

2. ULEXITE; BORONATROCALCITE.

Composition $\text{NaCaB}_5\text{O}_9 \cdot 8\text{H}_2\text{O}$, = boron trioxide, 43 per cent; lime, 13.8 per cent; soda, 7.7 per cent; water, 35.5. Color, white, with silky luster. Occurs usually in rounded masses of loose texture, which consist mainly of fine acicular crystals or fibers. (See Specimen No. 18128, U.S.N.M., from Rhodes Marsh, Nevada.) Insoluble in cold water, and only slightly so in hot, the solution being alkaline. Hardness, 1; specific gravity, 1.65.

3. COLEMANITE.

Composition $\text{Ca}_2\text{B}_6\text{O}_{11} \cdot 5\text{H}_2\text{O}$, = boron trioxide, 50.9 per cent; lime, 27.2 per cent; water, 21.9 per cent. Color, milky to yellowish-white, or colorless; transparent to translucent. Hardness, 4 to 4.5; specific gravity, 2.41. Insoluble in water, but readily so in hot hydrochloric acid. Priceite and pandermite are hydrous calcium borates closely allied to colemanite, occurring in loosely coherent and chalky or massive forms. (Specimen No. 63362, U.S.N.M.).

4. BORACITE OR STASSFURTITE; BORATE OF MAGNESIA.

Composition $\text{Mg}_7\text{Cl}_2\text{B}_{16}\text{O}_{30}$, = boron trioxide, 62.5 per cent; magnesia, 31.4 per cent; chlorine, 7.9 per cent. Color, white to yellow or greenish. In crystals transparent to translucent. Crystals cubic and tetrahedral. Insoluble in water; readily soluble in hydrochloric acid. Hardness, 7; specific gravity, 2.9 to 3. (Specimen No. 64742, U.S.N.M., from Stassfurt.)

Localities and mode of occurrence.—As has been stated by Kemp¹ the Great Basin region of the United States contains, along the Nevada-California border at least ten salines or marshes which have been found to hold boracic deposits. The marshes are regarded as the beds of relatively restricted lakes which received boracic water, probably from hot springs. Volcanic phenomena are abundant and were doubtless the stimulating causes. Besides borax, ulexite (borate of lime and soda) and priceite (borate of lime) are found commingled with more or less gypsum, carbonate, chloride, and sulphate of soda and various other alkaline salts. The best known of the salines in Nevada are Teels Marsh, Columbus Marsh, Fish Lake Valley, and Rhodes Marsh, all in Esmeralda County. These cover an area of thousands of acres, but the productive portions are comparatively limited. In Churchill County, this same State, there is a minor deposit at Salt Wells (Specimen No. 15522, U.S.N.M.). In California there is an important deposit known as Searles Marsh, in San Bernardino County, and a vein

¹The Mineral Industry, 1892, p. 43.

of calcium borate (colemanite) in the Calico District, this same county. The Saline Valley, the Amargosa, and Furnace Creek deposits, in Inyo County, are also extensive. (Specimen No. 62444, U.S.N.M.). Large deposits of priceite are also found 5 miles north of Chetco, in Curry County (Specimen No. 63362, U.S.N.M.), Oregon. The mineral is stated by Dana to occur in a hard, compact form in layers, between a bed of slate above, the cavities and fissures of which it fills, and a tough, blue steatite below; also occurring in bowlders or rounded masses completely embedded in the steatite. These masses vary from the size of a pea to those of 200 pounds weight each.

The Calico District colemanite above referred to occurs, according to W. H. Storms,¹ as a bedded "vein" in sedimentary strata which in Tertiary times were uplifted in the Calico Range, the sedimentary rocks consisting of sandstones, sandy clays, and clayey sands. "The borax 'vein' is traceable for several thousand feet, striking along the western and northern side of the largest sedimentary hill in the range, and finally passing down a canyon to the eastward, where it becomes a well-defined vein. Toward the western end the borate of lime appears to be much mixed with the sandy sediments, gypsum, and clays, giving the appearance of having been formed near the shore line of the basin in which this great mass of material has been left as a residuary deposit, due to the evaporation of the water containing the calcium borate." There are apparently two beds of borate from 7 to 10 feet in thickness in close proximity, but which are believed by Mr. Storms to be portions of the same bed repeated as the result of an anticlinal fold, and exposed through erosion. See Plate 21.

The following description of Searles Marsh, in San Bernardino County, is from the reports of the State mineralogist.²

This marsh is situated in the northwestern corner of San Bernardino County, occupying a portion of T. 25 S., R. 43 E., M. D. M. The site is distant from San Francisco southeast 500 miles; from San Bernardino, the shire town of the county, due north 175 miles, and from Mohave, nearest station on the Southern Pacific Railroad, northeast 72 miles; these distances being measured by the usually traveled routes.

Locally considered, Searles Marsh lies near the center of an extensive mountain-girdled plain, to which the phrases "Alkali Flat," "Dry Lake," "Salt Bed," "Borax Marsh" have variously been applied, the contents and physical features of the basin-shaped depression well justifying the several names that have so been applied to it. It is, in fact, a dry lake, the bed of which has been filled up in part with the several substances named. Its contents consist of mud, alkali, salt,

¹ Eleventh Annual Report of the State Mineralogist of California, 1892, p. 345.

² Tenth Annual Report of the State Mineralogist of California, 1890, p. 534.



BORAX MINE NEAR DAGGETT, CALIFORNIA.
Interior and exterior views.



and borax, largely supplemented with volcanic sand. This depression, which has an elevation of 1,700 feet above sea level, and an irregular oval shape, is about 10 miles long and 5 miles wide, its longitudinal axis striking due north and south. It is surrounded on every side but the south by high mountains, the Slate Range bounding it on the east and north, and the Argus Range on the west.

There is no doubt but this basin was once the bed of a deep and wide-extended lake, the remains of a former inland sea. The shore line is distinctly visible along the lower slopes of the surrounding mountains at an elevation of 600 feet above the surface of the marsh. Farther up, one above the other, faint marks of former water lines can be seen, showing the different levels at which the surface of the ancient lake has stood. In the course of time the lake became extinct, having been filled with the sediments from the adjacent mountains.

What may have been the depth of the lake has not yet been ascertained, borings put down 300 feet having failed to reach bed rock. These borings, commenced in 1878, disclosed the following underlying formations:

First, 2 feet of salt and thenardite [Na_2SO_4]; second, 4 feet of clay and volcanic sand, containing a few crystals and bunches of hanksite, [$4\text{Na}_2\text{SO}_4, \text{Na}_2\text{CO}_3$]; third, 8 feet of volcanic sand and black, tenacious clay, with bunches of trona, of black, shining luster, from inclosed mud; fourth, 8-foot stratum, consisting of volcanic sand containing glauberite, thenardite, and a few flat, hexagonal crystals of hanksite; fifth, 28 feet of solid trona of uniform thickness; sixth, 20-foot stratum of black, slushy, soft mud; smelling strongly of hydrosulphuric acid, in which there are layers of glauberite, soda, and hanksite. The water has a density of 30° Baumé; seventh, 230 feet (as far as explored) of brown clay, mixed with volcanic sand and permeated with hydrosulphuric acid.

Overlying No. 5 a thin stratum of a very hard material was encountered. Being difficult to penetrate, and its character not recognized, this was simply called "hard stuff," its more exact nature being left for future determination.

As is the case with all salines of like character, this has no outlet, the water that comes into it escaping only by evaporation, which process goes on here very rapidly for two-thirds of the year.

While most of the water contained in this basin is subterranean, a little during very wet winters accumulates and stands for a short time on portions of the surface. In no place, however, does it reach a depth of more than a foot or two, hardly anywhere more than 3 or 4 inches.

Within the limits of the actively producing portion of the marsh, which covers an oblong area of about 1,700 acres, the water stands on

a tract of some 300 acres for a longer period than it does elsewhere; but even here it nowhere reaches a depth of more than a foot.

Between this 300-acre tract and the main flat lying a little lower there interposes a slight ridge, which prevents the surface water from escaping to the lower ground.

The water of the lake is of a dark-brown color, strongly impregnated with alkali, and has a density of 28° Baumé. The salts obtained from it by crystallization contain carbonate and chloride and borate of sodium, with a large percentage of organic matter.

Summarized, the following minerals have been found associated with the borax occurring in the Searles marsh: Anhydrite, calcite, celestite, cerargyrite, colemanite, dolomite, embolite, gay-lussite, glauberite, gypsum, halite, hanksite, natron, soda, niter, sulphur, thenardite, tincal, and trona, the most of these occurring, of course, in only minute quantities. There is, however, reason to believe that hanksite will yet be found abundantly, both here and in the other salines of this region.

The submerged tract above described is called the "Crystal Bed," the mud below the water being full of large crystals, which occur in nests at irregular intervals to a depth of 3 or 4 feet. Many of these crystals, which consist of carbonate of soda and common salt with a considerable percentage of borate, are of large size, some of them measuring 7 inches in length. The water 15 feet below this stratum of mud contains, according to Mr. C. N. Hake, who made, not long since, a careful examination of these deposits, carbonate of soda, borax, and salts of ammonia. The ground in the immediate vicinity, a dry hard crust about 1 foot thick, contains, on the same authority:

Sand	50
Sulphate of soda	16
Common salt	12
Carbonate of soda	10
Borax	12

The borax here occurs in the form of the borate of soda only, no ulexite (borate of lime) having yet been found.

The chief foreign sources of borax salts are northern Chili, Stassfurt in Germany, Italy, Asia Minor, and Thibet.

The Chilean mineral is ulexite and is reported as occurring throughout the province of Atacama and the newly acquired portions of Chile. Ascotan, which is now on the borders of the Republic, but formerly belonged to Bolivia, and Maricunga, which is to the north of Copeapo, are the places which have proved most successful commercially. The crude material occurs in both places in lagoons or troughs, which, instead of being entirely filled with common salt, as is usually the case in the desert, contains zones or layers of boronatrocalcite embedded

in it. The lagoons of Maricunga lie about 64 kilometers from the nearest railway station and are estimated to cover 3,000,000 square meters. The boronatrocalcite occurs in beds alternating with layers of salt and salty earth.

The raw material contains, in the form of gypsum and glauberite, a large amount of calcium sulphate.

Dana also mentions ulexite as occurring also in the form of rounded masses from the size of a hazelnut to that of a potato in the dry plains of Iquique, where it is associated with pickeringite, glauberite, halite, and gypsum. The German mineral is boracite (stassfurtite) and is found in small granular masses associated with the salt deposits of Stassfurt. In Italy sassolite, or crystallized boric acid, has long been obtained by the evaporation of hot springs in Sienna, in Tuscany. Concerning the deposits of Asia Minor little is accurately known. The mineral is pandermite (colemanite), which is found in thick white lumps at Suzurlu, south of the sea of Marmora. Borax or tincal, from Thibet, in northern India, was probably the first of the boron salts to be utilized. It is stated to be brought on the backs of sheep from the lakes in which it is formed across the Himalayas to the shipping points in India.

Methods of mining and manufacture.—At the East Calico Colemanite mine, in San Bernardino County, the mineral is taken out in the same manner as ores of the precious metals. Inclined shafts are sunk, drifts and levels run, and stopes carried up as in any other mine. The material, when hoisted to the surface, is loaded into wagons and hauled to Dagget, whence it is shipped to the works at Alameda. The process of extracting the boracic acid is not known to the public.

At Searles's marsh the overlying crust mentioned constitutes the raw material from which the refined borax is made.

The method of collecting it is as follows: When the crust, through the process of efflorescence, has gained a thickness of about 1 inch, it is broken loose and scraped into windrows far enough apart to admit the passage of carts between them, and into which it is shoveled and carried to the factory located on the northwest margin of the flat, 1 to 2 miles away.

As soon as removed, this incrustation begins again to form, the water charged with the saline matter brought to the surface by the capillary attraction evaporating and leaving the salt behind. This process having been suffered to go on for three or four years, a crust thick enough for removal is again formed, the supposition being that this incrustation, if removed, will in like manner go on reproducing itself indefinitely.¹

¹In order to determine the proportionate growths of the various salts contained in this crust while undergoing this recuperative process, analyses were made on samples representing respectively six months', two, three, and four years' growth. From the

Uses.—The various borax salts are used in the preparation of boracic acid and the borate of sodium, the borax of commerce.

XI. URANATES.

1. URANINITE; PITCHBLEND.

Composition very complex, essentially a uranate of uranyl, lead, thorium, and other metals of the lanthanum and yttrium groups. The mineral is unique in containing nitrogen, being the only one among the constituents of the primary rocks of the earth's crust in which the presence of this element has been thus far determined.¹ The analyses given below are for the most part by Hillebrand, to whom is due the credit of a large share of the present knowledge on the subject.

Locality.	UO ₃ .	UO ₂ .	ThO ₂ .	CeO ₂ .	La ₂ O ₃ .	Y ₂ O ₃ .	PbO.	CaO.	N.	H ₂ O.	Fe ₂ O ₃ .	Misc.
Glastonbury, Connecticut	23.03	59.93	11.10				3.08	0.11	2.41	0.43	0.29	1.11
North Carolina.....	50.83	39.31	2.78	0.26	0.50	0.20	4.20	0.85	0.37	1.21	.....	0.48
Ånnerød, Norway ..	30.63	46.13	6.00	0.18	0.27	1.11	9.04	0.37	1.17	0.74	0.25	4.66
Johanngeorgenstadt	59.30	22.33	.....	.....	.....	.....	6.39	1.00	0.02	3.17	0.21	5.53

Several varieties of uraninite are recognized, the distinctions being based upon the relative proportions of the two oxides UO₂ and UO₃ (see analyses above). Inasmuch, however, as these variations may be

ground from which these were taken the crust had been removed several times during the preceding twelve years.

The analysis of samples gave the following results:

Constituents.	Six months' growth.	Two years' growth.	Three years' growth.	Four years' growth.
Sand	58.0	55.4	52.4	53.3
Carbonate of soda	5.2	5.0	8.1	8.0
Sulphate of soda	11.7	6.7	16.6	16.0
Chloride of soda.....	10.9	20.0	11.1	11.8
Borax	14.2	12.9	11.8	10.9
Total	100.0	100.0	100.0	100.0

From this list it will be seen that the first six months' growth is richest in borax, and that the proportion of carbonate of soda to borax increases regularly. The presence of so much sand as is here indicated is caused by the high winds that blow at intervals, bringing in great quantities of that material from the mountains to the west. This sand, it is supposed, facilitates the formation of the surface crust by keeping the ground in a porous condition.

¹The mineral has since been found to contain some 0.23 per cent of the new elements helium and argon.

due merely to oxidation they need not be taken into consideration here. When crystallized, the mineral assumes octahedral and dodecahedral forms, more rarely cubes. Hardness 5.5, specific gravity 9 to 9.7. Color grayish, greenish to velvet black, streak brown; fracture conchoidal, uneven. The massive and probably amorphous variety, containing few, if any, of the rarer earths and no nitrogen, is known under the name of pitchblende. This last is the chief commercial source of uranium salts. Through oxidation and hydration the mineral passes into gummite, a gum-like yellow to brown or red mineral of a hardness of but 2.5 to 3 and specific gravity of 3.9 to 4.2. (See Specimen No. 53062, U.S.N.M., showing zone of gummite around a nucleal mass of unaltered uraninite.)

Localities and mode of occurrence.—Uraninite occurs as a primary constituent of granitic rocks and as a secondary mineral, with sulphide ores of silver, lead, gold, copper, etc. In this form, according to Dana, it is found at Johanngeorgenstadt, Marienberg, and Schneeberg, Saxony; at Joachimsthal (Specimen No. 53061, U.S.N.M.) and Příbram, in Bohemia (Specimens Nos. 66843, 67755, U.S.N.M.), and Rezbánya, in Hungary. Considerable quantities have been mined from the tin-bearing lodes of Cornwall, England. The crystallized variety *bröggerite* is found in a pegmatite vein near Ånnerød, Norway, and the variety *cleveite* in a feldspar quarry at Arendal. In the United States the mineral has been found in small quantities in several localities, but only those of Mitchell and Yancey Counties, North Carolina (Specimens Nos. 53062, 60927, 62755, U.S.N.M.), where the mineral occurs partially altered to gummite and uranaphane, in mica mines; Llano County, Texas; Black Hawk, near Central City, Colorado (Specimen No. 83629, U.S.N.M.), and the Bald Mountain district of the Black Hills of South Dakota need here be mentioned. Of the above the Cornwall localities are at present of greatest consequence, having during 1890 yielded some 22 tons of ore, valued at some £2,200 (\$11,000). During 1891, it is stated, the output was 31 long tons, valued at £620, and in 1892, 37 tons, valued at £740. The next most important locality is that of Joachimsthal, in Bohemia, where 22.52 metric tons of ore were produced in 1891 and 17.71 tons in 1892, the value being some 1,000 florins a ton.

In the Cornwall mines the pitchblende is stated¹ to occur in small veins crossing the tin-bearing lodes. At the St. Austell Consols Mines it was associated with nickel and cobalt ores; at Dolcoath with native bismuth and arsenical cobalt in a matrix of red quartz and purple fluorspar; at South Tresavean with kupfer-nickel, native silver, and argentiferous galena. At the Wood Lode, Russell district, in Gilpin County, Colorado, pitchblende was found in the form of a

¹The Mineral Industry, II, p. 572.

lenticular mass in one of the ordinary gold-bearing lodes traversing the gneiss and mica schists of the district. The body occurred some 60 feet below the surface and was some 30 feet long by 10 feet deep and 10 inches thick. The mass yielded some 4 tons of ore carrying 70 per cent oxide of uranium.

Other natural uranium compounds, but which at present have no use in the arts, are as below: Torbernite, a hydrous phosphate of uranium and copper; autunite, a hydrous phosphate of uranium and calcium; zeunerite, an arsenate of uranium and copper; uranospinite, an arsenate of uranium and calcium; uranocircite, a phosphate of barium and uranium; phosphuranylite, a hydrous uranium phosphate; trögerite, a hydrous uranium arsenate; walpurgite, probably an arsenate of bismuth and uranium; and uranosphaerite, a uranate of bismuth.

Carnotite is a recently described uranium compound containing, according to analyses, some 52 per cent uranium oxide (UO_3); 20 per cent of vanadium oxide (V_2O_5), and 11 per cent of potash. It is of a beautiful light lemon-yellow color and of an earthy or ocherous texture. According to descriptions gleaned from correspondence, and from samples received at the U. S. National Museum (Specimens Nos. 53491, 53492, 53649, U.S.N.M.), the material occurs mainly as an impregnation in the form of an extremely fine, crystalline powder in the Dakota sandstones in the vicinity of La Sal Creek and Roc Creek, Montrose County, and near Placerville, San Miguel County, Colorado.¹

Uses.—Uranium is never used in the metallic state, but in the form of oxides, or as uranate of soda, potash, and ammonia, finds a limited application in the arts. The sesquioxide salt imparts to glass a gold yellow color with a beautiful greenish tint, and which exhibits remarkable fluorescent properties. The protoxide gives a beautiful black to high-grade porcelains. The material has also a limited application in photography. Recently the material has been used to some extent in making steel in France and Germany, but the industry has not yet passed the experimental stage. It has been stated that the demand, all told, is for about 500 tons annually. Should larger and more constant sources of supply be found, it is probable its use could be considerably extended. According to Nordenskiöld, £50,000 worth of uranium minerals are consumed every year, the various salts produced being used in porcelain and glass manufacture, in photography, and as chemical reagents.²

¹Since the foregoing was written Mr. W. F. Hillebrand, of the U. S. Geological Survey, has published (American Journal of Science, Vol. X, 1900, pp. 120-144) the results of an exhaustive study of the material from this and other localities, and shows that the so-called carnotite is probably a mixture of minerals made up to a large extent of calcium and barium compounds intimately mixed with amorphous silicates containing vanadium in the trivalent state.

²Quarterly Journal of the Geological Society of London, LVI, 1900, p. 527.

XII. SULPHATES.

1. BARITE; HEAVY SPAR.

Composition BaSO_4 , = Sulphur trioxide 34.3 per cent, baryta 65.7 per cent; specific gravity 4.3 to 4.6; hardness 2.5 to 3.5.

Occurrence.—The sulphate of barium to which the mineralogical name of barite is given occurs as a rule in the form of a white, translucent to transparent, coarsely crystalline mineral, about as hard as common calcite, but from which it may be readily distinguished by its great weight and its not effervescing when treated with acid. A common form of the mineral is that of an aggregate of straight or somewhat curved plates, separating readily from one another when struck with a hammer, and cleaving readily into rhomboidal forms much like calcite. (Specimens Nos. 54988, 67372, U.S.N.M.) It is also found in globular and nodular concretions (Specimen No. 66851, U.S.N.M.), stalactitic and stalagmitic (Specimen No. 63778, U.S.N.M.), granular, compact, and earthy masses, and in single and clustered broad and stout crystals. In nature the material is rarely pure, but nearly always contaminated with other elements, as noted in the following analyses of samples from Fulton, Blair, and Franklin counties, Pennsylvania.¹

Constituents.	Fulton County.		Blair County.	Franklin County.	
	(699) Locke.	(345) Locke.	(698) Galbreath.	(735) Shockey.	(582) Shockey.
Sulphate of barium	95.22	96.91	97.08	95.91	98.65
Oxides of iron and aluminum.....	0.38	0.31	0.76	0.24	0.14
Oxide of manganese	0.05	None.	None.	None.	None.
Lime	0.59	Trace.	None.	0.17	Trace.
Magnesia	0.18	Trace.	Trace.	0.11	Trace.
Carbonic acid	0.65	None.	None.	None.	None.
Water	0.23	0.08	0.32	0.09	0.20
Silica	2.45	2.35	1.74	2.80	1.11
Total	99.75	99.65	99.90	99.32	100.10

The mineral occurs commonly in connection with metallic ores or as a secondary mineral associated with sand and limestones, sometimes in distinct veins, or as in southwest Virginia, where it fills irregular fractures in certain beds of the Cambrian limestone or in part replaces the limestone itself. (Specimen No. 67357, U.S.N.M.). In Washington County, in this State, the mineral has been mined in an itinerant manner by farmers on whose land it occurs, and who work mostly from open cuts or trenches, rarely making an opening of sufficient size to be termed a mine. As the material is less soluble in atmospheric waters than is the limestone in which it occurs, it follows that often

¹Pennsylvania Second Geological Survey, Chemical Analyses, pp. 368, 369.

the barite is found in loose, disconnected masses embedded in a residual clay, and the process of mining is resolved into merely digging so long as the yield is sufficient to pay expenses.

Preparation and uses.—The mineral is washed and ground like grain between millstones and used as an adulterant for white lead or to give weight and body to certain kinds of cloth and paper.

According to a writer in the Mineral Resources of the United States for 1885, the "floated" or "cream-floated" barite used for paint is prepared as follows: The crude mineral as mined is first sorted by hand and cleaned, after which it is crushed into pieces about the size of the tip of one's finger. Next, it is refined by boiling in dilute sulphuric acid until all the impurities are removed, when it is washed by boiling in distilled water and dried by steam. It is then ground to flour, mixed with water, and run through troughs or sluiceways into receiving vats, whence it is taken, again dried by steam, and barreled. This cream-floated barite is quoted as worth about \$30 a ton, while the crude material is worth only about one-fourth as much.

Sources.—The principal sources in the United States are Lynchburg, Hurt, Toshes, and Otter River, Virginia; Sandy Bottom and Hot Springs, in North Carolina, and Cadet, Old Mines, Mineral Point, Morrellton, and Potosi, in Missouri. A small amount is imported from Mackellar Islands, Lake Superior. The total production for 1897 was some 27,316 tons, valued at \$4 a ton.¹

2. GYPSUM.

Composition $\text{CaSO}_4 + 2 \text{H}_2\text{O}$, = sulphur trioxide 46.6 per cent, lime 32.5 per cent, water 20.9 per cent. The natural mineral is often quite impure through the presence of organic, ferruginous, and aluminous matter, together with small quantities of the carbonates of lime and magnesia (see analysis, p. 407). Specific gravity 2.3, hardness 1.5 to 2. Color usually white or gray, but brown, black and red through impurities. The softness of the mineral, which is such that it can be easily cut with a knife or even by the thumb nail, is one of its most marked characteristics. Three principal varieties are recognized, (1) the crystallized, foliated, transparent variety, selenite (Specimens Nos. 53593, 53608, 62089, U.S.N.M.), (2) the fine fibrous, often opalescent variety, satin spar (Specimen No. 62477, U.S.N.M.), and (3) the common massive, finely granular variety, gypsum (Specimen No. 53348, U.S.N.M.). When of a white color and sufficiently compact for small statues and other ornamental works, it is known as alabaster (Specimen No. 63394, U.S.N.M.), though this name has unfortunately become confounded with the calcareous rock travertine and stalagmite.²

¹The Mineral Industry, VI, 1897, p. 57.

²See The Onyx Marbles, their Origin, Uses, etc., Report of the U. S. National Museum, 1893, pp. 539-585.

The following is an analysis of a commercial gypsum from Ottawa County, Ohio, as given by Professor Orton:¹

Lime	32.52
Sulphuric acid	45.56
Water	20.14
Magnesia	0.56
Alumina	0.16
Insoluble residue	0.68
	99.62

Origin.—Gypsum in considerable quantities occurs associated only with stratified rocks and is regarded mainly as a chemical deposit resulting from the evaporation of waters of inland seas and lakes; it may also originate through the decomposition of sulphides and the action of the resultant sulphuric acid upon limestone; through the mutual decomposition of the carbonate of lime (limestone) and the sulphates of iron, copper, and other metals; through the hydration of anhydrite and through the action of sulphurous vapors and solutions from volcanoes upon the rocks with which they come in contact. According to Dana,² the gypsum deposits in western New York do not form continuous layers in the strata, but lie in imbedded, sometimes nodular masses. In all such cases, this authority says, the gypsum was formed after the beds were deposited, and in this particular instance are the product of the action of sulphuric acid from springs upon the limestone. "This sulphuric acid, acting on limestone (*carbonate of lime*), drives off its carbonic acid and makes *sulphate of lime*, or gypsum; and this is the true theory of its formation in New York." Dr. F. J. H. Merrill, however, regards a portion at least of the New York beds as a product of direct chemical precipitation from sea water.³

The gypsum deposits of northern Ohio are regarded by Professors Newberry and Orton as deposits from the evaporation of landlocked seas, as was also the rock salt which overlies it. By this same process must have originated a large share of the more recent gypsum deposits of the Western States.

Geological age and mode of occurrence.—As may be readily inferred from what has gone before, beds of gypsum have formed at many periods of the earth's history and are still forming wherever proper conditions exist. The deposits of New York State occur in a belt extending eastward from Cayuga Lake and in beds belonging to the Salina period of the Upper Silurian age. The rock is often earthy and impure, and is used nearly altogether for land plaster. It is associated with dark, nearly black, limestones and shales and beds of rock salt. In southwest Virginia, along the Holston River, are also beds

¹ Geology of Ohio, VI, 1888, p. 700.

² Manual of Geology, p. 234.

³ Bulletin No. 11, of the New York State Museum, April, 1893.

of gypsum associated with salt and referred by Dana to this same horizon. The rock is mined at Saltville in Washington County from underground pits, and is used mainly for fertilizing. (Specimens Nos. 27129, 27153, U.S.N.M.)

Gypsum deposits of varying thickness and occurring at various depths below the surface are found continuous over thousands of square miles in northern Ohio, but are at present worked only in Ottawa County at a station on the Lake Shore and Michigan Southern Railway which bears the appropriate name of Gypsum (Specimens Nos. 31624, 17969, U.S.N.M.). The associated rocks are Lower Helderberg limestones and shales and the beds, which vary from 3 to 7 feet in thickness, are found at all depths up to 200 or 300 feet.

The following is a section of the Ottawa County beds as given by Orton:

	Feet.
Drift clays.....	12 to 14
No. 1. Gray rock, carrying land plaster.....	5
Blue shale.....	$\frac{1}{2}$
No. 2. Boulder bed carrying gypsum in separate masses embedded in shaly limestone.....	5
Blue limestone, in thin and even courses.....	1
No. 3. Main plaster bed.....	7
Gray limestone in courses.....	1
No. 4. Lowest plaster bed, variable.....	3 to 5
Mixed limestone and plaster, bottom of quarry. ¹	

Sections like the above are stated to be capable of yielding 50,000 tons of plaster an acre.

The purest gypsum of the region occurs in No. 2, the boulder bed, as given above. It consists of calcareous shales through which are scattered concretionary balls of gypsum varying in diameter from 6 to 24 inches. This pure variety is used mainly for *terra alba*; about 40 per cent of the total product has in years past been calcined for use as stucco or plaster of paris and 60 per cent for land plaster.

At Fort Dodge, in Iowa, is a deposit of quite pure, light gray, regularly bedded gypsum, resting unconformably upon St. Louis limestone and lower coal strata and overlain by drift. It is supposed to cover an area of some 25 square miles. The material was at one time used for building purposes but proved too soft² and is now used mainly for land plaster (Specimens Nos. 26804, 63058, 63059, U.S.N.M.). (See Plate 22.)

There are large deposits of gypsum in Michigan, the most extensive, so far as explored, being near Grand Rapids, Kent County, in the western part of the State (Specimen No. 56397, U.S.N.M.), and at Alabaster Point, in Iosco County, on the eastern margin of the State.

¹ Geological Survey of Ohio. Economic Geology, VI, 1888, p. 698.

² Stones for Building and Decoration, 2d ed., 1897, p. 76.



VIEW OF A GYPSUM QUARRY, FORT DODGE, IOWA.
From a photograph by the Iowa Geological Survey.

At both localities there is a succession of beds beginning at or near the surface and aggregating many feet in depth. The beds are regarded as of Carboniferous age. The following section shows the number and thickness of the beds thus far discovered:

	Feet.
Earth stripping	20
Gypsum	8
Soft shale, slate	1
Gypsum	12
Shale or clay slate	7
Gypsum	6½
do	8½
Slate, shale	3½
Gypsum	12½
Shale or clay slate	1½
Gypsum	9½
Shale, clay slate	8
Total	98

West of the front range of the Rocky Mountains are many important beds of gypsum, but which have as yet been but little exploited owing to cost of transportation, there being but little local demand. These beds so far as yet worked are mostly of more recent origin than those in the eastern United States, many being of Tertiary or even Quaternary age.

Near Fillmore, Utah, are deposits of gypseous sand formed by the winds blowing up from the dry beds of playa lakes the minute crystals deposited by evaporation (Specimen No. 53380, U.S.N.M.). The material thus blown together forms veritable dunes from which the material may be obtained by merely shoveling. Prof. I. C. Russell has estimated these dunes to contain not less than 450,000 tons of gypsum.

Important deposits of gypsum also occur in Kansas (Specimen No. 53348, U.S.N.M.), Colorado (Specimen No. 53265, U.S.N.M.), South Dakota (Specimen No. 53462, U.S.N.M.), Wyoming (Specimen No. 63485, U.S.N.M.), California (Specimens Nos. 56419 and 67690, U.S.N.M.), and New Mexico (Specimens Nos. 62254, 67948, and 28586, U.S.N.M.).

Gypsum is a very abundant mineral in New Brunswick, the deposits being numerous, large, and in general of great purity. They occur in all parts of the Lower Carboniferous district in Kings, Albert, Westmoreland, and Victoria, especially in the vicinity of Sussex, in Upham, on the North River in Westmoreland, at Martin Head on the bay shore, on the Tobique River in cliffs over 100 feet high, and about the Albert Mines. At the last-named locality the mineral has been extensively quarried from beds about 60 feet in thickness, and calcined in large works at Hillsborough.¹

¹ Dawson's *Acadian Geology*, p. 249.

The mineral is usually met with in very irregular masses, associated with red marls, sandstones, and limestones, and varies much in character. At Hillsborough, in the quarries being worked, ten to fifteen years ago there was exposed a total head of rock from 90 to 100 feet, of which about 70, forming the upper portion, consists mostly of "soft plaster" or true gypsum, which rests on beds of hard plaster or anhydrite of unknown depth. At the same point considerable masses of very beautiful snow-white gypsum or alabaster are also met with, associated with the varieties named above, but comparatively little selenite, while at Petitcodiac, where the deposits has a breadth of about 40 rods and a total length of about 1 mile, the whole is fibrous and highly crystalline and traversed by a vein of nearly pure selenite, 8 feet wide, through its entire extent. The rock on the Tobique River, which rises in bluffs along the stream some 30 miles above its mouth, is mostly soft, granular or fibrous, and of a more decidedly reddish color than in the other localities.

Important beds of gypsum belonging to the same geological horizon likewise occur in Nova Scotia, particularly at Wentworth and Montague in Hants County, at Oxford, River Philip, Plaster Cove, Wallace Harbor, and Bras d'Or Lake, Cape Breton. At Wentworth there are stated to be "cliffs of solid snowy gypsum from 100 to 200 feet in height." (Specimen No. 13690, U.S.N.M., from Windsor, Hants County.)

Gypsum deposits occur in the Onondago formations of Ontario, Canada, and are exploited along the Grand River between Cayuga and Paris. The mineral here occurs in lenticular masses varying from a few yards to a quarter of a mile in horizontal diameter and from 3 to 7 feet in thickness. (See Specimen No. 62145, U.S.N.M.).

The foreign sources of gypsum are almost too numerous to mention. Important beds occur in Lincolnshire and Derbyshire, England; near Paris, France, in Spain, Italy, Germany, Austria, and Switzerland. The Paris beds are of Tertiary age, and the mineral carries some 10 to 20 per cent of carbonate of lime, together with silica in a soluble form. The presence of these constituents is stated to cause the plaster to set much harder, permitting it, therefore, to be used for external work. The Italian gypsum is often of great purity. The finest alabaster is stated to come from the Val di Marmolago, near Castellina. (Specimen No. 63394, U.S.N.M.)

Uses.—These have been already, in part, noted. The principal uses of gypsum of the ordinary massive varieties is for fertilizers (land plaster) (Specimen No. 63059 U.S.N.M.), and in the manufacture of plaster of paris, or stucco. (Specimens Nos. 53348, 53462, U.S.N.M.)

As above noted, gypsum is but little used for building purposes, being too soft. Several residences, a railway station, and other minor

structures are, however, stated to have been built of this stone at Fort Dodge, in Iowa. (Specimen No. 26804, U.S.N.M.) The variety satin spar is sometimes used for small ornamentations, but it is only the snow-white variety (alabaster) that is of any economic importance as an ornamental stone. The main use of alabaster is for small statues, vases, fonts, and small columns; it is too soft for exposed positions where subjected to much wear. At present there are not known any deposits of alabaster within the limits of the United States which are of sufficient purity and extent to be of commercial value. A large share of the alabaster statuettes now on our markets are of Italian make as well as of Italian materials.

In preparing the gypsum for market the stone is first broken in a crusher into pieces of the size of a hickory nut, after which it is ground between millstones (French buhrstones) to a proper degree of fineness and then put up in bags or barrels, if designed for land plaster; if for stucco it is calcined after being ground. This process is in Michigan carried on in large kettles some 8 feet in diameter, and capable of holding about 14 barrels at a charge. The powder is heated until all the included water is driven off, being subjected to constant stirring in the meantime, and is then drawn off through the bottom of the kettles and conveyed by carrying belts and spouts to the packing room.¹

Under the name of "terra alba" (white earth) ground gypsum is used as an adulterant in cheap paints.

The commercial value of gypsum depends mainly on accessibility to market. In 1899 the ground material was quoted at \$2.00 a ton in New York. In Michigan the average price of crude material has been some \$1.25 a ton, and for calcined plaster (plaster of paris) \$3.00 to \$5.00 a ton.

3. CELESTITE.

Composition sulphate of strontium SrSO_4 , = sulphur trioxide, 43.6 per cent; strontia, 56.4 per cent. Hardness, 3 to 3.5; specific gravity, 3.99; color, white, often bluish, transparent to translucent. Differs from the carbonate (strontianite) by being insoluble in acids, but gives the characteristic red color to the blowpipe flame.

According to Dana the mineral occurs usually associated with limestones or sandstones of Silurian or Devonian, Jurassic, and other geological formations, occasionally with metalliferous ores. It also occurs in beds of rock salt, gypsum, and clay, and is abundantly associated with the sulphur deposits of Sicily. (Specimen No. 60877, U.S.N.M.) The principal localities in the United States are in the limestones of Drummond Island, Lake Huron; Put in Bay, Lake Erie (Specimen No. 53094, U.S.N.M.); Kingston, Ontario, in crystalline

¹See Mineral Statistics of Michigan, 1881, for details of plaster work of that State.

masses, and in radiating fibrous masses in the Laurentian formations about Renfrew. Large crystals of a red color are also found in Brown County, Kansas, and at Lampasas and near Austin, Texas. (Specimen No. 67936, U.S.N.M.) Near Bells Mills, Blair County, Pennsylvania, the mineral occurs in lens-shaped masses between the bottommost beds of the Lower Helderberg (No. VI) limestone. On South Bass Island, in Put in Bay, Lake Erie, the mineral occurs frequently in the form of beautiful crystals of all sizes up to 100 pounds in weight, transparent to translucent and sometimes of a fine blue color, lining the walls and floor of limestone caverns.

Uses.—Celestite is used in the preparation of nitrate of strontia employed in fireworks, its value for this purpose being due to the fine crimson color it imparts to the flame. The demand for the material is very small.

4. MIRABILITE OR; GLAUBER SALT.

This is a hydrous sodium sulphate, $\text{Na}_2\text{SO}_4 + 10 \text{H}_2\text{O}$, = sulphur trioxide, 24.8 per cent; soda, 19.3 per cent; water, 55.9 per cent. In its pure state white, transparent to opaque; hardness, 1.5 to 2; specific gravity, 1.48. Readily soluble in water, taste cool, then saline and bitter.

Occurrence.—Aside from its occurrence in soda lakes associated with other salts as described later this sulphate is of common occurrence as an efflorescence on limestones, and in protected places, as in Mammoth Cave, Kentucky, may accumulate in considerable quantities, though not sufficient to be of economic value. (Specimen No. 68156, U.S.N.M., in Cave series.) Salt Lake, Utah, contains a proportionately large amount of this sulphate, which during the winter months is precipitated to the bottom, whence it is not infrequently thrown upon the shore by waves.

According to Prof. J. E. Talmage,¹ when the temperature falls to a certain point, the lake water assumes an opalescent appearance from the separation of the sulphate. This sinks as a crystalline precipitate and much is carried by the waves upon the beach and there deposited. Under favorable circumstances the shores become covered to a depth of several feet with crystallized mirabilite. The writer has on several occasions waded through such deposits, sinking at every step to the knees. Speaking only of the amounts thrown upon the shores, and of most ready access, the source is practically inexhaustible. The substance must be gathered, if at all, soon after the deposit first appears; as, if the water once rises above the critical temperature, the whole deposit is taken again into solution. This change is very rapid, a single day being oftentimes sufficient to effect the entire disappearance of all the deposit within reach of the waves. Warned by these circumstances, the collectors heap the substance on the shores above the lap of the waters, in which situation it is comparatively secure until needed. To a slight depth the mirabilite effloresces, but within the piles the hydrous crystalline condition is maintained. At the present time there are thousands of tons of this material, heaped in the manner described, remaining from the collections of preceding winters. The sodium sulphate thus lavishly sup-

¹Science, XIV, 1889, p. 446.

plied is of a fair degree of purity, as will be seen from the following analyses of two samples of the crystallized substance, taken from opposite shores of the lake:

Constituents.	Per cent.	Per cent.
Water	55.070	55.760
Sodium sulphate (Na_2SO_4)	43.060	42.325
Sodium chloride (NaCl)	0.699	0.631
Calcium sulphate (CaSO_4)	0.407	0.267
Magnesium sulphate (MgSO_4)	0.025	0.018
Insoluble	0.700	0.756
Total	99.961	99.757

Some 14 miles southwest of Laramie, in Albany County, Wyoming, there exist deposits of sulphate of soda, such as are locally known as "lakes." The deposits in question comprise three of these lakes lying within a stone's throw of one another. They have a total area of about 65 acres, the local names of the three being the Big Lake, the Track Lake, and the Red Lake. Being the property of the Union Pacific Railroad Company, they are generally known as the Union Pacific Lakes.

In these lakes the sulphate of soda occurs in two bodies or layers. The lower part, constituting the great bulk of the deposit, is a mass of crystals of a faint greenish color mixed with a considerable amount of black, slimy mud. It is known as the "solid soda," of which an analysis is given below.

Constituents.	Anhy- drous.	Crystal- lized.
Na_2SO_4	36.00	81.63
CaSO_4	1.45	1.82
MgCl_2	0.77	1.64
NaCl	0.21	0.21
	38.43	85.30
Insoluble residue (at 100 C.)		13.86
		99.16

Total chloride calculated as NaCl equals 1.16 per cent. This, calculated on 100 parts anhydrous Na_2SO_4 , equals 3.22 per cent NaCl .

This solid soda is stated to have a depth of some 20 or 30 feet. Borings were made a number of years ago under the direction of the Union Pacific Railroad agents, but, as the records have been mislaid or lost, with what results is not definitely known. There is nothing to prove that the depth is not less than stated above.

Above the solid soda occurs the superficial layer of pure white crystallized sulphate of soda. This is formed by solution in water of the upper part of the lower body, the crystals being deposited by

evaporation or by cooling, or by the two combined. A little rain in the spring and autumn furnishes this water, as do also innumerable small, sluggishly flowing springs present in all the lakes. But on account of the dry air of this arid region the surface is generally dry or nearly so, and in midsummer the white clouds of efflorescent sulphate that are whirled up by the ever-blowing winds of Wyoming can be seen for miles. Even should there be a little water present there is no difficulty in gathering the crystals by the train load. The spring, however, is the worst season of the year, on account of the warm weather and of the rains—conditions unfavorable to the formation of crystals. The layer of this white sulphate is from 3 to 12 inches in thickness. When the crystals are removed the part laid bare is soon replenished by a new crop.

The following is an analysis of the purest of this white sulphate of soda, calculated upon an anhydrous basis, that being the condition, of course, in which it would be used:

Na ₂ SO ₄	99.73
MgCl ₂ .....	.26
Insoluble	Trace.
	<hr/>
	99.99

Below is given an analysis of the water of the lake:

Density=14 $\frac{1}{2}$ ° Tw. (=1.0725 specific gravity). Ten cubic centimeters contains:

	Grams.	Per cent.
Na ₂ SO ₄	0.7563=	92.23
CaSO ₄	0.0146=	1.79
MgSO ₄	0.0070=	.85
MgCl ₂	0.0300=	3.66
Na ₂ B ₄ O ₇	0.0121=	1.47
	<hr/>	<hr/>
Total solids	0.8200	100.00
Total solids by evaporation.	0.8240	

One cubic foot of this water contains 10.72 of pure crystallized sulphate of soda.¹

(See Specimens Nos. 62086, 53427, U.S.N.M., from Albany County, Wyoming.)

Other similar deposits occur in Carbon and Natrona counties, and still others are reported in Fremont, Johnson, and Sweetwater counties.

It has recently been stated² that glauber salts has been found on the bottom of the Bay of Kara Bougas, an inlet of the Caspian Sea, in deposits sometimes a foot in thickness.

¹Journal of the Franklin Institute, CXXXV, 1893, pp. 53, 54, 56.

²Engineering and Mining Journal, LXV, 1898, p. 310.

5. GLAUBERITE.

Composition sodium and calcium sulphate. $\text{Na}_2\text{SO}_4 \cdot \text{CaSO}_4$ = sulphur trioxide, 57.6 per cent; lime, 20.1 per cent; soda, 22.3 per cent. This is a pale yellow to gray salt, partially soluble in water—leaving a white residue of sulphate of lime—and with a slightly saline taste. On long exposure to moisture it falls to pieces, and hence is to be found only in protected places or arid areas. It occurs associated with other sulphates and carbonates, as with thenardite and mirabilite at Borax Lake, in San Bernardino County, California, and with halite in rock salt at Stassfurt (Specimen No. 40229, U.S.N.M.) and other European localities.

6. THENARDITE.

Composition anhydrous sodium sulphate. Na_2SO_4 = sulphur trioxide, 43.7 per cent; soda, 56.3 per cent. Color when pure, white, translucent to transparent; hardness, 2 to 3; specific gravity, 2.68; brittle. In cruciform twins or short prismatic forms roughly striated. Readily soluble in water. Is found in various arid countries, as on the Rio Verde in Arizona, at Borax Lake, California, and Rhodes Marsh in Nevada, associated with other salts of sodium and boron.

7. EPSOMITE; EPSOM SALTS.

Composition sulphate of magnesia $\text{MgSO}_4 + 7\text{H}_2\text{O}$ = sulphur trioxide, 32.5 per cent; magnesia, 16.3 per cent; water, 51.2 per cent.

This is a soft white or colorless mineral readily soluble in water and with a bitter saline taste. It is a constant ingredient of sea water and of most mineral waters as well. Being readily soluble, it is rarely met with in nature except as an effervescence in mines and caves. In the dry parts of the limestone caverns of Kentucky, Tennessee, and Indiana it occurs in the form of straight acicular needles in the dirt of the floor and in peculiar recurved fibrous and columnar forms or in loose snow-white masses on the roofs and walls. (Specimens Nos. 68145, 68153, U.S.N.M., from Wyandotte Cave, Indiana.) In all these cases it is doubtless a product of sulphuric acid set free from decomposing pyrites combining with the magnesia of the limestone. It is stated that at the so-called "alum cave" in Sevier County, Tennessee, masses of epsomite very pure and nearly a cubic foot in volume have been obtained. The material in all these cases is of little value, the chief source of the commercial supply being that obtained as a by-product during the manufacture by evaporation of common salt (sodium chloride).

In Albany County, Wyoming, are several lakes, the largest of which has an area of but some 90 acres, in which deposits of epsom salts are formed on a very large scale, but which are of little commercial value, owing to cost of transportation. The material forms compact, almost

snow-white aggregates of small acicular crystals of a high degree of purity. (Specimen No. 62088, U.S.N.M.) The composition of the natural salt is given as follows:¹ Insoluble residue, 0.08 per cent; magnesium sulphate (containing traces of calcium and sodium sulphates), 51.22 per cent; water, 47.83 per cent; chloride of sodium, calcium, and magnesium, 0.42 per cent; iron, trace; loss, 0.45.

8. POLYHALITE. 9. KAINITE. 10. KIESERITE.

For description of these minerals see under Halite, p. 195.

11. ALUMS.

Under this head are included a variety of minerals consisting essentially of hydrous sulphates of aluminum or iron, with or without the alkalis, and which are not always readily distinguished from one another but by quantitative analyses. The principal varieties are kalinite, tschermigite, mendozite, pickeringite, apjohnite, halotrichite, and alunogen. Aluminite and alunite are closely related chemical compounds, but differ in hardness and general physical qualities and in being insoluble except in acids.

Although possible sources of alum, none of these minerals have been to any extent utilized in the United States, owing to a lack of quantity or inaccessibility, the main source of the alum of commerce being cryolite, bauxite, and clay, as elsewhere noted. (See pp. 214, 229, and 325.)

KALINITE is a native potash alum; composition $K_2SO_4 \cdot Al_2(SO_4)_3 + 24H_2O$, = sulphur trioxide, 33.7 per cent; alumina, 10.8 per cent; potash, 9.9 per cent; water, 45.6 per cent, or, otherwise expressed, potassium sulphate, 18.1 per cent; aluminum sulphate, 36.3 per cent; water, 45.6 per cent. Hardness, 2 to 2.5; specific gravity, 1.75. This in its pure state is a colorless or white transparent mineral, crystallizing in the isometric system, readily soluble in water, and characterized by a strong astringent taste. In nature it occurs as a volcanic sublimation product, or as a secondary mineral due to the reaction of sulphuric acid set free by decomposing iron pyrites upon aluminous shales. Its common mode of occurrence is therefore in volcanic vents (Specimen No. 60685, U.S.N.M., from Vulcano) or as an efflorescence upon pyritiferous and aluminous rocks. Being so readily soluble, it is to be found in appreciable amounts in humid regions only where protected from the rains, as in caves and other sheltered places. So far as known to the author, the mineral is nowhere found native in such quantities as to have any great commercial value.

TSCHERMIGITE is an ammonia alum of the composition $(NH_4)_2SO_4 \cdot Al_2(SO_4)_3 + 24H_2O$, = aluminum sulphate, 37.7 per cent; ammonium sulphate, 14.6 per cent; water, 47.7 per cent. So far as reported this salt has been found only at Tschermig and in a mine near Dux, Bohemia.

¹Bulletin No. 14, October, 1893, Wyoming Experiment Station.

It is obtained artificially from the waste of gas works. Mendozite is a soda alum of the composition $\text{Na}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 + 24\text{H}_2\text{O}$, = sodium sulphate, 15.5 per cent; aluminum sulphate, 37.3 per cent; water, 47.2. The mineral closely resembles ordinary alum, and has been reported from Mendoza, in the Argentine Republic, hence the name. Pickeringite is a magnesium alum of the composition $\text{MgSO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 + 22\text{H}_2\text{O}$, = aluminum sulphate, 39.9 per cent; magnesium sulphate, 14 per cent; water, 46.1 per cent. The mineral is of a white, yellowish, or sometimes faintly reddish color, of a bitter, astringent taste, and occurs in acicular crystals or fibrous masses. (Specimen No. 53043, U. S. N. M., from Tarapacá, Chile.) Halotrichite has the composition $\text{FeSO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 + 24\text{H}_2\text{O}$, = aluminum sulphate, 36.9 per cent; ferrous sulphate, 16.4 per cent; water, 46.7 per cent. The mineral is of a white or yellowish color, and of a silky, fibrous structure, hence the name from the Greek word *ἅλς*, salt, and *θρίξ*, a hair. Apjohnite has the formula $\text{MnSO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 + 24\text{H}_2\text{O}$, = manganese sulphate, 16.3 per cent; aluminum sulphate, 37 per cent; water, 46.7 per cent. It occurs in silky or asbestiform masses of a white or yellowish color, and tastes like ordinary alum. It has been found in considerable quantities in the so-called "alum cave" of Sevier County, Tennessee. According to Safford:¹

This is an open place under a shelving rock. * * * The slates around and above this contain much pyrites, in fine particles and even in rough layers. * * * The salts are formed above and are brought down by trickling streams of water. * * * Fine cabinet specimens could be obtained, white and pure, a cubic foot in volume.

Dana states that the cave is situated at the headwaters of the Little Pigeon, a tributary of the Tennessee River, and that it is properly an overhanging cliff 80 or 100 feet high and 300 feet long, under which the alum has collected. It occurs, according to this authority, in masses, showing in the cavities fine transparent needles with a silky luster, of a white or faint rose tinge, pale green or yellow. Epsomite and melanterite occur with it. Alunogen has the composition $\text{Al}_2(\text{SO}_4)_3 + 18\text{H}_2\text{O}$, = sulphur trioxide, 36 per cent; alumina, 15.3 per cent; water, 48.7 per cent; hardness, 1.5 to 2; specific gravity, 1.6 to 1.8. This is a soft white mineral of a vitreous or silky luster, soluble in water, and with a taste like that of the common alum of the drug stores. It occurs in nature both as a product of sublimation in volcanic regions, and as a decomposition product from iron pyrites (iron disulphide) in the presence of aluminous shales. So far as the present writer is aware, the native product has no commercial value, being found (on account of its ready solubility) in too sparing quantities in the humid East, while the known deposits in the arid regions are remote and practically inaccessible. A white fibrous variety is

¹ Geology of Tennessee, 1869, p. 197.

stated by Dana to occur in large quantities at Smoky Mountain, in North Carolina, and large quantities of an impure variety, often of a yellowish cast, are found in Grant County, on the Gila River, about 40 miles north of Silver City, New Mexico. (Specimen No. 67841, U.S.N.M.) The mineral is also found in Crooke and Fremont counties, Wyoming (Specimen No. 62087, U.S.N.M.); in Schemnitz, Hungary (Specimen No. 53047, U.S.N.M.), and in Japan (Specimen No. 34402, U.S.N.M.).

The chief use of the material, were it procurable cheaply and in quantities, would be as a source of alumina for use in chemical manufacture and as an ore of aluminum.

Concerning the occurrence of alunogen on the Gila River, New Mexico, W. P. Blake writes:

In a region about half a mile square, of nearly horizontal strata of volcanic origin, there has been extensive alteration and change by solfataric action, or possibly by the decomposition of disseminated pyrites producing aluminous solutions, which, flowing slowly by capillary movement from within outwards, suffer decomposition at the surface with the production of sulphate of alumina (alunogen) in crusts and layers upon the outer portions of the rocks, attended by the deposition of siliceous crusts and the separation of ferric sulphate, while the rocks so traversed appear to be deprived of a part, at least, of their silica and of their alkalis, with the formation of bauxite.

The alunogen is thus an outer deposit, while the bauxite is not a deposit, but is an internal residual mass in place. Its color is generally bluish-white; structure, amorphous, granular, without concentric or pisolitic grains. When dried in the sun and air it will still lose about 20 per cent by ignition. It gives only about 1 per cent of soluble matter by leaching with water; is infusible, and reacts for alumina. The amount of residual silica and alkalis has not yet been ascertained, and no careful full analysis has been made. The composition is no doubt variable in samples from different places, for the original rocks give evidence of a great difference within short distances.¹

Material from this locality (represented by Specimen No. 67841, U.S.N.M.) analyzed in the laboratories of the United States Geological Survey, yielded results as below:²

Alumina (Al_2O_3)	15.52
Sulphur trioxide (SO_3)	34.43
Water (H_2O)	42.56
Insoluble residue.....	7.62
	<hr/> 100.13

An asbestiform halotrichite from the same locality yielded—

Alumina (Al_2O_3)	7.27
Iron protoxide (FeO)	13.59
Sulphur trioxide (SO_3)	37.19
Water	40.62
Insoluble residue.....	0.50
	<hr/> 99.17

¹ Transactions of the American Institute of Mining Engineers, XXIV, 1894, p. 572.

² American Journal of Science, XXVIII, 1884, p. 24.

In New South Wales the material is commonly met with as an efflorescence in caves and under sheltered ledges of the Coal Measure sandstone, usually with epsomite, as at Dabee, County Phillip; Wallerawang and Mudgee road, County Cook; the mouth of the Shoalhaven River, and other places. Also found in the crevices of a blue slate at Alum Creek, and at the Gibraltar Rock, County Argyle. Occurs as a deposit, with various other salts, from the vents at Mount Wingen, County Brisbane, together with native sulphur in small quantities; and at Appin, Bulli, and Pitt Water, County Cumberland. At Cullen Bullen, in the Turon district, County Roxburgh; at Tarcutta, County Wynyard; Manero; Wingello Siding, and Capertee.

A specimen in the form of fibrous masses, made up of long, acicular crystals, white, silky luster, like satin spar, found as an efflorescence in a sandstone cave near Wallerawang, was found to have the following composition:

Water	47.585
Matter insoluble in water	1.079
Alumina.....	15.198
Sulphuric acid	34.635
Soda .....	.931
Potash .....	.337
Loss.....	.235
	<hr/>
	100.000

The formula for the above is practically $\text{Al}_2\text{O}_3 \cdot 3\text{SO}_3 + 18\text{H}_2\text{O}$. Another specimen from the same place was found to contain a notable quantity of magnesium sulphate.

Water, by difference	47.388
Silica.....	1.908
Alumina.....	13.113
Sulphuric acid	33.067
Lime .....	.798
Magnesia	3.726
	<hr/>
Total	100.000

The formula for the above is also practically $\text{Al}_2\text{O}_3 \cdot 3\text{SO}_3 + 18\text{H}_2\text{O}$.

ALUMINITE.—Aluminite is a dull, lusterless earthy, aluminum sulphate of the composition indicated by the formula $\text{Al}_2\text{O}_3 \cdot \text{SO}_3 \cdot 9\text{H}_2\text{O}$ = sulphur trioxide 23.3 per cent; alumina 29.6 per cent; water 47.1 per cent. It is soluble only in acids, white in color, opaque, and occurs mainly in beds of Tertiary and more recent clays.

ALUNITE.—Composition $\text{K}_2\text{O} \cdot 3\text{Al}_2\text{O}_3 \cdot 4\text{SO}_3 \cdot 6\text{H}_2\text{O}$ = sulphur trioxide 38.6 per cent; alumina 37.0 per cent; potash 11.4 per cent; water 13.0 per cent. Hardness 3.5 to 4; specific gravity 2.58 to 2.75. This mineral occurs native in the form of a fibrous, or compact finely granular rock of a dull luster somewhat resembling certain varieties of aluminous limestones. It is infusible and soluble only in sulphuric acid. The more compact varieties are so hard and tough as to be used for mill-

stones in Hungary. No deposits of such extent as to be of economic importance are known within the limits of the United States. Alunite as an alteration product of rhyolite has been described by Whitman Cross¹ as occurring at the Rosita Hills in Colorado, the alteration being brought about through the influence of sulphurous vapors incident to the volcanic outbursts. The altered rhyolite as shown by analyses had the following composition: Silica 65.94 per cent; alumina 12.95 per cent; potash 2.32 per cent; soda 1.19 per cent; sulphur trioxide 12.47 per cent; water 4.47 per cent; Fe_2O_3 , etc., 0.55 per cent. This indicates that the rock is made up of alunite and quartz, in the proportion of about one-third of the former to two-thirds of the latter. The most noted occurrences of alunite are at Tolfa, near Rome; Montioni, in Tuscany, Italy (Specimen No. 62863, U.S.N.M.); Musaz, in Hungary (Specimens Nos. 60925, 66854, U.S.N.M.) on the islands of Milo, Argentiera and Nevis in the Grecian Archipelago; Mount Dore in France, and at Bulledelah in New South Wales. At the last-named locality the mineral occurs in compact, micro-crystalline forms of a slight flesh pink tint, in "a large deposit forming the summit of a ridge about three-fourths mile long by one-half mile wide, and rising about 1,000 feet above the level of Lyall-Creek, on which it is situated. Viewed from the creek it presents a massive outcrop resembling limestone. It yields from 60 to 80 per cent of alum upon roasting, lixiviating, and evaporating" (Specimen No. 62179, U.S.N.M.).

Alunite from the mines at Tolfa varies considerably in composition. The crystallized variety contains about 32 per cent alumina, whereas the cruder specimens which contain a large quantity of silica have only about 17.5 per cent. The following is an analysis of an average sample:

Alumina	27.60
Sulphuric acid	29.74
Potash	7.55
Water	11.20
Iron	1.20
Silica	22.71
Total	100.00

When crushed it is easily reduced to a powder, the finer portions of which are richer in alumina than the coarser portions, and for this reason the author recommends that only the former should be exported, the latter being converted into commercial products in the vicinity of the mine.³

¹ American Journal of Science, XLI, 1891, p. 468.

² Catalogue of New South Wales Exhibits, World's Columbian Exposition, Chicago, 1893, Dept. E, p. 358.

³ Journal of the Society of Chemical Industry, I, 1882, p. 501.

ALUM SLATE OR SHALE is a somewhat indefinite name given to fine-grained arenaceous rocks consisting essentially of siliceous and fieldspathic sands and clays with disseminated iron pyrites. The following analyses from Bischof's Chemical Geology will serve to show their varying composition:

Constituents.	I.	II.	III.
Silica	65.44	72.40	50.13
Alumina	14.87	16.45	10.73
Iron oxides	1.05	.....	2.27
Lime .....	.15	.17	.40
Magnesia	1.34	1.48	1.00
Potash	4.59	5.08	.....
Soda .....	.48	.53	.....
Iron pyrites	1.25	2.26	7.53
Carbon and water	Undet.	Undet.	25.04

(I) An alum slate from Opsloe, near Christiania, Norway, (II) from Bornholm, and (III) from Garnsdorf, near Saalfeld, Prussia. Concerning No. III it is stated that "on the roof of the adit, driven into the slate, there are almost everywhere yellow or white opaque stalactites, and more rarely a green transparent deposit is produced. Both consist of hydrated basic sulphate of alumina and peroxide of iron. In the former, iron predominates; in the latter, alumina. Both substances are quite insoluble in water.

From shales and slates of this type the alum is obtained by crushing and allowing to undergo prolonged weathering or submitted to a roasting process. The essential part of the reaction consists in oxidizing the bisulphide to the condition of a sulphate and finally into iron sesquioxide, with separation of free sulphuric acid which attacks the alumina, forming an equivalent quantity of sulphate of aluminum or alum. So far as is known this process is not carried on at all in the United States.

The alum shale of the English Upper Liassian formation consists of hard blue shale with cement stones. On exposure to the air it gradually becomes incrustated with sulphur, and occasionally with alum.

In composition the alum shale is as follows:

Iron sulphide	8.50
Silica	51.16
Iron protoxide	6.11
Alumina	18.30
Lime	2.15
Magnesia	0.90
Sulphuric acid	2.5
Potash	Trace.
Soda	Trace.
Carbon	8.29
Water	2.00
Total	99.91

From this shale potash-alum was formerly made near Whitby and Redcar, the aluminum sulphate being extracted from the shale, and the potash-salt being added. The trade which since the days of Queen Elizabeth has been largely carried on, has now almost passed away, as alum is now manufactured in other places from coal-shale. Alum works formerly existed at the Peak, Robin Hood's Bay, Stow Brow, Sandsend, Kettleness, Lofthouse (Loftus), Osmotherly, etc.¹

According to F. Stolba,² the so-called Bohemian fuming sulphuric acid is made from vitriol obtained from Silurian pyritiferous schists ("vitriolschiefer"). The method as given is as follows: Large masses of the schist, which consist essentially of a quartzose matrix containing pyrite, carbonaceous matter, and clay, are exposed to the weathering action of the atmosphere for three years. The products of oxidation so formed are ferrous sulphate and sulphuric acid, which latter acts energetically upon the clay, and finally aluminum sulphate and other sulphates are yielded. The ferrous sulphate at first formed becomes by oxidation ferric sulphate, which, together with the aluminum sulphate, is the principal product of the weathering of the vitriol slate. Ferrous sulphate remains only in small quantities. The next operation is lixiviation of the mass with water, after which the liquor obtained is concentrated to a density of 40° Baumé, and finally evaporated in pans until, on cooling, a crystalline cake of vitriol stone is obtained. The vitriol stone is now calcined in order to remove the greater part of its water. The resulting product, when heated to a very high temperature in clay retorts, yields sulphuric anhydride, and a residue, termed colcothar, remains in the retorts. The composition of vitriol stone and colcothar will be seen from the following analyses:

VITRIOL STONE.		VITRIOL STONE.	
Fe ₂ O ₃	20. 07	Fe ₂ (SO ₄) ₃	50. 17
Al ₂ O ₃	4. 67	Al ₂ (SO ₄) ₃	11. 94
FeO.....	0. 64	FeSO ₄	1. 35
MnO.....	Traces.	MgSO ₄	1. 17
CaO.....	0. 14	CaSO ₄	0. 33
MgO.....	0. 39	CuSO ₄	0. 20
K ₂ O.....	0. 07	K ₂ SO ₄	0. 13
Na ₂ O.....	0. 05	Na ₂ SO ₄	0. 11
CuO.....	9. 10	H ₂ SO ₄	1. 49
SiO ₂	0. 10	MnO, As, and P ₂ O ₅	Traces.
P ₂ O ₅	Traces.	SiO ₂	9. 10
SO ₃	40. 51	H ₂ O.....	32. 31=99. 29
As.....	Traces.		
H ₂ O.....	32. 58=99. 32		

¹The Geology of England and Wales, p. 279.

²Journal of the Society of Chemical Industry, V, 1886, p. 30.

COLCOTHAR.

Fe ₂ O ₃	74.62
Al ₂ O ₃	12.53
MgO.....	3.23
CaO.....	0.82
SO ₃	5.17
SiO ₂	1.17
CuO.....	0.20
H ₂ O.....	1.30=99.04

XIII. HYDROCARBON COMPOUNDS.

1. COAL SERIES.

Here are included a variety of more or less oxygenated hydrocarbons varying widely in physical and chemical properties, but alike in originating from decomposing plant growth protected from the oxidizing influences of the air. According to the amount of change that has taken place in the original plant material, the amount of volatile matter still retained by it, its hardness and burning qualities, several varieties are recognized.

Origin.—The idea long prevalent but never entirely accepted to the effect that the coal beds resulted from the accumulation *in situ* of organic matter growing on gradually subsiding marshes has of late given way quite largely to another more in accord with the facts as now known.

While we have indubitable proof that peat may and does thus originate, as is to be seen in many a modern peat bog, and while, too, there is no doubt as to the possibility of such, under proper conditions, becoming converted into coal, still there are many facts which tend to show that perhaps the most and the largest of the coal deposits are due to the accumulation of transported plant remains laid down at the mouths of rivers as in deltas and lagoons. They are in fact as true sedimentary deposits as the shales and sandstones with which they are associated. This view best accounts for the constant interlamination of the coal with clay and sand, with the marked stratification of the coal itself, as well as the amorphous nature of the material, since, as is well known, calcium sulphate, a constituent of sea water, tends to decompose organic matter, reducing it to a pulplike, and at times almost mucilaginous condition.

The idea, too, long prevalent, that anthracite is but a bituminous coal from which a large portion of the volatile matter has been driven off by the heat and pressure incidental to mountain making or the intrusion of igneous rocks is also in part being set aside. Undoubtedly anthracite may be thus produced and in some cases has been thus produced, as in the Cerrillos coal field of New Mexico, where a bituminous coal containing some 30 per cent of volatile matter has been locally

converted into anthracite through the intrusion of a mass of an andesitic trachyte.¹

Prof. J. J. Stevenson has, however, argued² that the difference between anthracite and the bituminous coals is due, not to metamorphism through heat and pressure after being buried, but rather to the former having been longer exposed to the percolating action of water, whereby the volatile constituents were removed, prior to its final burial, and the consolidation of the inclosing rocks.

The subject is, however, altogether too large to be satisfactorily discussed here, and the reader is referred to the special works on the subject noted in the bibliography.

PEAT represents the plant matter in its least changed condition. It results from the gradual accumulation in bogs and marshes of growths consisting mainly of sphagnum mosses, a low order of plants having the faculty of continuing in growth upward as they die off below. In this way the deposits often assume a very considerable thickness. When sufficiently thick the weight of the overlying matter may have converted the lower portions into a dense brownish-black mass somewhat resembling true coal. The deposits of peat are all comparatively recent and occur only in humid climates. They are developed to an enormous extent in Ireland—about one-seventh of the entire country being covered by them—and average in some cases 25 feet in thickness. (Specimen No. 53242, U.S.N.M., from County Kerry.) They are also abundant on the continent of Europe and various parts of North America. In Europe, and especially in Ireland, the material is extensively utilized for fuel, and there would seem no good reason for not so utilizing it in America. As prepared for use the material is simply dug from the bogs and stacked up until sufficiently dry for burning, or pressed into bricks of suitable size and shape for convenient handling. Many processes have been invented for reducing the material to a pulp and subsequently condensing by pressure, but all involve too great an outlay to be profitable.³

In America the chief use of the material is as a fertilizer, a material for "mulching." An impure variety containing a considerable quan-

¹ Bulletin of the Geological Society of America, VII, 1895-96, p. 525.

² Idem, V, 1894, p. 39.

³ A new method of making charcoal from peat has been patented in England by Mr. Blundell and is to be tried in Italy, where there are large deposits of peat which can, it is claimed, be handled very cheaply. In this process the peat is first reduced to a fine paste and leaves the machine in a continuous thick tube 3 to 5 inches in diameter, and is then cut off in sticks and dried for three days on wooden supports and for a longer period in the air on wire netting. After twenty-five days the sticks become dry and hard and may be burned as fuel; but it is more profitable to convert these sticks into charcoal. This is accomplished in six hours in a retort, and 3 tons of peat make 1 ton of charcoal.—Engineering and Mining Journal, LXV, February 26, 1898, p. 248.



VIEW OF PEAT BEDS OVERLYING GOLD-BEARING GRAVELS, MIAS, RUSSIA.
From a photograph by A. M. Miller.

tity of silicious sand, and locally known as "muck," is thus used throughout New England.

According to J. E. Kehl, United States consul at Stettin, Germany, the manufacture of peat briquettes in that country is likely to become an industry of some importance. The material fresh from the moor is cut and ground quite finely by machinery, dried by steam, and pressed into the desired form. The material thus prepared is said to be clean to handle, gives a good heat, and burns satisfactorily in both stoves and open grates. The peat briquettes retail at the rate of 8 for a cent, American money.¹

From a study made by Drs. J. W. Dawson and B. J. Harrison some years ago² it was concluded that the peat deposits of Prince Edward Island were capable of economic utilization. Three deposits were referred to, the possibilities of which were given as below:

Lenox Island bog, at \$4 a ton, 20,000 tons, value	\$80,000
Squirrel Creek bog, at \$4 a ton, 500,000 tons, value	2,000,000
Black Bank bog, at \$4 a ton, 1,777,248 tons, value	7,108,992
Total	9,189,992

The following analyses of peats are given by this authority:

Constituents.	Hydroscopic water.	Volatile combustible matter.	Fixed carbon.	Ash.
Champlain peat.....	14.96	59.60	22.20	3.24
Hodges peat.....	17.06	50.725	25.96	6.265
Indian Island peat.....	23.71	41.195	19.835	15.26
Black Bank peat.....	16.52	53.29	22.48	7.71

Below are given the results of analyses of I, peat from bog of Allan, Ireland; II, a "muck" from Maine, United States; and III, Commander Islands in Behring Sea (Specimen No. 59320, U.S.N.M.):

Constituents.	I.	II.	III.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Carbon	61.04	21	60.48
Volatile matter.....	37.53	72	39.53
Ash.....	1.83	7	3.30

LIGNITE OR BROWN COAL.—This name is given to a brownish-black variety of coal characterized by a brilliant luster, conchoidal fracture, and brown streak. Such contain from 55 to 65 per cent of carbon and burn easily, with a smoky flame, but are inferior to the true coals for heating purposes. They are also objectionable on account of the soot they create, and their rapid disintegration and general deterioration

¹ United States Consular Reports, January, 1899, p. 99.

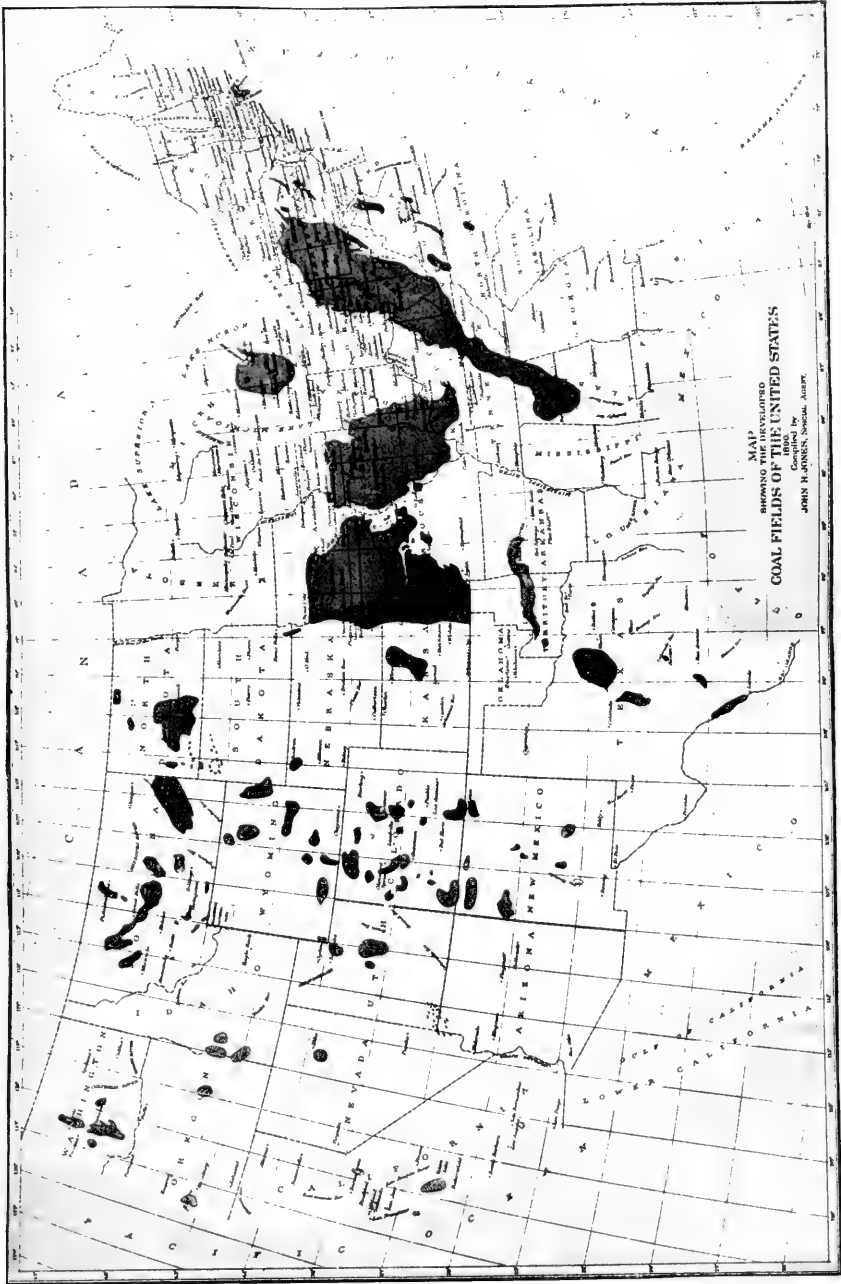
² Report on the Geological Structure and Mineral Resources of Prince Edward Island, 1871.

when exposed to the air. They occur in beds under conditions similar to the true coals, but are of more recent origin. The lignitic coals of the regions of the United States west of the Mississippi River are mainly of Laramie (Upper Cretaceous) age, and often show easily recognizable traces of their organic origin, such as compressed and flattened stems and trunks of trees with traces of woody fiber (Specimen No. 4795, U.S.N.M.).

Jet is a resinous, coal-black variety of lignite sufficiently dense to be carved into small ornaments (Specimens Nos. 62930, 62804, U.S.N.M.). According to Professor Phillips, it is simply a coniferous wood, and still shows the characteristic structure under the microscope. It has been known since early British times, having at first been found on the seashore at Whitby and other places. The largest seam on record was obtained from the North Bats, near Whitby. It weighed some 5,180 pounds and was valued at about \$1,250. The material is now regularly mined both in the cliffs and inland, and is one of the most valuable products of the Yorkshire coast.¹

BITUMINOUS COALS.—Under this name are included a series of compact and brittle products in which no traces of organic remains are to be seen on casual inspection, but which under the microscope often show traces of woody fiber, spores of lycopods, etc. These coals are usually of a brown to black color, with a brown or gray-brown streak, breaking with a cubical or conchoidal fracture, and burning readily with a yellow, smoky flame. They contain from 35 to 75 per cent of fixed carbon, 18 to 60 per cent of volatile matter, from 2 to 20 per cent of water, and only too frequently show traces of sulphur, due to included iron pyrites. Several varieties of bituminous coals are recognized, the distinctions being based upon their manner of burning. *Coking* coals are so called from the facility with which they may be made to yield coke. Such give a yellow flame in burning and make a hot fire. (Specimens Nos. 55490, U.S.N.M., Connellsville, Pennsylvania, and 59260, U.S.N.M., from New River, West Virginia.) Other varieties of apparently the same composition and general physical properties can not for some unexplained reason be made to yield coke, and are known as *noncoking coals*. (Specimens Nos. 59428, U.S.N.M., from Vigo County, Indiana, and 59208, U.S.N.M. (splint coal), from Fayette County, West Virginia.) *Cannel* coal has a very compact structure, breaks with a conchoidal fracture, has a dull luster, ignites easily, and burns with a yellow flame. It does not coke. Its chief characteristic is the large amount of volatile matter given off when heated, whereby it is rendered of particular value for making gas. (Specimens Nos. 56280, 56284, and 58496, U.S.N.M., are characteristic.) Before the discovery of petroleum it was used for the distillation of oils. Below is given the composition of a (I) coking coal from the

¹Geology of England and Wales, p. 278.



MAP SHOWING THE DEVELOPED COAL FIELDS OF THE UNITED STATES.
From the Report of the Eleventh Census.

Connellsville Basin of Pennsylvania, and (II) a cannel coal from Kanawha County, West Virginia.¹

Constituents.	I.	II.
Water	1.105	.....
Volatile matter.....	29.885	58.00
Fixed carbon.....	57.754	23.50
Ash.....	9.895	18.50
Sulphur.....	1.339	.....
Total	99.978	100.00

ANTHRACITE COAL.—This is a deep black, lustrous, hard and brittle variety, and represents the most highly metamorphosed variety of the coal series. Traces of organic nature are almost entirely lacking in the matter of the anthracite itself, though impressions of ferns, lycopods, sigillaria and other coal-forming plants are frequently associated with the beds in such a manner as to leave little doubt as to their origin. Anthracite is ignited with difficulty and burns with little flame, but makes a hot fire. Below is given the average composition of a coal from the Kohinoor Colliery, Shenandoah, Pennsylvania.²

Water.....	3.163
Volatile matter.....	3.717
Fixed carbon	81.143
Sulphur	0.899
Ash	11.078
	100.00

(Specimens Nos. 59058, 59062, from Pennsylvania, and 30854, from Colorado, are sufficiently characteristic.) Like the other coals, anthracite occurs in true beds, but is confined mostly to rocks of the Carboniferous age. Thin seams of anthracite sometimes occur in Devonian and Silurian rocks, but which are too small to be of economic value. Rarely coals of more recent geological horizon have been formed locally, altered into anthracite by the heat of igneous rocks. Through a still further metamorphism, whereby it loses all its volatile constituents, coal passes over into graphite (Specimens Nos. 17299 and 59099, from near Newport, Rhode Island), and it is possible, though scarcely probable, that all graphite may have originated in this way.

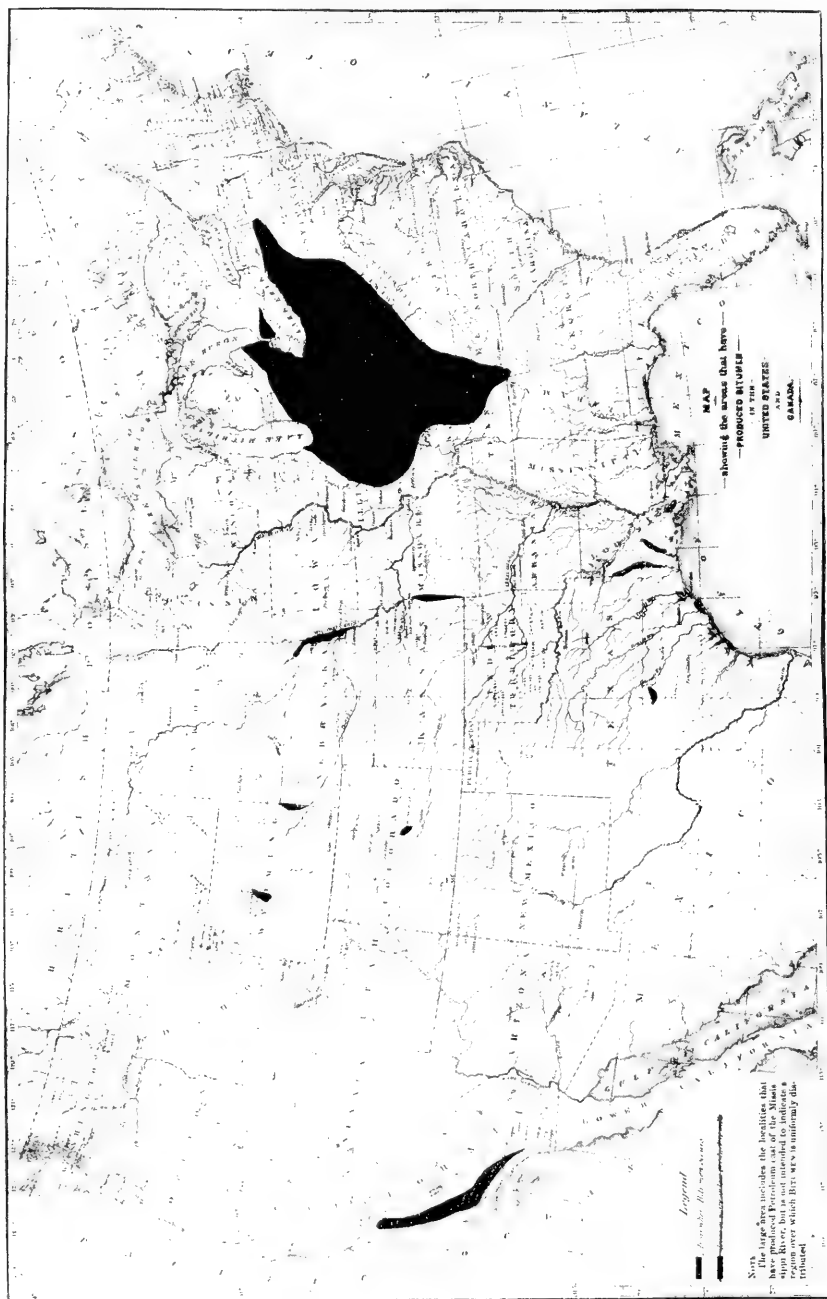
The principal anthracite coal regions of the United States are in eastern Pennsylvania. From here westward throughout the interior States to the front range of the Rocky Mountains the coals are all soft, bituminous coals. Those of the Rocky Mountain region proper are largely lignitic, passing into the bituminous varieties.

¹ F. P. Dewey, Bulletin 42, United States National Museum, 1891, p. 231.

² Idem, p. 221.

BIBLIOGRAPHY.

- The bibliography of coal, even though limited to the United States, would be enormous. In all cases reference should be made to the publications of the various State surveys, where such have existed. The few titles here given are of articles of general interest and, as a rule, not relating to the coals of one particular locality alone.
- WALTER R. JOHNSON. A Report to the Navy Department of the United States on American Coals Applicable to Steam Navigation and to other purposes.
Washington, D. C., 1844, pp. 607.
- RICHARD COWLING TAYLOR. Statistics of Coal. The Geographical and Geological Distribution of Mineral Combustibles or Fossil Fuel, etc.
Philadelphia, 1848, pp. 754.
- J. LE CONTE. Lectures on Coal.
Report of the Smithsonian Institution, 1857, p. 119.
- T. H. LEAVITT. Peat as a Fuel.
Second Edition. Boston, 1866, pp. 168.
— Facts About Peat as an Article of Fuel.
Third Edition. Boston, 1867, pp. 316.
- E. W. HILGARD. Note on Lignite Beds and their Under Clays.
American Journal of Science, VII, 1874, p. 208.
- LEO LESQUEREUX. On the Formation of Lignite Beds of the Rocky Mountain Region.
American Journal of Science, VII, 1874, p. 29.
- J. S. NEWBERRY. On the Lignites and Plant Beds of Western America.
American Journal of Science, VII, 1874, p. 399.
- JAMES MACFARLANE. Coal Regions of America.
New York, 1875.
- MIALl GREEN, THORPE, RÜCKER, and MARSHALL. Coal; Its History and Uses. Edited by Professor Thorpe. London, 1878, pp. 363.
- RAPHAEL PUMPELY. Report on the Mining Industries of the United States, with special investigation into the Iron Resources of the Republic and into the Cretaceous Coals of the Northwest.
Tenth Census of the United States, XV, 1880.
- W. IVISON MACADAM. Analyses of Coals from New Zealand and Labuan.
Transactions of the Edinburgh Geological Society, IV, pt. 2, p. 165, session 1881-82.
- J. S. NEWBERRY. On the Physical Conditions under which Coal was Formed.
Science, I, March 2, 1883, p. 89.
- CHARLES A. ASHBURNER. The Classification and Composition of Pennsylvania Anthracites.
Transactions of the American Institute of Mining Engineers, XIV, 1885, p. 706.
- LEO LESQUEREUX. On the Vegetable Origin of Coal.
Annual Report of the Geological Survey of Pennsylvania, 1885, p. 95.
- S. W. JOHNSON. Peat and its Uses as Fertilizer and Fuel.
New York, 1886, pp. 168.
- GRAHAM MACFARLANE. Notes on American Cannel Coal.
Transactions of the American Institute of Mining Engineers, XVIII, 1890, p. 436.
- W. GALLOWAY. The South African Coal Field.
Proceedings of the South Wales Institute of Engineers, No. 2, XVII, 1890, p. 67.
- LEVI W. MEYERS. L'Origine de la Houille.
Revue de Quest. Scientifique Brussels, July, 1892, pp. 5-47.
- WILLIAM H. PAGE. The Carboniferous Age and the Origin of Coal.
Engineering and Mining Journal, LVI, 1893, p. 347.
Note sur la formation des Terraines Houillères.
Bulletin de la Société Géologique de France, XXIV, 1896, p. 150.
Making Coal of Bog Peat.
The Iron Age, LXII, Aug. 18, 1898, p. 3.



MAP SHOWING AREAS WHERE BITUMEN OCCURS IN THE UNITED STATES AND CANADA.
From the Report of the Tenth Census.

2. BITUMEN SERIES.

Under this head are included a series of hydrocarbon compounds varying in physical properties from solid to gaseous and in color from coal black through brown, greenish, red, and yellow to colorless. Unlike the members of the series already described, they are not the residual products of plant decomposition *in situ*, but are rather, in part at least, distillation products from deeply buried organic matter of both animal and vegetable origin. The different members of the series differ so widely in their properties and uses that each must be discussed independently. The grouping of the various compounds as given below is open to many objections from a strictly scientific standpoint, but, all things considered, it seems best suited for the present purposes.¹

*Tabular classification of hydrocarbons.*²

Hydrocarbons.	Bituminous	Gaseous	Marsh gas (Natural gas).
		Fluidal	Petroleum (Naphtha).
		Viscous and semisolid	Pittasphalt (Maltha).
			Mineral tar.
		Elastic	Asphalt.
			Elaterite.
	Solid	Wurtzillite.	
		Albertite.	
	Resinous	Grahamite.	
		Uintaite.	
		Succinite.	
		Copalite.	
	Cerous (waxy)	Torbanite.	
Ambrite.			
Ozokerite.			
		Hatchettite.	

Tabular classification or grouping of natural and artificial bituminous compounds.

Bituminous Compounds.	Natural.	Mixed with limestone, "asphaltic limestone."	Seyssel, Val de Travers, Lobsan, Illinois, and other localities.
		Mixed with silica and sand, "asphaltic sand."	California, Kentucky, Utah, and other localities. "Bituminous silica."
		Mixed with earthy matter, "asphaltic earth."	Trinidad, Cuba, California, Utah.
		Bituminous schists	Canada, California, Kentucky, Virginia, and other localities.
	Artificial.	Fluid	Thick oils from the distillation of petroleum. "Residuum."
		Viscous	Gas-tar.
			Pitch.
		Solid	Refined Trinidad asphaltic earth. Mastic of asphaltite.
			Gritted asphaltic mastic. Paving compounds.

¹See article What is Bitumen? by S. F. Peckham, Journal of the Franklin Institute, CXL, 1895, pp. 370 to 383.

²W. P. Blake, Transactions of the American Institute of Mining Engineers, XVIII, 1890, p. 582.

Table of occurrence of important natural bitumen.¹

Important natural bitumens.	Natural gas		Ohio, Pennsylvania, California, etc., in the United States; Russia, France, etc.
	Natural naphtha		Found in petroleum districts (of little value, superseded by artificial naphtha from crude petroleum).
	Petroleum		Pennsylvania, Ohio, Wyoming, California, etc., in United States; Russia, etc. (consult books on petroleum).
	Maltha		California, Wyoming, Alabama, Utah, Colorado, Kentucky, New Mexico, Ohio, Texas, Indian Territory, etc.; Russia, France, Germany, etc.
	Asphaltum almost pure.	North America	Utah, California, Texas, etc.
		Central America	Cuba, Mexico, etc.
		South America	Trinidad, Venezuela, Peru, Colombia, etc.
		Europe	Caucasia, Syran-on-the Volga, Germany, France, Italy, Austria, etc.
		Asia	Hit on the Euphrates, Asia Minor, Palestine, etc.
		Africa	Oran in Egypt; probably other places.
	Asphaltum Asphaltic compounds.	North America	West Virginia, Kentucky, Texas, Wyoming, Utah, Colorado, California, Indian Territory, Montana, New Mexico.
		Central America	Mexico, Cuba, etc.
		South America	Trinidad (largest supply, most used), Venezuela, Peru, Colombia, etc.
		Europe	Germany, Switzerland, France, Italy, Sicily, Russia, Austria, Spain, etc.
		Asia	Asia Minor, Palestine, Bagdad, and probably in China.
		Africa	Egypt, and probably elsewhere in Africa.

Origin.—Of the many views, mainly theoretical, that have been put forward to account for the origin of bituminous compounds, but two need be noted in detail here. Interested readers are referred to the bibliography given on page 460, and particularly to the works of Peckham, Orton, and Redwood. Prof. Edward Orton, after an

¹J. W. Howard, as quoted by S. P. Sadtler, *Journal of the Franklin Institute*, CXL, 1895, p. 200.

exhaustive consideration of the occurrence of petroleum, natural gas, and asphalt in Kentucky,¹ gives the following precise summary:

1. Petroleum is derived from organic matter.
2. Petroleum of the Pennsylvania type is derived from the organic matter of bituminous shales, and is probably of vegetable origin.
3. Petroleum of the Canadian type is derived from limestones, and is probably of animal origin.
4. Petroleum has been produced at normal rock temperatures (in American fields), and is not a production of destructive distillation of bituminous shales.
5. The stock of petroleum in the rocks is already practically complete.

Hofer² regards petroleum as of animal origin only, and advances the arguments given below in support of his theory:

1. Oil is found in strata containing animal, but little or no plant remains. This is the case in the Carpathians, and in the limestone examined in Canada and the United States by Sterry Hunt.
2. The shales from which oil and paraffin were obtained in the Liassic oil shales of Swabia and of Steirdorf, in Styria, contained animal, but no vegetable remains. Other shales, as, for instance, the copper shales of Mansfield, where the bitumen amounts to 22 per cent, are rich in animal remains and practically free from vegetable remains.
3. Rocks which are rich in vegetable remains are generally not bituminous.
4. Substances resembling petroleum are produced by the decomposition of animal remains.³
5. Fraas observed exudations of petroleum from a coral reef on the shores of the Red Sea, where it could be only of animal origin.

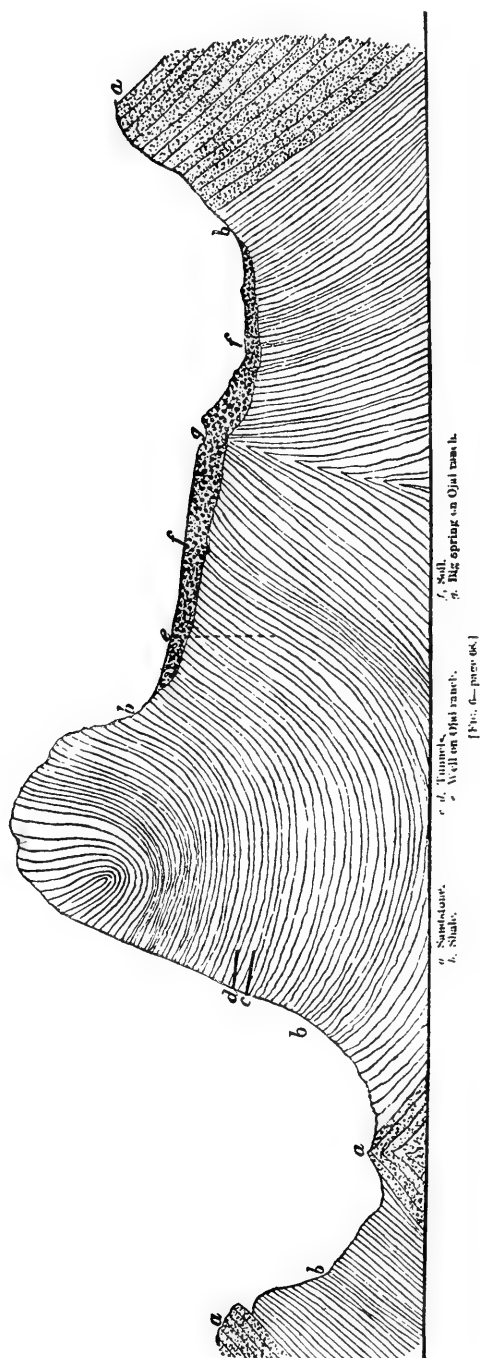
The relationship which exists between the solid or viscous bitumen and the fluidal petroleum have not in all cases been satisfactorily worked out, though Peckham has shown⁴ that in California at least there are almost infinite gradations from one extreme to the other. In Ventura County, for instance, the petroleum is held, primarily, in strata of shale, from which it issues as petroleum or maltha, accordingly as the shales have been brought into contact with the atmosphere, the asphaltum being produced by a still further exposure to the atmosphere after the bitumen has reached the surface. This relationship between the more fluidal and viscous varieties is shown in fig. 13, copied from Professor Peckham's paper above referred to, and which represents a section across a portion of Sulphur Mountain between the Hayward Petroleum Company's tunnels in Wheeler Canyon, and the Big Spring Plateau on the Ojai ranch. In this section it will be noted that the mountain is formed of a synclinal fold of shale, the strata dipping

¹Report on the Occurrence of Petroleum, etc., in Western Kentucky. Geological Survey of Kentucky, John R. Proctor, director, 1891.

²As quoted by Redwood, I, p. 238.

³Dr. Engler, as quoted by Redwood, obtained by distillation of menhaden oil, among other products, a substance remarkably like petroleum, and a lighting oil indistinguishable from commercial kerosene.

⁴See Report of the Tenth Census, p. 68.



Section through Sulphur mountain and Ojai plateau, Ventura county, California.

Fig. 13.

SECTION THROUGH SULPHUR MOUNTAIN, CALIFORNIA.
 After S. F. Peckham.

inward on both sides and coming to the surface almost vertically on the right, and more nearly horizontally on the left (the south). The tunnels are driven into the nearly vertical face of the mountain and the oil-bearing rock is protected by some 700 or 800 feet of overlying shales. The oil obtained is the lightest thus far found in southern California. On the other hand, the material which exudes on the north side, when the shales are upturned at such an angle as to give free access to atmospheric agencies, is in the form of maltha, or mineral tar, and so viscous, in December, 1865, that it could be gathered and rolled into balls like dough.

The relationship between petroleum and natural gas is scarcely better defined. That the gas can be derived from petroleum is undoubted, and indeed the latter apparently never occurs free from gas. But on the other hand, as Professor Orton states, the gas often originates under many conditions in which petroleum does not occur. The formation of marsh gas from decomposing plant remains on the bottom of stagnant pools, and its presence in coal mines would show with seeming conclusiveness that a part, at least, of the gas is formed quite independently of petroleum. It would seem on the whole most probable that no one theory was universally applicable to all cases.

MARSH GAS; NATURAL GAS.—This is a colorless and odorless gas arising from the decomposition of organic matter protected from the oxidizing influence of atmospheric air. By itself it burns quietly, with a slightly luminous flame, but when mixed with air it forms a dangerous explosive. It is this gas which forms the dreaded fire damp of the miners. In small quantities this gas may be found and collected, if desired, from the bottom of shallow pools and stagnant bodies of water by merely disturbing the decomposing plant matter at the bottom, when the bubbles of the gas will rise to the top. Under this head may properly be considered the so-called *natural gas*, which has of late years become of so much importance from an economic standpoint. This gas is, however, by no means a simple compound, but a variable admixture of several gases, samples from different wells showing considerable variation in composition, as well as those from the same well collected at different periods. This last is shown by the seven analyses following, and which may serve well to illustrate the average composition, though in some instances the percentage of marsh gas has been found greater.¹

¹ From Orton's Report on Petroleum, Natural Gas, and Asphalt in Kentucky, pp. 108-110.

Constituents.	I.	II.	III.	IV.	V.	VI.	VII.
Hydrogen	1.89	1.64	1.74	2.35	1.86	1.42	1.20
Marsh gas	92.84	93.35	93.85	92.67	93.07	94.16	93.58
Olefiant gas	0.20	0.35	0.20	0.25	0.49	0.30	0.15
Carbonic oxide.....	0.55	0.41	0.44	0.45	0.73	0.55	0.60
Carbonic acid	0.20	0.25	0.23	0.25	0.26	0.29	0.30
Oxygen	0.35	0.39	0.35	0.35	0.42	0.30	0.55
Nitrogen	3.82	3.41	2.98	3.53	3.02	2.80	3.42
Sulphuretted hydrogen	0.15	0.20	0.21	0.15	0.15	0.18	0.20
Total	100.00	-----	-----	-----	-----	-----	-----

I, Fostoria, Ohio; II, Findlay, Ohio; III, St. Marys, Ohio; IV, Muncie, Indiana; V, Anderson, Indiana; VI, Kokomo, Indiana; VII, Marion, Indiana.

Natural gas in quantities to be of economic importance is necessarily limited to rocks of no particular horizon. It is not, however, indigenous to the rocks in which it is now found, but occurs in an overlying more or less porous sand or lime rock into which it has been forced by hydrostatic pressure. The first necessary condition for the presence of gas in any locality may indeed be said to depend upon the existence of such a porous rock as may serve as a reservoir to hold it, and also the presence of an impervious overlying strata to prevent its escape. In Pennsylvania the reservoir rock is a sandstone of Carboniferous or Devonian age; in Ohio and Indiana a cavernous dolomitic limestone of Silurian (Trenton) age.

PETROLEUM.—This is the name given to a complex hydrocarbon compound, liquid at ordinary temperatures, though varying greatly in viscosity, of a black, brown, greenish, or more rarely red or yellow color, and of extremely disagreeable odor. Its specific gravity varies from 0.6 to 0.9. Through becoming more and more viscous the material passes into the solid and semisolid forms asphalt and maltha. Chemically it is considered as a mixture of the various hydrocarbons included in the marsh gas, ethylene and paraffin series.

An ultimate analysis of several samples, as given by the reports of the Tenth Census of the United States (1880), showed the following percentages of the three essential constituents:

Locality.	Hydrogen.	Carbon.	Nitrogen.
West Virginia	13.359	85.200	0.54
Mecca, Ohio.....	13.071	86.316	0.23
California	11.819	86.934	1.109

Petroleum is limited to no particular geological horizon, but is found in rocks of all ages, from the Lower Silurian to the most recent, its existence in quantities sufficient for economic purposes being dependent upon local conditions for its generation and subsequent preservation. Inasmuch as its accumulation in large quantities necessitates a

rock of porous nature to act as a reservoir, the petroleum-bearing rocks are mostly sandstones, though not uniformly so. Petroleums are found in California and Texas in Tertiary sands; in Colorado in the Cretaceous; in West Virginia both above and below the Crinoidal (Carboniferous) limestones; in Pennsylvania in the "mountain" sands (Lower Carboniferous) and the Venango sands (Devonian); in Canada in the Corniferous (Lower Devonian) limestones; in Kentucky in the Hudson River shales (Lower Silurian), and in Ohio in the Trenton limestone. (See series illustrating geological distribution.)

In some instances petroleum oozes naturally from the ground, forming at times a thin layer on the surface of pools of water, whence in times past it has been gathered and used for chemical and medicinal purposes. The so-called "Seneca oil" thus used some fifty or sixty years ago was thus obtained from a spring in Cuba, Allegany County, in New York. The immense supply now demanded for commercial purposes is, however, obtained altogether from artificial wells of varying depths, and which are in some cases self-flowing, while in others the oil is raised by means of pumps. Wells of from 500 to 1,500 feet in depth are of common occurrence, while those upwards of 2,000 feet are not rare. The principal sources of petroleum are in the United States—New York, Pennsylvania, and Ohio, with smaller fields in West Virginia, Kentucky, Tennessee, Indiana, Texas, Colorado, and California. The chief foreign source is the Baku region on the Caspian Sea, and Galicia, in Austria.

Uses of petroleum.—The early uses of petroleum in America seem to have been for medicinal purposes only (Specimen No. 59834, U.S.N.M., from Kentucky). The oil as pumped from the wells has but a limited application in its crude condition excepting as a fuel, and owes its great value to the large and varied series of derivatives which it yields. A discussion of the methods employed in obtaining these derivatives belongs properly to the department of chemical technology and can not be dwelt upon here. It must suffice for present purposes to say that the treatment as ordinarily carried out at present involves a process of destructive distillation whereby the crude material, heated under pressure, is resolved into a variety of products of different densities, and varying from gaseous through liquid to solid forms. Prominent among these derivatives may be mentioned, aside from the gaseous compounds, rhigolene, gasoline, naphtha, benzine, kerosene, various lubricating oils, paraffin, and the solid residues (coke, etc.). Various pharmaceutical compounds are prepared from petroleum products, many of which are well known to the public, as vaseline, cosmoline, etc. It is also used as a basis for ointments and in soaps.

The accompanying map (Plate 25) from the reports of the Tenth Census will serve to show the distribution of petroleum and allied

bituminous compounds in the United States. For full and detailed information relative to the petroleum industry of the world the reader is referred to the works mentioned in the Bibliography, that of Boverton Redwood being the most systematic and complete.

The petroleum series in the Museum collections is quite large (some 303 samples), and is arranged for exhibition so as to illustrate (1) variation in specific gravity, (2) in color, (3) geological distribution, (4) depth of source, (5) geographical distribution. This last, nearly as it stands to-day, was described in Mr. Dewey's Handbook, Collections in Economic Geology,¹ and the list is not entirely reprinted here.

In this connection reference should be made to the series of sands and rocks associated with petroleum and bituminous deposits in a separate case. This comprises oil-bearing sands from wells in Washington County, Pennsylvania (Specimens Nos. 52025, 62997, 59930, 59932, U.S.N.M.); Oil City, Venango County, Pennsylvania (Specimen No. 62998, U.S.N.M.); Butler County, Pennsylvania (Specimen No. 62996, U.S.N.M.), and a block of sandstone weighing 8 pounds, blown from well No. 9, on Barse tract, McKean County, Pennsylvania, at a depth of 1,730 feet. Also oil sands from Marion County, West Virginia (Specimens Nos. 62790, 62994, 62995, U.S.N.M.); oil-bearing shales from Ventura County, California (Specimens Nos. 62785, 62914, 62915, U.S.N.M.); oil-bearing shales from Santa Barbara County, California (Specimens Nos. 62939-62943, U.S.N.M.); core of diamond drill from well No. 19, Pico oil field, California (Specimen No. 62921, U.S.N.M.); bituminous dolomite from Cook County, Illinois (Specimen No. 62789, U.S.N.M.); geodes of quartz filled with bitumen from Hancock County, Illinois (Specimen No. 40364, U.S.N.M.); asphaltic sands from Wyoming (Specimen No. 62716, U.S.N.M.); Indian Territory (Specimen No. 62245, U.S.N.M.); Germany (Specimen No. 66855, U.S.N.M.); a series of sands, sandstones, and shales, with varieties of asphalt, from the island of Trinidad (Specimens Nos. 68050-68066, U.S.N.M.); trappean rock with bitumen, Hartford County, Connecticut (Specimen No. 59934, U.S.N.M.); andesite with bitumen, Lake Tahoe, Nevada (Specimen No. 33884, U.S.N.M.); shale associated with albertite, Albert County, New Brunswick (Specimens Nos. 59936, 59938, 59939, U.S.N.M.); and clays associated with ozokerite and salt, Boryslaw, Galicia (Specimens Nos. 66087, 66088, U.S.N.M.).

1. EXHIBIT ILLUSTRATING VARIATION IN SPECIFIC GRAVITY.

The series is arranged to show gradually decreasing specific gravity. It begins with a very dark oil of 22° Baumé=0.9210 specific gravity. In general as the specific gravity decreases the color grows lighter. To this, however, there are several notable exceptions. For instance, No. 59736 ($32\frac{1}{2}^{\circ}$ Baumé=0.8614 specific gravity) is much lighter in

¹Bulletin No. 42 of the U. S. National Museum, 1891.

color than its associates. The same is also true of No. 59735 (45° Baumé=0.8000 specific gravity) and No. 59743 (47° Baumé=0.7909 specific gravity). On the other hand, Specimens Nos. 59506 (48° Baumé=0.7865 specific gravity) and 59591 (48½° Baumé=0.7843 specific gravity) are darker than their associates, while the color of Specimen No. 59584, with the very low gravity of 50½° Baumé=0.7755 specific gravity, is as dark as any member of the series.

(1) 22° Baumé=0.9210 specific gravity, dark greenish. Colorado. (59741.)

(2) 23½° Baumé=0.9120 specific gravity, black. From the Trenton limestone. J. W. Mitchell well, Plum Lick Creek, near Middletown, Bourbon County, Kentucky. (59594.)

(3) 27° Baumé=0.8917 specific gravity, black. From the millstone grit (Carboniferous). Lem Beck well, near Volcano, Wood County, West Virginia. (59553.)

(4) 28½° Baumé=0.8833 specific gravity, black. From the millstone grit (Carboniferous), near Volcano, Wood County, West Virginia. (59555.)

(5) 29° Baumé=0.8805 specific gravity, black. Brockin well, Johnson County, Kentucky. (59597.)

(6) 30° Baumé=0.8750 specific gravity, black. From the millstone grit (Carboniferous), near Volcano, Wood County, West Virginia. (59557.)

(7) 31½° Baumé=0.8668 specific gravity, dark greenish. Broward well, Johnson County, Kentucky. (59598.)

(8) 32½° Baumé=0.8614 specific gravity, dark greenish red. Greensburgh, Westmoreland County, Pennsylvania. (59736.)

(9) 33° Baumé=0.8588 specific gravity, black. From the Trenton limestone. Taskin well, near North Baltimore, Wood County, Ohio. (59566.)

(10) 34° Baumé=0.8536 specific gravity, black. Oil in sand; here 23 feet in thickness; depth of well 551 feet; drilled, 1877; torpedoed; yielded 3 barrels of oil on first day of flow. Lot 4823, Howe, Forest County, Pennsylvania. (59805.)

(11) 35° Baumé=0.8484 specific gravity, black. From the first sandstone of the Great Conglomerate (Upper Carboniferous). Well No. 6, West Virginia Oil and Oil Land Company, White Oak district, Ritchie County, West Virginia. (59857.)

(12) 36° Baumé=0.8433 specific gravity, dark greenish. From the first sandstone of the Great Conglomerate (Upper Carboniferous). Oil in sand. Well No. 7, West Virginia Oil and Oil Land Company, White Oak district, Ritchie County, West Virginia. (59858.)

(13) 37° Baumé=0.8383 specific gravity, black. Oil in limestone, here 50 feet in thickness; depth of well 1,321 feet; drilled 1885; torpedoed; yielded 50 barrels of oil on first day of flow. Brick Yard well, Findlay, Hancock County, Ohio. (59807.)

(14) 38° Baumé=0.8333 specific gravity, dark greenish. From the first sandstone of the Great Conglomerate (Upper Carboniferous). Oil in sand. West Virginia Oil and Oil Land Company, White Oak district, Ritchie County, West Virginia. (59860.)

(15) 39° Baumé=0.8284 specific gravity, dark greenish red. From Clarion County sand; depth of well 860 feet; drilled 1883; torpedoed; yielded 2 barrels of oil on first day of pumping. Cumming's well No. 1, Cumming's farm, Tionesta, Forest County, Pennsylvania. (59816.)

(16) 40° Baumé=0.8235 specific gravity, dark greenish. Bradford County, Pennsylvania. (59734.)

(17) 41° Baumé=0.8187 specific gravity, dark greenish. Parker County, Pennsylvania. (59733.)

(18) 42° Baumé=0.8139 specific gravity, dark greenish. From the third sandstone of the Petroleum Measures (Venango). Black Gas well, Pleasantville, Venango County, Pennsylvania. (59580.)

(19) 43° Baumé=0.8092 specific gravity, dark greenish red. Oil-bearing sand here 20 feet in thickness; depth of well 1,855 feet; drilled 1883; torpedoed; yielded 2,200 barrels of oil on first day of flow. Reno well No. 1, Cooper tract, Sheffield, Warren County, Pennsylvania. (59765.)

(20) 44° Baumé=0.8045 specific gravity, dark greenish. Bullion district, Warren County, Pennsylvania. (59737.)

(21) 44½° Baumé=0.8023 specific gravity, dark greenish. From third sandstone of the Petroleum Measures (Venango). Sand here 14 feet in thickness. Oil in sand; depth of well 708 feet; drilled 1868; torpedoed; yielded 330 barrels of oil on first day of flow. Well No. 6, Hamby farm, Rockland, Venango County, Pennsylvania. (59788.)

(22) 45° Baumé=0.8000 specific gravity, dark amber. Clarion County, Pennsylvania. (59735.)

(23) 45½° Baumé=0.7977 specific gravity, dark greenish red. Thom Creek district, Butler County, Pennsylvania. (59746.)

(24) 46° Baumé=0.7954 specific gravity, dark greenish. Foxburgh, Clarion County, Pennsylvania. (59739.)

(25) 46½° Baumé=0.7932 specific gravity, black. Depth of well 660 feet; drilled 1866; yielded 600 barrels of oil on first day of flow. Well No. 184, Burtes lease, Allegheny County, Pennsylvania. (59769.)

(26) 46¾° Baumé=0.7921 specific gravity, black. From the third sandstone of the Petroleum Measures (Venango). Titusville, Venango County, Pennsylvania. (59507.)

(27) 47° Baumé=0.7909 specific gravity, dark amber. Smith's Ferry, Allegheny County, Pennsylvania. (59743.)

(28) 47½° Baumé=0.7887 specific gravity, dark greenish red. From the first sandstone of the Petroleum Measures (Venango). Beck well, near Pleasantville, Venango County, Pennsylvania. (59583.)

(29) 47¾° Baumé=0.7876 specific gravity, dark greenish red. From the fourth sandstone of the Petroleum Measures; oil in sand; depth of well 14 feet; drilled 1871; torpedoed; yielded 900 barrels of oil on first day of flow. Well No. 1, farm of J. Blaney, Fairview, Butler County, Pennsylvania. (59799.)

(30) 48° Baumé=0.7865 specific gravity, black. Webb Oil Company, Taskill, Venango County, Pennsylvania. (59506.)

(31) 48¼° Baumé=0.7843 specific gravity, dark greenish. From the third sandstone of the Petroleum Measures (Venango), Cogley Field, Ashley, Clarion County, Pennsylvania. (59591.)

(32) 48½° Baumé=0.7832 specific gravity, dark amber. Oil in sand, here 16 feet in thickness; depth of well 1,025 feet; drilled 1878; torpedoed; yielded 20 barrels of oil on first day of flow. Well No. 1, Lot No. 55, Mead, Warren County, Pennsylvania. (59780.)

(33) 49° Baumé=0.7821 specific gravity, light greenish red. Oil in sand; depth of well 1,254 feet. Tiona Oil Company, Warren County, Pennsylvania. (59514.)

(34) 50° Baumé=0.7777 specific gravity, light greenish red. Oil in sand, here 50 feet in thickness. Cameron well, Smith pool, Washington County, Pennsylvania. (59589.)

(35) 50½° Baumé=0.7755 specific gravity, black. Haskell well, Wigglesworth Tract, Venango County, Pennsylvania. (59584.)

(36) 51° Baumé=0.7734 specific gravity, light greenish yellow. Oil in sand, here 50 feet in thickness. Nicholas well, Vanceville, Washington County, Pennsylvania. (59600.)

(37) 54° Baumé=0.7608 specific gravity, dark amber. Oil in sand; depth of well 2,113 feet; drilled 1885; torpedoed; yielded 15 barrels of oil on first day of flow. Gantz well No. 1, Little Washington, Washington County, Pennsylvania. (59777.)

2. EXHIBIT ILLUSTRATING VARIATION IN COLOR.

The series may be divided into two portions, beginning with a thoroughly black specimen and following through increasing amounts of green and red to a light greenish yellow in the first portion, and in the second beginning with a dark red and following through to a light straw, in which the greenish element of the color does not appear:

- (1) Black. Bear Creek, Burkesville, Cumberland County, Kentucky. (59832.)
- (2) Black, tinged with green. Mecca, Trumbull County, Ohio. (59757.)
- (3) Dark greenish. Anchor well No. 3, Glade, Warren County, Pennsylvania. (59761.)
- (4) Dark greenish red. Dale Brothers' well No. 1, Batten farm, near Rockland, Venango County, Pennsylvania. (59767.)
- (5) Dark greenish red. Kane, Armstrong County, Pennsylvania. (59752.)
- (6) Light greenish red. Gordon well, Washington, Washington County, Pennsylvania. (59526.)
- (7) Greenish yellow. Leedecker well, Butler County, Pennsylvania. (59750.)
- (8) Dark red. New Brinker well, Pleasant Valley, Westmoreland County, Pennsylvania. (59520.)
- (9) Light red. Galtz well, Washington, Washington County, Pennsylvania. (59527.)
- (10) Amber. Hess, Sacket & Eichner well No. 1, Reidsburgh, Clarion County, Pennsylvania. (59581.)
- (11) Yellow. Riggs Gas well, Moundsville, Marshall County, West Virginia. (59579.)
- (12) Light yellow. Farm of J. Somerville, near Brady's Bend, Armstrong County, Pennsylvania. (59494.)
- (13) Light straw. Holden Run, Armstrong County, Pennsylvania. (53516.)
- (14) Nearly colorless. Venezuela. (59835.)

3. EXHIBIT ILLUSTRATING GEOLOGICAL DISTRIBUTION.

The series is arranged in a generally descending order. There is a certain amount of overlapping, however, between the West Virginia and Pennsylvania series, since the oil-bearing strata in these two States have not been correlated.

- (1) From the Tertiary sandstone. Dark greenish. Pico district, Los Angeles County, California. (59552.)
- (2) From the Cretaceous formation. Dark greenish. Cañon City, Fremont County, Colorado. (59548.)

The following thirteen specimens are from the West Virginia oil field. Their location in depth is referred to the Crinoidal limestone as a datum line:

- (1) 50 feet above the Crinoidal limestone. Black; specific gravity 28° Baumé. Oil in sand; depth of well 56 feet; drilled 1859; not torpedoed; yielded 100 barrels of oil on first day of pumping. Well No. 1, Dutton farm, Aurelius, Washington County, Ohio. (59855.)
- (2) 100 feet below the Crinoidal limestone. Dark greenish. Oil in sand; depth of well 150 feet; drilled 1882; torpedoed; yielded 10 barrels of oil on first day of pumping. Farm of Frank Atkinson, Aurelius, Washington County, Ohio. (59854.)

(3) 200 feet below the Crinoidal limestone. Black. Oil in sand; depth of well 160 feet; not torpedoed. Rathbone oil tract, Burning Springs district, Wirt County, West Virginia. (59837.)

(4) 250 feet below the Crinoidal limestone. Dark greenish. Oil in sand; depth of well 350 feet. Well No. 6, farm of George Rice, Aurelius, Washington County, Ohio. (59853.)

(5) 300 feet below the Crinoidal limestone. Black. Oil in sand; depth of well 275 feet. Rathbone oil tract, Burning Springs district, Wirt County, West Virginia. (59838.)

(6) 450 feet below the Crinoidal limestone. Dark greenish. Oil in sand; depth of well 500 feet; drilled 1865; torpedoed; yielded 8 barrels of oil on first day of pumping. Well No. 1, farm of George Rice, Aurelius, Washington County, Ohio. (59852.)

(7) 650 feet below the Crinoidal limestone. Black. Oil in sand; depth of well 800 feet; not torpedoed; yielded 5 barrels of oil on first day of pumping. Newton Farm, Aurelius, Washington County, Ohio. (59850.)

(8) 820 feet below the Crinoidal limestone. Black. Oil in sand; depth of well 840 feet. Petty Farm, Burning Springs district, Wirt County, West Virginia. (59839.)

(9) 930 feet below the Crinoidal limestone. Dark greenish; specific gravity 28° Baumé. Oil in sand; depth of well 400 feet. Volcanic Coal and Oil Company, White Oak district, Ritchie County, West Virginia. (5984.)

(10) 980 feet below the Crinoidal limestone. Dark greenish; specific gravity 30° Baumé. Oil in sand; depth of well 400 feet. Volcanic Oil and Coal Company, White Oak district, Ritchie County, West Virginia. (59843.)

(11) 1,100 feet below the Crinoidal limestone. Dark greenish; specific gravity 47° Baumé. Oil in sand; depth of well 1,100 feet. Gracy lease, Burning Springs district, Wirt County, West Virginia. (59840.)

(12) 1,350 feet below the Crinoidal limestone. Amber; specific gravity 39° Baumé. Oil in sand; depth of well 1,350 feet; drilled 1880; torpedoed; yielded 18 barrels of oil on the first day of flow. Well No. 14, farm of George Rice, Aurelius, Washington County, Ohio. (59851.)

(13) 1,500 feet below the Crinoidal limestone. Dark greenish; specific gravity 50° Baumé. Oil in sand; depth of well 1,000 feet. Gale tract, White Oak district, Ritchie County, West Virginia. (59849.)

The following eleven specimens illustrate the occurrence at different depths in the Pennsylvania field:

(1) 180 feet below the Pittsburg coal bed. Light greenish red; specific gravity 34° Baumé. Bailey farm, Dunkard Creek, Greene County, Pennsylvania. (59536.)

(2) 460 feet below the Pittsburg coal bed. Greenish red; specific gravity 35° Baumé. Maple well, Dunkard, Greene County, Pennsylvania. (59577.)

(3) 650 feet below the Pittsburg coal bed. Drilled in 1885, and only a few gallons of oil were obtained; light greenish red. Clark's farm, Washington County, Pennsylvania. (59523.)

(4) "Mountain Sand" of the Petroleum Measures (Lower Carboniferous). Dark greenish red. Manifold well No. 1, Washington County, Pennsylvania. (59519.)

(5) 1,400 feet below the Pittsburg coal bed. Light greenish red. Huskill well, Mount Morris, Greene County, Pennsylvania. (59534.)

(6) From the first sandstone of the Petroleum Measures (Venango). Sand here 16 feet in thickness; oil in sand; depth of well 337 feet; drilled, 1870; torpedoed; yielded 225 barrels of oil on first day of pumping. Black; specific gravity 32° Baumé. Well No. 1, farm of J. Blakely, Sugar Creek, Venango County, Pennsylvania. (59781.)

(7) From the second sandstone of the Petroleum Measures (Venango). Sand here 38 feet in thickness; oil in sand; depth of well 583 feet; drilled 1872; torpedoed; yielded 2 barrels of oil on first day of pumping. Black; specific gravity 43° Baumé.

Well No. 3, farm of Jennings & Ralston, Jackson, Venango County, Pennsylvania. (59774.)

(8) From just above the third sandstone of the Petroleum Measures (Venango). Sand here 22 feet in thickness; oil in sand; depth of well 1,076 feet, drilled 1885; torpedoed; yielded 18 barrels of oil on first day of pumping. Dark greenish; specific gravity 49° Baumé. Well No. 5, Diamond farm, Cranberry, Venango County, Pennsylvania. (59795.)

(9) From the third sandstone of the Petroleum Measures (Venango). Sand 18 feet in thickness; oil in sand; depth of well 957 feet; drilled 1885; not torpedoed; yielded 35 barrels of oil on first day of pumping. Black; specific gravity $48\frac{1}{2}^{\circ}$ Baumé. Well No. 1, Heckerthorne farm, Cranberry, Venango County, Pennsylvania. (59815.)

(10) From the fourth sandstone of the Petroleum Measures. Dark greenish red; specific gravity $44\frac{1}{2}^{\circ}$ Baumé. Kangaroo well No. 1, East Brady, Clarion County, Pennsylvania. (59489.)

(11) From the third Bradford sand. Black. Nile Oil Company, Wert, Allegany County, New York. (59477.)

The following five specimens from various localities continue the section to the lowest point at which petroleum has been found:

(1) From the Middle Devonian formation. Black. Near Glasgow, Barren County, Kentucky. (59544.)

(2) From the Corniferous limestone. Black; specific gravity 35.5° Baumé. Crown well, Enniskillen, Province of Ontario, Canada. (59569.)

(3) From the Upper Hudson River shales (Lower Silurian). Dark greenish; specific gravity 43.5° Baumé. Well No. 2, near Glasgow, Barren County, Kentucky. (59599.)

(4) From the Hudson River group (Lower Silurian). Black; specific gravity 32° Baumé. Pioneer well, Francisville, Pulaski County, Indiana. (59575.)

(5) From the Trenton limestone. Black. Farm of Whitacre, Liberty, Wood County, Ohio. (59601.)

ASPHALTUM; MINERAL PITCH.—These are names given to what are rather indefinite admixtures of various hydrocarbons, in part oxygenated and which for the most part solid or at least highly viscous at ordinary temperatures, pass by insensible gradations into pittasphalts or mineral tar and these in turn into the petroleums. They are characterized by a black or brownish-black color, pitchy luster, and bituminous odor. The solid forms melt ordinarily at a temperature of from 90 to 100 F., and burn readily with a bright flame, giving off dense fumes of a tarry odor. The fluidal varieties become solid on exposure to the atmosphere, owing to evaporation of the more volatile portions.

The nature of the material, its mode of occurrence, and indeed the uses to which it can be put vary to such an extent with each individual occurrence that a few only of what are the most noted or best known can here be mentioned.

On the island of Trinidad is an immense superficial deposit having an area of about 114 acres and a depth varying from 18 to 78 feet. The surface is nearly level and of a brownish-black color. (See Specimens Nos. 68063, 68065, 68066, U.S.N.M.)

The deposit has in numerous publications been compared to a lake

and stated to be fluidal and at a high temperature in the center.¹ This is quite erroneous and misleading.

The crude material has the following composition and physical characteristics:²

Specific gravity. 1.28; hardness at 70° F., 2.5 to 3 of Dana's scale; color, chocolate brown; composition:

Bitumen.....	39.83
Earthy matter	33.99
Vegetable matter.....	9.31
Water	16.87
	<hr/> 100.00

In western Kentucky asphalt exudes from the ground in the form of "tar springs," and occurs also disseminated through sandstones and limestones of sub-Carboniferous age. (Specimen No. 63345, U.S.N.M.) Frequently, as in the dolomite underlying Chicago, Illinois, the bituminous matter is so diffused throughout the rock as to give it on exposure a brownish-black appearance, and cause it to exhale an odor of petroleum appreciable for some distance. (Specimen No. 62789, U.S.N.M.) In the Dead Sea bituminous masses of considerable size have in times past risen like islands to the surface of the water and furnished thus the material used by the ancients in pitching the walls of buildings and rendering vessels water-tight. The ancient name of this body of water was *Lake Asphaltites*, and from it our word asphalt is derived. These illustrations are sufficient to indicate the numerous conditions under which the substance occurs. The material is world wide in its geographic distribution and equally cosmopolitan in its geological range, being found in gneissic rocks of presumably Archæan age in Sweden, and in rocks of all intermediate horizons down to late Tertiary.

Some 10 miles east of the city of Habana, Cuba, is a deposit of asphalt described³ as occupying an irregular branching fissure in a soft clay rock, with eruptive rocks, diorites, and euphotides in the near vicinity. The asphalt, described as "Coal" in the paper referred to, lies in parallel horizontal layers of from 1 to 4 inches in thickness across the vein, the laminae being somewhat deflected near the walls as if pressed by the sides or walls. The deposit is regarded as having originated as an open fissure terminating upward in a wedge-like form and into which was subsequently injected from below the carbonaceous matter. The asphalt itself was described as of a jet-black

¹ See Mineral Resources of the United States, 1883-84, p. 937; also Dana's System of Mineralogy, 1892, p. 1018; and especially S. F. Peckham's paper on the Pitch Lake of Trinidad, American Journal of Science, July, 1895, p. 33.

² Transactions of the American Institute of Mining Engineers, XVII, 1889, p. 363.

³ London and Edinburgh Philosophical Magazine and Journal of Science, X, 1837, p. 161.

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PLAN
OF
PITCH LAKE
AND
VICINITY.

PLAN OF PITCH LAKE, TRINIDAD.
After S. F. Peckham.

color, resplendent luster, conchoidal fracture, and specific gravity varying from 1.42 to 1.97. An analysis showed 63 per cent volatile matter, 34.97 per cent carbon, and 2.03 per cent ash.

According to R. T. Hill,¹ asphaltum of unusual richness occurs beneath the waters of the Cardenas Bay of Cuba and in several other parts of the island in beds of late Cretaceous and early Eocene age. The Cardenas deposits, four in number, are of interest in that all are submerged beneath the waters of the bay. The material has been mined for the past twenty-five years by mooring a lighter over the shaft, which is from 80 to 125 feet in depth below the water surface. The material is loosened by dropping a long, pointed iron bar from the vessel, the detached blocks being loaded into a net by a naked diver and then brought to the surface. The asphalt thus obtained is stated to resemble cannel coal in appearance, though with a more brilliant luster. Only from one to one and a half tons are mined in this manner daily, the material being shipped to New York and being used in the manufacture of varnishes. The price formerly obtained varied from \$80 to \$125 a ton.

A large deposit of an inferior grade, and used mainly for roofing, is situated near Diana Key, 15 miles from the city of Cardenas, and a massive bed, some 12 feet in thickness, near Villa Clara. Material from this last source has, during years past, been used for making the illuminating gas used in the city.

Baron H. Eggers has described² the two groups of asphalt deposits near the Gulf of Maracaibo, South America (Specimen No. 51720, U.S.N.M.), which are perhaps sufficiently distinctive to merit attention. One, the El Menito deposit, is in the form of a rounded hill composed of reddish stony soil covered with scanty grass. Over its summit are scattered a number of small truncated cones about 2 feet high, with round, crater-like openings, from which the asphalt, or pitch, flows in a black, viscous stream down to the foot of the hill, where it collects and forms pools or small lakes. The outflowing asphalt is quite cold, and hardens in the course of a few days. The Mene Grande deposit is quite similar, but much larger, and has been calculated to yield some 2 tons a day. Other deposits occur in the region.

Sandstones and limestones are sometimes so impregnated with bituminous matter that they may be used as sources of the material by refining processes or for the direct manufacture of pavements by simply crushing. Such are the so-called bituminous or asphaltic sand rocks and limestones of Kentucky (Specimen No. 63345, U.S.N.M.), Texas (Specimen No. 63342, U.S.N.M.), Utah, Colorado, California, Wyoming (Specimen No. 53181, U.S.N.M.), and other States, and of

¹Cuba and Porto Rico, 1898, p. 83.

²Scottish Geographical Magazine, XIII, 1897, p. 209. An abstract of original paper in the Deutsche Geographische Blätter, XIX, Pt. 4.

Canada (Specimen No. 59927, U.S.N.M.) and Spain (Specimen No. 40011, U.S.N.M.).

According to G. H. Stone,¹ the asphaltic sandrock of western Colorado and eastern Utah consists of grains of sand which are in contact with one another, the spaces between the grains being filled with asphalt, the proportioned amount of which varies up to 15 per cent by weight, or 27 per cent by volume. The thickest stratum of fully charged rock in the region described was nearly 40 feet in thickness, though usually the strata of high-grade material are not more than 4 to 10 feet thick and alternate with others which are quite poor or barren, so that the amount of "pay rock" is often grossly exaggerated.

Shales and marls may often be so highly charged with bituminous matter as to be nearly or quite black, and even approach cannel coal in composition, though much richer in ash. Those of Colorado and Utah, according to Stone, contain but from 10 to 20 per cent of carbonaceous matter, though burning readily with a bright flame. They are of Tertiary age. Asphaltic sands and sandrocks are of common occurrence in Kern, San Luis Obispo, Santa Barbara, Santa Cruz, Ventura, and other counties in California, and in some cases are quite extensively utilized.²

In Ventura County the material is reported as occurring in the form of a fissure vein in siliceous clay, of Miocene age, the vein being from 7 to 15 inches thick on the surface, but widening rapidly in descent to a thickness of 5 feet at a depth of 65 feet (Specimens Nos. 67675, 67676, U.S.N.M.). This material is as taken from the vein far from pure asphalt, but rather an asphaltic sand. The Las Conchas Mine in Santa Barbara County consists of a body of sand soaked with maltha, embracing an area of 75 acres and estimated to be 25 feet or more in thickness. At the Pacific Asphalt Company's mine the asphalt occurs in irregular masses and veinlike bunches in soft, sandy clay, and is said to be 50 to 60 per cent pure.

On the Sisquoc Grant, 8 miles north of Los Alamos are two very large deposits, one some 10,560 feet long, 500 feet wide, and averaging 300 feet in thickness, and the other 5,000 feet long, 800 feet wide, and 100 feet thick. In Santa Cruz County there are enormous deposits of bituminous rock lying in nearly horizontal strata in the foothills facing the coast west and north of the city of Santa Cruz. The beds have been extensively eroded so that the outcrops occur in irregular, detached hillocks. At one of the open cut mines the materials lie as follows:

	Feet.
Light-colored shales	60
Massive bituminous rock	30
Very soft sandstone	8
Massive bituminous rock	12

¹ American Journal of Science, XLII, 1891, p. 148.

² See Thirteenth Annual Report State Mineralogist of California, 1894.

These underlaid by soft sands and shales. The analyses given below are of interest as showing percentage of bituminous matter in samples from various localities.

San Luis Obispo Bituminous Rock Company's mine.

Sand	6.83
Clay	3.36
Lime	2.81
Asphaltum	87.00

Waldorf Mine, Santa Barbara County.

Bitumen	76.2
Moisture	1.8
Mineral residue	22.0
	<hr/>
	100.0

Punta Gorda Mine, Ventura County.

Bitumen	28.53
Silica	51.64
Clay	4.76
Sulphate of lime	2.45
Carbonate of lime	11.96
Carbonate of magnesia .....	.55
	<hr/>
	99.89

Uses.—The uses of the common type of material such as is known simply as asphalt are quite varied. The walls of Babylon are stated to have been cemented with it, and doubtless it was so used in other ancient cities. It was also, as at present, used for making vessels water-tight. At the present day the refined asphalts are used, according to F. V. Greene,¹ as a varnish or paint, as an insulating material, for waterproofing, as a cement in ordinary construction, and as a cement in roofing and paving compounds. For these purposes it is first tempered with some form of oil, the kind and amount used depending on the purposes to which it is to be applied. A mixture of asphalt and sand forms the ordinary concrete for sidewalks and basement floors. The most extensive use of asphaltic compounds is at present for street pavements, the material for this purpose being mixed with fine sand and sometimes powdered limestone. The asphaltic sands, sandstones, and limestones are sometimes so evenly impregnated with bituminous matter that they may be crushed and applied directly to the roadbed. The uses to which are put the higher grades of asphaltic compounds, such as are designated by special names, are given further on.

MANJAK.—The local name of *manjak* is applied to a variety of bitumen somewhat resembling uintaite, occurring on the island of Barbados,

¹ Asphalt and its Uses, Transactions of the American Institute of Mining Engineers, XVII, 1889, p. 335.

in the West Indies. The material is described¹ as a very pure hydrocarbon of a black color, high luster, and with a bright conchoidal fracture. It is brittle, and so friable that it can be ground to powder between the thumb and fingers. (Specimen No. 53539, U.S.N.M.) It occurs in seams or veins, varying from one-fourth of an inch to 30 feet in thickness, cutting the country rock, which is an argillite or shale, at all angles with the horizon and with a general NNE strike. In places the bituminous matter has saturated the entire rock in the neighborhood of the veins, producing a shale from which as much as 37 gallons a ton of petroleum has been obtained by destructive distillation. Thus far the greatest development is along a vein 200 feet in length, 100 feet in depth, and from 8 to 9 feet in width. One vein, which has been explored to a depth of 200 feet, is stated to have dwindled down to a width of 6 feet, though 30 feet wide at the surface.

Uses.—Like gilsonite, the material is used for making varnishes, insulating electric wires, etc., bringing the price of this mineral, from \$5 to \$10 a ton, according to quality and freedom from impurities.

ELATERITE; MINERAL CAOUTCHOUC.—This is the name given to a soft and elastic variety of bitumen much resembling pure india rubber. It is easily compressible in the fingers, to which it adheres slightly, of a brownish color, and of a specific gravity varying from 0.905 to 1.00. It has been described from mines in Derbyshire and elsewhere in England (Specimens Nos. 63848, 68001, U.S.N.M.), but so far as the writer is aware is of no commercial value. Its composition, so far as determined, is carbon 85.47 per cent, hydrogen 13.28 per cent.

WURTZILLITE.—The name *wurtzillite* has been given by Prof. W. P. Blake to a hydrocarbon very similar in appearance to the uintaite (described on page 450), but differing in physical and chemical properties. It is described as a fine black solid, amorphous in structure, brittle when cold, breaking with a conchoidal fracture, but when warm tough and elastic, its elasticity being best compared with that of mica. If bent too quickly it snaps like glass. It cuts like horn, has a hardness between 2 and 3, a specific gravity of 1.03, gives a brown streak, and in very thin flakes, shows a garnet-red color. It does not fuse or melt in boiling water, but becomes softer and more elastic; in the flame of a candle it melts and takes fire, burning with a bright luminous flame, giving off gas and a strong bituminous odor. It is not soluble in alcohol, and but sparingly so in ether, in both of which respects it differs from elaterite. In the United States it occurs near Scofield, Carbon County, and in the Uinta Mountains of Wasatch County, Utah (Specimens Nos. 53356, 67265, 67860, U.S.N.M.).

ALBERTITE.—This is a brilliant jet black bitumen compound breaking with a lustrous, conchoidal fracture, having a hardness of between

¹W. Merivale, Engineering and Mining Journal, LXVI, 1898, p. 790; also the Mineral Industry, VI, 1897, p. 54.

1 and 2 of Dana's scale, a specific gravity of 1.097, black streak, and showing a brown color or very thin edge. In the flame of a lamp it shows signs of incipient fusion, intumescs somewhat and emits jets of gas, giving off a bituminous odor; when rubbed it becomes electric. According to Dana it softens slightly in boiling water, is only a trace soluble in alcohol, 4 per cent in ether, and some 3 per cent soluble in turpentine. The following is the composition as given by Wetherill: Carbon, 86.04 per cent; hydrogen, 8.96 per cent; oxygen, 1.977 per cent; nitrogen, 2.93 per cent; ash, 0.10 per cent.

Dr. Antisell made the following comparative tests to show the relative richness of the material in volatile matter:

Constituents.	Cannel coal.	South American asphalt.	Lake asphalt.	Albertite.
Volatile matter.....	50.52	70.15	71.67	59.88
Coke.....	47.69	29.85	28.04	39.59
Ash.....	1.79	.....	0.29	0.53
Total.....	100.00	100.00	100.00	100.00

The mineral is described by C. H. Hitchcock¹ as occurring in "true cutting veins" in shale of Lower Carboniferous age in Hillsborough County, New Brunswick. The shales themselves contain a large amount of carbonaceous matter and by distillation have been made to yield 30 gallons to the ton of refined illuminating oil. They contain immense numbers of fossil fish and are mostly inflammable. The veins vary from a fraction of an inch to 12 feet in width with a general N. 65° east course, sometimes vertical and sometimes inclined north-westward from 75° to 80°. They enlarge and contract very irregularly, but in general increase in thickness as followed downward. Hitchcock regards the veins as having been filled by the injection of the material in a liquid state and being subsequently indurated.

Uses.—This vein seems to have been discovered about 1840 by Dr. Abraham Gesner who, in 1850 took out a patent in the United States for the manufacture of illuminating gas from this and other asphalts.² A company was organized and for some years active mining operations were carried on, but have been discontinued since the discovery of petroleum. (Specimens Nos. 59935, 66701, U.S.N.M.)

GRAHAMITE.—Grahamite is a hydrocarbon compound closely related to albertite, but differing physically in having a duller luster and more cokelike aspect. It has been described by Dr. Henry Wurtz as occur-

¹American Journal of Science, XXXIX, 1865, p. 267; see also Dawson's *Acadian Geology*, 3d ed., pp. 231-241.

²Review of reports on the Geological Relations, etc., of the coal of the Albert Coal Mining Company, situated in Hillsborough, Albert County, New Brunswick, as written and compiled by Charles T. Jackson, M. D., a Fellow of the Geological Society of London, etc., New York, 1852.

ring in shrinkage fissures whose course is N. 76° to 80° E. in Carboniferous shales and sandstones, on a branch of Hughes River, Ritchie County, West Virginia. It is completely soluble in chloroform and carbon disulphide, nearly so in turpentine, and partially so in naphtha and benzine, but not at all in alcohol. Melts somewhat imperfectly, beginning to smoke and soften like coking coal at a temperature of about 400° F. (Specimen No. 59924, U.S.N.M.)

As occurring in the vein the material shows four distinct, though somewhat irregular, divisional planes, having a general parallelism with the walls. Next to the walls the structure of the mineral is coarsely granular, with an irregularly cuboidal jointed cleavage, very lustrous on the cleavage surfaces, that in immediate contact with the walls usually adhering thereto very tenaciously, as if fused fast to the granular sandstone. (Specimen No. 59941, U.S.N.M. A "horse" or fragment of sandstone from the vein, showing adhering grahamite.)

Next to these two outside layers, which are very irregular and from 2 to 3 inches or more in thickness, is found, on each side of the vein, a layer averaging from 15 to 16 inches in thickness, which is composed of a variety highly columnar in structure and very lustrous in fracture, the columns being long and at this place at right angles to the walls. Finally, in the center of the vein, varying in thickness, but averaging about 18 inches, is a mass differing greatly in aspect from the rest, being more compact and massive, much less lustrous in fracture, and with the columnar structure much less developed, in places not at all. The fracture and luster of this portion of the vein are clearly resinoid in character.

The general aspect of the mass, as well as all the results of a minute examination of the accompanying phenomena, lead irresistibly to the conclusion that we have here a fissure which has been filled by an exudation, in a pasty condition, of a resinoid substance derived from or formed by some metamorphosis of unknown fossil matter contained in deep-seated strata intersected by the fissure or dike.

The density of a mass of the mineral was found to be 1.145. The horizontal extent of visible outcrop actually measured by me was 530 fathoms, thinned out at east end to 30 inches and at west end to 8 inches; but as these points were at least 70 to 80 fathoms vertically higher than the bottom of the ravine, the width (averaging about 50 inches) at the latter depth points to a rapid widening of the fissure in descent.¹

J. P. Kimball has described² a deposit of similar material on the west bank of the Capadero River in the Huasteca, Vera Cruz, Mexico. The country rock is a fossiliferous Tertiary shale overlaid by conglomerate.

The grahamite occurs in a fissure some 34 inches in thickness terminating in an "overflow" some $6\frac{1}{2}$ feet in maximum thickness, thinning away at the edges, but the full extent of which was not determined. The evidence showed that the fissure had been filled by material oozing up from below and spreading out upon the surface prior to the deposition of the overlying gravel. The strike

¹ Proceedings of the American Association for the Advancement of Science, XVIII, 1869, pp. 125-128.

² American Journal of Science. XII, 1876, p. 277.

of the fissure was nearly north and south, and at the time of making the report noted (1876) it had been developed to a distance of some 300 feet. The material is described as more uniformly lustrous than that from Ritchie County, and of a greater coherence, though none the less distinctly cleaved and jointed. An analysis of a sample from the Cristo mine, as given, yielded results as follows:

Specific gravity	1.156
Volatile matter:	
Illuminating gas	63.32
Sulphur	0.46
Water	0.36
	<hr/> 64.14 <hr/>
Coke:	
Fixed carbon	31.63
Sulphur	0.37
Ash	5.86
	<hr/> 37.86 <hr/>
	100.00

CARBONITE OR NATURAL COKE is the name given to a peculiar hydrocarbon compound occurring in the form of beds like bituminous coal, in Chesterfield County, Virginia, and having a dull black and, for the most part, lusterless aspect, somewhat resembling coke. (Specimens Nos. 63499, 63500, U.S.N.M.)

An analysis by Wurtz¹ yielded the following:

	Per cent.
Coke	84.57
Volatile combustible matter.....	15.43

Other analyses by Dr. T. M. Drown² on two portions, the one dull and lusterless and the other lustrous, yielded:

Constituents.	Dull portion.	Lustrous portion.
Specific gravity.....	1.375	1.350
Loss at 100° C.....	2.00	0.69
Volatile matter.....	15.47	11.10
Ash.....	3.20	6.68
Fixed carbon.....	79.33	81.53
	<hr/> 100.00 <hr/>	<hr/> 100.00 <hr/>
Sulphur	4.08	1.60

Occurrence.—The material occurs interbedded with shales much like ordinary bituminous coal, there being, according to Raymond, three distinct beds varying from 1 foot 9 inches to 9 feet in thickness, inter-

¹ Transactions of the American Institute of Mining Engineers, III, 1875, p. 456.

² Idem, XI, 1883, p. 448.

stratified with the shales, the lowermost bed of 9 feet thickness being underlaid by fire clay. The origin of the material is in doubt, the earlier writers regarding it as a bituminous coal coked by the heat of intrusive rocks. Later writers throw doubt upon this by stating that there are in the vicinity no intrusives of such size as to warrant any such assumption.

Uses.—The material is said to burn without smoke or soot, like anthracite, and to have been used for domestic purposes.

UINTAITE; GILSONITE. This is a black, brilliant, and lustrous variety of bitumen, giving a dark-brown streak, breaking with a beautiful conchoidal fracture, and having a hardness of 2 to 2.5 and a specific gravity of 1.065 to 1.07. It fuses readily in the flame of a candle, is plastic, but not sticky while warm, and unless highly heated will not adhere to cold paper. Its deportment is stated to be much like that of sealing wax or shellac. Like albertite and grahamite it dissolves in turpentine and is not soluble in alcohol. It is a good nonconductor of electricity, but like albertite becomes electric by friction. Its composition as given is: Carbon, 80.88 per cent; hydrogen, 9.76 per cent; nitrogen, 3.30 per cent; oxygen, 6.05 per cent, and ash, 0.01 per cent. Specimens Nos. 62379, 53355, U.S.N.M., are characteristic.

Occurrence.—According to George H. Eldridge¹ the gilsonite deposits of Utah occur filling a series of essentially vertical fissures in Tertiary sandstones lying within the Uncompahgre Indian Reservation, or in its immediate vicinity. The fissures have smooth, regular walls and vary in width the sixteenth of an inch to 18 feet, and in length from a few hundred yards to 8 or 10 miles.

The larger veins are somewhat scattered, one lying about $3\frac{1}{2}$ miles east of Fort Duchesne, a second in the region of the Upper Evacuation Creek, and the three others of most importance in the vicinity of the White River and the Colorado-Utah line. Besides these there is a 14-inch vein crossing the western boundary of the reservation near the fortieth parallel; another about equal size about 6 miles southeast of the junction of the Green and White rivers; a third in the gulch $\frac{1}{4}$ or $\frac{1}{2}$ miles north of Ouray Agency, west of the Duchesne River, and a number from one-sixteenth of an inch to a foot in thickness in an area about 10 miles wide, extending from Willow Creek eastward for 25 miles along both sides of the Green and White rivers. The veins are sometimes slightly faulted, and often pinch out to mere feather edges. The filling material is quite structureless excepting where, as near the surface, it has been exposed to the atmospheric influences, where it shows a fine pencillate or columnar structure at right angles to the walls. The walls of the veins themselves are impregnated with the gilsonite for a distance of several inches, but all indications point

¹Seventeenth Annual Report U. S. Geological Survey, 1895-96, Pt. I, p. 915.

to their having been filled, not by lateral impregnation, but by injection from below.

The mining of gilsonite is conducted in the ordinary manner by means of shafts and tunnels. The work is, however, attended with considerable difficulty and some danger, owing to the fine dust arising from it. This penetrates the skin and lungs and is a source of great annoyance, and moreover becomes highly explosive when mixed with atmospheric air.

Uses.—The principal use of gilsonite thus far has been in the manufacture of varnishes for ironwork and baking japans. It is not well adapted for coach varnishes. It has been also used for mixing with asphaltic limestone for paving material. Other possible uses suggested by Mr. E. W. Parker, in the *Mineral Resources of the United States* for 1893, are as below: For preventing electrolytic action on iron plates of ship bottoms; for coating barbed-wire fencing, etc.; for coating sea walls of brick or masonry; for covering paving brick; for acid-proof lining for chemical tanks; for roofing pitch; for insulating electric wires; for smokestack paint; for lubricants for heavy machinery; for preserving iron pipes from corrosion and acids; for coating poles, posts, and ties; for torredo-proof pile coating; for covering wood-block paving; as a substitute for rubber in the manufacture of cotton garden hose; as a binder pitch for culm in making brickette and eggette coal.

3. OZOKERITE; MINERAL WAX; NATIVE PARAFFIN.

This is a wax-like hydrocarbon, usually with a foliated structure, soft and easily indented with the thumb nail; of a yellow brown or sometimes greenish color, translucent when pure, with a greasy feeling, and fusing at 56° to 63° ; specific gravity, 0.955. It is essentially a natural paraffin. The name is derived from two Greek words, signifying to smell, and wax. Below is given the composition of (I) samples from Utah and (II) from Boryslaw, in Galicia.

Constituents.	I.	II.
Carbon	85.47	85.78
Hydrogen	14.57	14.29
Total	100.04	100.07

The substance is completely soluble in boiling ether, carbon disulphides, or benzine, and partially so in alcohol.

The following, from a paper by Boverton Redwood,¹ will serve to show the varying characters of the material from the various reported sources.

¹Journal of the Society of Chemical Industry, XI, 1892, p. 114.

Colorado.—Dull black, hard, and pulverizable; melting point, 76° C.
 Yields on distillation:

	Percentage (by difference).
Paraffin and oil	90.00
Loss in gas	2.12
Loss in water	2.60
Residue	5.28
	<hr/> 100.00

It commences to distill at 360° C., when nearly 3 per cent of oil setting at 30° C. comes over. At a much higher temperature it distills steadily and furnishes a product suitable for use as a source of paraffin.

Baku.—Specific gravity, 0.903; melting point, 76° C.:

Paraffin mass	81.80
Gas	13.80
Coke	4.40
	<hr/> 100.00

Persia.—Dark green, rather hard; specific gravity, 0.925:

Light oil, 0.740 to 0.780	2.35
Light oil, 0.800 to 0.820	3.50
Oil, 0.880	16.63
Paraffin	53.55
Coke	16.73
Loss	7.24
	<hr/> 100.00

England (Urpeth, near Newcastle).—Soft and sticky, brownish.
 Specific gravity, 0.890; melting point, 60° to 70° C.:

Light oil, boiling point 80° to 120° C	3.00
Light oil, boiling point 150° to 200° C	7.50
Lubricating oil, boiling point 200° to 250° C	7.80
Paraffin	64.95
Coke	11.15
Gas, loss	5.60
	<hr/> 100.00

Boryslaw.—Specific gravity, 0.930—I, dark yellow; II, dark brownish black:

Constituents.	I.	II.
Benzine, 0.710 to 0.750	4.32	3.50
Kerosene, 0.780 to 0.820	25.65	27.83
Lubricating oil, 0.895	7.64	6.95
Paraffin, etc	56.54	52.27
Coke	2.85	4.63
Loss	3.00	4.82
	<hr/> 100.00	<hr/> 100.00

Olive-green, rather hard; specific gravity, 0.9236; melting point, 60.5° C.:

Light oil, boiling point up to 150° C.....	6.25
Heavy oil, with paraffin, 150° to 300° C ...	35.10
Paraffin, etc., over 300° C	49.73
Residue in retort, and loss	8.92
	<hr/> 100.00

Occurrences.—Ozokerite occurs in the United States in Emery and Uinta counties, Utah, where, in the form of small veins in Tertiary rocks, it extends over a wide area (Specimens Nos. 59984, 62805, and 63203, U.S.N.M.). It is also found in Galicia, Austria, in Miocene deposits (Specimens Nos. 66077, 66079, 66080, 66083, 66084, 66086, and 66860, U.S.N.M.); in Roumania, Hungary, Russia, and other Asiatic and European localities. As a rule, the deposits are in beds of Tertiary or Cretaceous age. The Galician deposits are the most noted of the above. According to Redwood it is difficult to say whether ozokerite is peculiar to any particular geological formation. Regarding it as a derivative of petroleum with a high melting point, Rateau points out that it would not be reasonable to expect that it would be confined to any one formation, and in fact it is found in many, though chiefly in the Tertiary and Cretaceous. The Boryslaw, Dwiniacz, and Starunia deposits are in Miocene, but ozokerite has been met with in the shales of Teschen, as well as in Neocomian and other formations elsewhere. The Kouban deposits are on the borders of the Lower Tertiary and Upper Cretaceous. In Teheleken it is found accompanying petroleum in pockets in beds of sand above the clay shales and muschelkalk of the Aralo-Carpathian formation. In southern Utah and Arizona it occurs in Tertiary rock, probably Miocene.

The soil of the valley in which Boryslaw lies is a bed of diluvial deposit some meters in thickness. In sinking a shaft, first yellow clay, then rounded flints and gravel, and then plastic clay are met with. Below this sandstone and blue shale, much disturbed, alternate, and it is in these beds, which have a thickness of some 200 meters, that the ozokerite is found. The ozokerite-bearing formation lies on a basis of petroliferous menilite shale, the strata of which, as they approach the surface, are disposed almost vertically, but inclined toward the south. The strata are composed of layers of coarse-grained sandstone, green marl, fine-grained sandstone with veins of calcite, dark shale alternating with gray sandy shale, imperceptibly merging into the main beds of the nonpetroliferous sandstone and shale. Below these are the Carpathian sandstones of the lower Eocene (nummulitic sandstone) and upper Cretaceous formations.

The geological conditions prevailing at Dwiniacz and Starunia are similar to those at Boryslaw, but the ozokerite is more largely mixed with petroleum. The soil is gray and red diluvial clay, below which

is a bed of gravel, lying on the Miocene formation, in which the ozokerite and petroleum occur in association with native sulphur, iron pyrites, and zinc blende. Still lower a highly porous calcareous rock is met with, containing cavities filled with petroleum and sulphureted water, and below this again is a marl with gypsum and the salt-clay formation destitute of petroleum.

The ozokerite occurs in the form of veins of a thickness ranging from a few millimeters to some feet, and is accompanied with more or less petroleum and gaseous hydrocarbons. It fills the many fissures with which the disturbed shales and Miocene sandstone abound, and frequently forms thus a kind of network. The Boryslaw deposit extends over a pear-shaped area, the axis of which lies E. 30° S. The upper layers of the richest portion of the deposit occupy an area of about 21 hectares, with a length of 1,000 meters and a maximum breadth of 350 meters, but outside this there is an outer zone of less productive territory which increases the total superficies to about 60 hectares, with dimensions of 1,500 meters by 560 meters. The deposit narrows considerably as the depth increases, and at a distance of 100 meters from the surface of the ground has a breadth of only 200 meters.

Uses.—The ozokerite, after being freed so far as possible from impurities, is melted and cast into loaves or blocks of the form of a truncated cone, and weighing about 50 to 60 kilos. There are two or three recognized commercial qualities of the melted and cast ozokerite. The first quality is transparent in thin sheets and its color ranges from yellow to greenish brown. Adulteration by means of crude petroleum, heavy oils, the residues from refineries, asphaltum, and even earthy matter, are not unknown, and occasionally by a process of double casting the exterior of the block is made to differ in quality from the interior.

The refined material is known as *ceresin* (Specimen No. 63204, U.S.N.M.). It is used for candles, an adulterant or a complete substitute for beeswax, in the manufacture of ointments and pomades. A residual product from the purifying process, of a hard waxy nature, is combined with india rubber and used as an insulating material for electrical cables. In this form it is known as *okanite*. A ball blacking, used on the heels of shoes, is also manufactured from it. (See Specimens Nos. 63204, 62235, 62236, 66076, U.S.N.M.)

The names *scheererite*, *hatchettite*, *fichtelite*, and *könite* are applied to simple hydrocarbons closely allied to ozokerite found in beds of peat and coal, but, so far as the writer is aware, never in such abundance as to be of commercial value.

The name *torbanite* or *kerosene shale* has been given to a dense coal-black substance appearing and breaking much like cannel coal, and which occurs in irregular, isolated, circumscribed, and lenticular deposits near the base of the carboniferous beds of New South Wales, Aus-

tralia, and near Bathgate in Linlithgowshire, Scotland. The better varieties contain from 70 to 80 per cent of volatile hydrocarbon, 6 to 8 per cent of fixed carbon, 7 to 20 per cent of ash, with a little sulphur and water. The material is used mainly for gas and oil making by distillation, the best qualities yielding from 150 to 160 gallons of crude oil to the ton and about 20,000 feet of gas of 48-candle intensity.¹ (Specimen No. 12786, U.S.N.M.)

4. RESINS.

SUCCINITE; AMBER. The mineral commonly known as amber is a fossil resin consisting of some 78.94 parts of carbon, 10.53 parts of oxygen, and 10.53 parts of hydrogen, together with usually from two to four tenths of a per cent of sulphur. It is not a simple resin, but a compound of four or more hydrocarbons. According to Berzelius, as quoted by Dana, it "consists mainly (85 to 90 per cent) of a resin which resists all solvents, along with two other resins soluble in alcohol and ether, an oil, and $2\frac{1}{2}$ to 6 per cent of succinic acid.

The mineral as found is of a yellow, brownish, or reddish color, frequently clouded, translucent or even transparent, tasteless, becomes negatively electrified by friction, has a hardness of 2 to 2.5, a specific gravity when free from inclosures of 1.096, a conchoidal fracture, and melts at 250° to 500° F. without previous swelling, but boils quietly, giving off dense white fumes with an aromatic odor and very irritating effect on the respiratory organs.

As above noted, amber is a fossil resin or pitch, an exudation product principally of the *Pinus succinifer*, a now extinct variety of pine which lived during the Tertiary period.

Occurrence.—Amber or closely related compounds has been found in varying amounts at numerous widely separated localities, but always under conditions closely resembling one another. The better known localities are the Prussian coast of the Baltic; on the coast of Norfolk, Essex, and Suffolk, England; the coasts of Sweden, Denmark, and the Russian Baltic provinces; in Galicia, Westphalia, Poland, Moravia, Norway, Switzerland, France, Upper Burma, Sicily (Specimen No. 61140, U.S.N.M.), Mexico, the United States at Martha's Vineyard and near Trenton and Camden, New Jersey.

The substance occurs in irregular masses, usually of small size. One of the largest masses on record weighed 18 pounds. This is now in the Berlin Museum. A mass found in the marl pits near Harrisonburg, New Jersey, weighed 64 ounces. This last is presumably not true amber, since it contained no succinic acid, which is now regarded as the essential constituent.

The amber of commerce comes now, as for the past two thousand

¹ Minerals of New South Wales, by A. Liversidge, p. 145.

years, mainly from the Baltic, where it occurs in a strata of lignite-bearing sands of Lower Oligocene age. According to Berendt¹ these are two amber-bearing strata, the one carrying the amber in nests and both underlaid and overlaid by clayey seams, and the second and lower a glauconitic sand commonly known as the blue earth. The material is mined by open cuts where the strata come to the surface; by means of shafts and tunnels, as in coal mining; and by dredging or diving, in the latter case the material having been derived originally from the amber-bearing strata and redeposited on the present sea bottom.²

The pieces obtained vary from the size of a pea to that of the hand. The annual product at present amounts to some 300,000 pounds, valued at about \$1,000,000. The price of the material varies greatly with the size and purity of the pieces. Pieces of one-fourth pound weight bring about \$15 a pound, while the small granules will not bring one-twentieth that amount. The value of the material is often lessened by the presence of flaws and impurities, or inclosures, such as insects and twigs of plants. (Specimens Nos. 53056, 61140, 66812, 67748, U.S.N.M.)

Uses.—Amber is used mainly in jewelry, in small ornamentations, and smokers' goods, the smaller pieces being used in making varnish. The clear pieces and chippings have of late been compressed by a newly discovered process into tablets some 6 by 3 by 1 inches in size, which can be utilized in the manufacture of articles for smokers' use.

RETINITE.—The name retinite is used by Dana to include a considerable series of fossil resins allied to amber, differing mainly in containing no succinic acid. They occur in beds of brown coal of Tertiary and Cretaceous age, much as does the amber proper. The principal varieties that have thus far proven of any economic importance are noted below:

CHEMAWINITE.—This is the name given by Professor Harrington³ to an amber-like resin found associated with woody débris on the south east shore of Cedar Lake in Canada (Specimen No. 62602, U.S.N.M.). The material occurs in granular form and in small sizes only, such as are quite unsuited for manufacturing purposes. The true gum-bearing stratum, if such exists, has not yet been discovered, the material thus far found being washed up by waves on the beach. According to O. J. Klotz⁴ the beach matter resembles the refuse of a sawmill, no stones and very little sand being associated with the débris, which is everywhere underlaid by clay. The principal beach was estimated to contain some 700 tons of granular material.

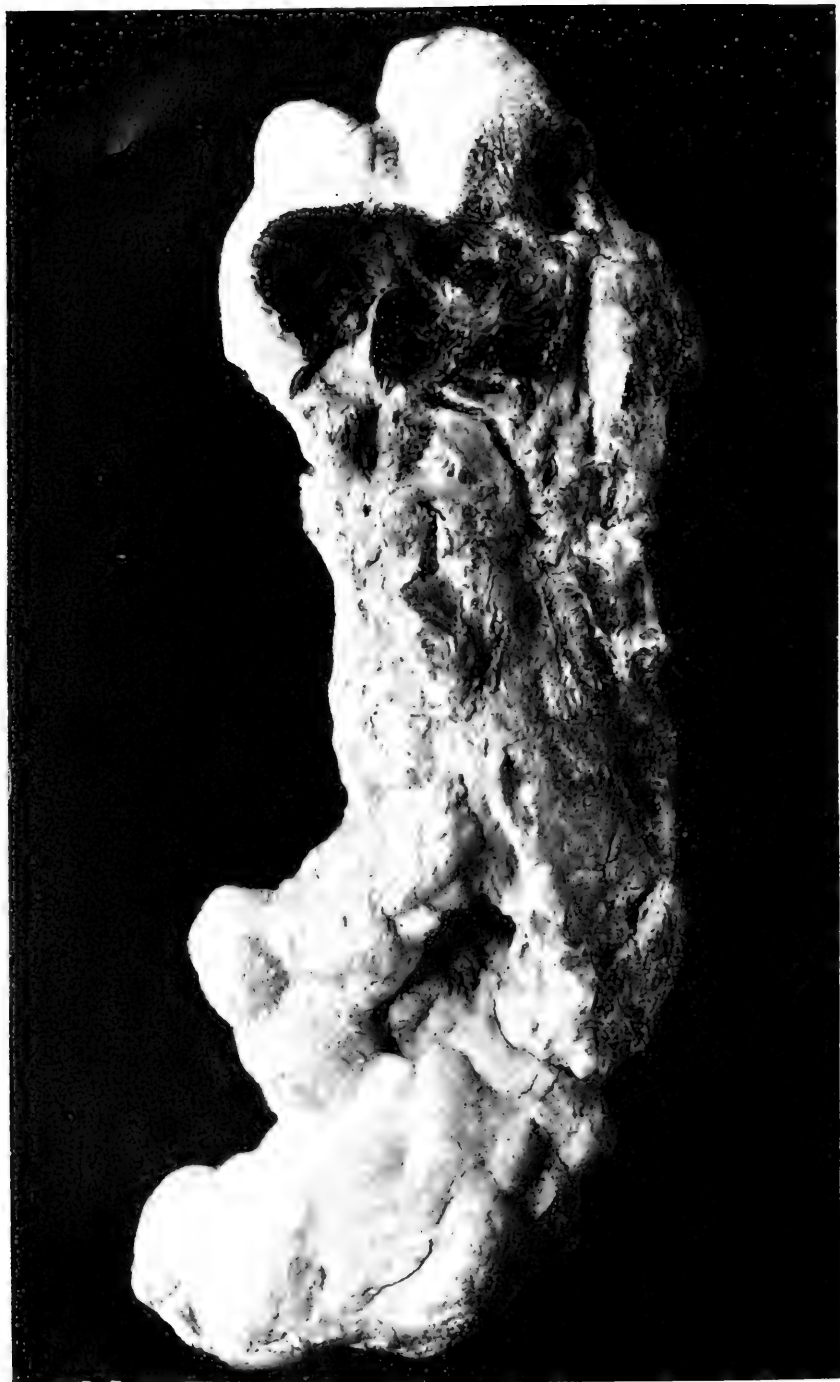
A somewhat similar resin is found in the lignite and soft greenish

¹Schriften der Physikalisch-ökonomischen Gesellschaft, VII, 1866.

²According to the Engineering and Mining Journal of May 20, 1893, the dredging process on the Baltic coast has been discontinued as no longer profitable.

³American Journal of Science, XLII, 1891, p. 332.

⁴American Jeweler, No. 2, XII, 1892.



NODULE OF GUM COPAL FROM CONGO RIVER REGION, AFRICA.

Weight, 4 pounds.

Specimen No. 651, U. S. N. M.

sandstone near Kuji, Japan.¹ It is reported as being of inferior quality, opaque, cloudy, and much fissured. It is, however, mined and shipped to Tokio, where it is presumably worked up into small ornaments.

The so-called Burmese amber, or *Burmite* from the Hukong Valley, is reported as occurring in a soft blue clay, probably of Lower Miocene age, and in lumps not exceeding the size of a man's hand.

GUM COPAL.—The name copal or gum copal is made to cover, commercially, a somewhat variable series of resins more or less fossilized and found for the most part buried in the sands in tropical and sub-tropical regions. They are in general amber-like or resin-like in appearance, of a hardness inferior to that of true amber, of a light yellow to brown color, brilliant glass-like luster, transparent to translucent, and have a conchoidal fracture. When cold they are brittle and can be readily crushed to powder, but possess a slight amount of elasticity. When rubbed on cloth they become electric and emit a peculiar resinous odor. The specific gravity varies from 1 to 1.10. When heated the material softens, swells up, and bubbles, finally melting, remaining liquid until carbonized. It burns with a yellow smoky flame; is partially soluble in alcohol, wholly so in ether, and also in turpentine on prolonged digestion. The so-called Kauri gum is a light amber-colored variety from the *Dammara Australis*, a living coniferous tree of New Zealand (Specimens Nos. 62468, 62469, U.S.N.M.). The principal source is the northern portion of the Auckland provincial district which has exported since 1863 (and up to 1897) some 134,630 tons of gum valued at £5,394,687, the product for 1890 being 7,438 tons valued at £378,563.

The gum-digging industry is one that gives employment to both Europeans and natives.² The gum is found but a short distance below the surface and is dug with the aid of a few implements, the entire outfit often consisting of a steel prod, a spade, and knife and haversack. With the copal is often found the more amber-like resin *ambrite*, which has a slightly greater hardness (2), a specific gravity of 1.034, a yellowish gray to reddish color and which yields on analysis carbon, 76.88; hydrogen, 10.54 per cent, and oxygen, 12.77 per cent. It becomes strongly electric by friction and is insoluble in alcohol, ether, chloroform, benzine, or turpentine and burns with yellow, smoking flame. Quite similar to the kauri gum is the copal of the African coasts. According to Dr. F. Welwitsch³ gum of the west coast and probably all the gum resin exported under this name from tropical Africa is to be regarded as a "fossil resin produced by trees which,

¹Transactions of the American Institute of Mining Engineers, V, 1876, p. 265.

²Report of the Mining Industry of New Zealand for 1888. In the report for 1887 it is stated that "according to the last census" the number of persons employed in the occupation of gum digging was 1,283.

³Journal of the Linnaean Society of London, Botany, IX, 1866, p. 287.

in periods long since past, adorned the forests of that continent, but which are at present either totally extinct or exist only in a dwarfed posterity." The gum, which is called by the Bunda negroes Ocate Cocoto, or Mucocoto, is found in the hilly or mountainous districts all along the coast of Angola, including the districts of Congo and Benguella, and is brought by the natives to the different market places on the coast of Angola, including the districts of Congo and Benguella. The larger quantities of the resin are mostly found in the sandy soil and it is apparently limited in its geographical distribution with that of the tree *Adansonia digitata*, the lands in the Government of Benguella extending along the mountain terrace of Amboin, Selles, and Mucobale, south of the Cuanza River being most productive, having yielded between 1850 and 1860 some 1,600,000 pounds of gum a year.

It is a general and widely spread opinion [writes Welwitsch] that the gum copal in Angola is gathered from trees; but this, according to my own observation, is obviously erroneous; for the gum copal is either dug out of the loose strata of sand, marl, or clay, or else it is found in isolated pieces washed out and brought to the surface of the soil by heavy rainfalls, earth-falls, or gales; and such pieces, where found, induce the negroes to dig for larger quantities in the adjacent spots. This digging after larger quantities is, as may be supposed, often very successful; but sometimes it is less satisfactory, or totally without result, just in the same manner as with people digging for gold. At times numerous larger and smaller pieces of copal are found close to the surface of the sand, or within the depth of a few feet; while in other places, after digging to the depth of 5 to 8 or even 10 or more feet, only single pieces, or sometimes none at all, are brought to light. As soon as a negro has discovered in any spot one or more pieces of copal, he hastens to his relations and to his commercial friends, telling them of his fortunate treasure-trove, showing what he has found, and concludes with them a kind of treaty of partnership whereby he becomes entitled to the larger share in the probable gains. The members of this partnership then provide themselves with digging implements, including large sacks, mostly made of the bark of the *Adansonia* or *Raphia* leaves, and they then proceed to the indicated spot to commence researches. As is natural, such a spot and its neighborhood are not left until the diggers have convinced themselves that they have completely exhausted the district, or that no more gum copal is to be found beyond the first indicating pieces. In the latter case it is supposed that the first pieces met with were washed down from afar, and further researches are then made accordingly.

If, after prolonged researches in the same district, no more gum copal is found, the diggers leave that place; the secured resin is cleaned by washing and packed in sacks, to be ready for sale in the markets on the coast. Different varieties of unequal value being often obtained on the same spot, the resin, when brought to market, has to be sorted before being sold. It is classified mostly according to its color; and the price is determined by weight. The deep-colored quality is generally worth double the price of the lighter sort. The shape in which the gum is found is quite variable; it often has the form of an egg, a ball, or a drop, at other times it looks like a flat, pressed cake, and it is also met with in sharp-canted pieces. The pieces vary as much in size as in shape; they are rarely larger than a hen's egg, and there are many much smaller, others (which, however, seldom occur) are as big as a man's fist, or even a child's head, weighing 3 to 4 pounds and more. All the pieces of different shape and size have one common characteristic, namely, that on their sur-

face they are covered with a thinner or thicker close-sticking whitish, nearly chalky crust, which exhibits on many pieces veins or network, while in most instances it covers the surface like an earthy powdery coat. The surface of fresh-broken pieces appears conchoidal, with finely radiating lines in each conchoidal impression. The luster is glossy, the mass is hard and transparent to a certain depth, and where scratched with a knife or needle it leaves a white powdered stroke. It can easily be scraped with a knife into powder which, if sprinkled over red-hot coals, changes instantaneously into thick vapors, at first with a slight yellow color, with a strong aromatic smell, somewhat similar to that of incense. Large pieces brought into contact with a light soon burn up, developing at the same time the above-mentioned vapors. When chewed it crackles between the teeth without leaving a noticeable taste.

The fact that there is often seen, even on the canted broken sides of many pieces, the same hard, whitish, earthy crust which covers the other unbroken surface of the same piece, tends to prove that after their falling off the mother tree they were forcibly transported from their original spot by floods or earth falls, by which they were broken before they came into the marl or sandy plains in which they are now found. At times the crust just alluded to is very hard, of considerable thickness, and with a glossy polish, which leads to the supposition that pieces in which it is found have been embedded for a long time in the ground, or perhaps in water basins. While an earthy crust of greater or less thickness is noticed on all pieces of gum copal before it is washed or rubbed off, the color in different pieces varies very much; some samples are yellowish white, some of honey or gold color, and others are distinguished by an intense reddish orange color. The general appearance of the pure pieces of this resin, especially in the gold-colored kind, has delusive resemblance to amber, with which, though much softer, it has the common properties of igniting and of becoming electrical by friction. The interior of the Angola copal pieces, when not mixed with earthy substances, or with remains of bark, is even glossy and transparent; but I have never observed insects in any of the numerous samples which, partly in Angola and partly at Lisbon, came under my notice, while in the copal sent to Lisbon from the province of Mozambique, on the east coast of Tropical Africa, various hymenopterous insects are to be met with. The different colors of the copal of Angola just described are connected more or less with its availability for varnishes, etc. Thus the copal dealers distinguish three sorts, namely, (1) red copal gum (*gomma copal vermellia*); (2) yellow (*g. c. amarella*); (3) whitish (*g. c. bianca*). The red and whitish sorts furnish the best and finest varnish, and therefore are most in request and the dearest, while the whitish quality is sold at the lowest price.¹

According to Burton² the present limit of distribution of the gum-yielding trees on the east coast is less extensive than that of the extinct forests which have yielded the true or "ripe" copal, or "sandarusi," as it is locally called. Every part of the coast from Ras Gomani, in south latitude 3, to Ras Delgado, in 10° 41', with a mean depth of 30 miles inland, may be called the copal coast. The material is found in red, sandy soil, but is not evenly distributed, occurring rather in patches, as though produced by isolated trees. Dr. Kirk considers

¹ Journal of the Linnean Society of London, Botany, IX, 1866, pp. 291-293.

² Lake Region of Central Africa, II, p. 403. See also report by Dr. M. C. Cooke on the gums, resins, etc., in the India Museum, or produced in India. London, India Museum, 1874.

this gum as a product of trees of the same species as those at present producing the raw gum called by the natives and Arabs sandarusizami or chakazi; that is, the *Trachylobium mozambicense* Peters. The gum when dug from the soil has superficially a peculiar pebbled appearance, best described as "goose skin" (Specimens Nos. 62472, 62473, U.S.N.M.), and which Burton considered as due to the impress of the sandy grains in which it had been buried, but which Dr. Kirk regards as due to the structure of the cellular tissues of the tree. The copal when dug up has, according to this authority, exteriorly no trace of the loose skin structure.

As is the case with the New Zealand and West African gums, the methods of digging are very crude, careless, and desultory. The diggings are mostly beyond the jurisdiction of Zanzibar, but as this is the principal port, most of the material is known commercially as Zanzibar copal.

BIBLIOGRAPHY.

- M. C. COOK. Report on Gums, Resins, Oleo-Resins, and Resinous Products in the India Museum, or produced in India.
London, India Museum, 1874, pp. 98-103.
- S. F. PECKHAM. Report on the Production, Technology, and Uses of Petroleum and its Products.
Report of the Tenth Census of the United States, X, 1880.
This important report contains a very complete bibliography on the subject up to date of publication.
- G. W. GRIFFIN The Kauri Gum of New Zealand.
U. S. Consular Reports, II, 1881, p. 241.
- R. W. RAYMOND. The Natural Coke of Chesterfield County, Virginia.
Transactions of the American Institute of Mining Engineers, XI, 1882, p. 446.
- EDWARD ORTON. A Source of the Bituminous Matter in the Devonian and Sub-Carboniferous Black Shales of Ohio.
American Journal of Science, XXIV, 1882, p. 171.
- ORAZIO SILVESTI. On the Occurrence of Crystallized Paraffin in the Hollow Spaces of a Basaltic Lava from Paterno, near Mount Etna.
Journal of the Society of Chemical Industry, I, 1882, p. 180.
- WILLIAM MORRISON. The Mineral Albertite and the Strathpeffer Shales.
Transactions of the Edinburgh Geological Society, V, 1883-1888, p. 34.
———. A New Mineral Tar in Old Red Sandstone: Ross-shire.
Transactions of the Edinburgh Geological Society, V, 1883-1888, p. 500.
- S. F. PECKHAM. The Origin of Bitumens.
American Journal of Science, XXVIII, 1884, p. 105.
- EDWARD ORTON. The Trenton Limestone as a Source of Petroleum and Natural Gas in Ohio and Indiana.
Eighth Annual Report U. S. Geological Survey, Pt. 2, 1886-87, pp. 483-662.
- J. L. KLEINSCHMIDT Asphalt Deposits in the Formation of Coal.
Berg- und Hüttenmännische Zeitung, XLVI, 1887, p. 78.
- JOSEPH M. LOCKE. Gilsonite or Uintahite. A New Variety of Asphaltum from the Uintah Mountains, Utah.
Transactions of the American Institute of Mining Engineers, XVI, 1887, p. 162.
- A. RATEAU. Note sur l'Ozokérite, ses Gisements, son Exploitation à Boryslaw et son Traitement Industriel.

- A. RATEAU. *Annales des Mines*, XI, Pt. I, 1887, p. 147. See also *Engineering and Mining Journal*, XLV, 1888, p. 415.
- . *Verarbeitung des galizischen Erdwachses.*
Berg- und Hüttenmännische Zeitung, XLVII, 1888, p. 435.
- A. LIVERSIDGE *Torbanite*.—*Cannel Coal or Kerosene Shale.*
Minerals of New South Wales, 1888, p. 145.
- MAX VON ISSER. *Die Bitumenschätze von Seefeld.*
Berg- und Hüttenmännisches Jahrbuch, XXXVI, 1888, Pt. 1, p. 1.
- L. BABU. *Note Sur L'Ozokerite de Boryslaw et les petroles de sloboda (Galicie).*
Annales des Mines, XIV, 1888, p. 162. See also *Transactions of the North of England Institute of Mining and Mechanical Engineers*, XXXVIII, 1889, p. 15.
- RALPH ROBINSON. *Kauri Gum Industry.*
Engineering and Mining Journal, XLVI, 1888, p. 462.
- R. W. RAYMOND. *Note on a specimen of Gilsonite from Uintah County, Utah.*
Transactions of the American Institute of Mining Engineers, XVII, 1888, p. 113.
- F. V. GREENE. *Asphalt and its uses.*
Transactions of the American Institute of Mining Engineers, XVII, 1888, p. 355.
- WILLIAM MORRISON. *Elaterite: A Mineral Tar in Old Red Sandstone, Ross-shire.*
Mineralogical Magazine, VIII, May, 1888, October, 1889, p. 133.
- HENRY WURTZ. *The Utah Mineral Waxes.*
Engineering and Mining Journal, XLVIII, July 13, 1889, p. 25.
- . *Uintahite a variety of Grahamite.*
Engineering and Mining Journal, XLVIII, August 10, 1889, p. 114.
- WILLIAM P. BLAKE. *Wurtzilite from the Uintah Mountains, Utah.*
Transactions of the American Institute of Mining Engineers, XVIII, 1890, p. 497.
- . *Uintaite, Albertite, Grahamite, and Asphaltum described and compared, with Observations on Bitumen and its Compounds.*
Transaction of the American Institute of Mining Engineers, XVIII, 1890, p. 563.
- HENRY WURTZ. *Wurtzilite, Prof. Blake's New Mineral.*
Engineering and Mining Journal, XLIX, 1890, p. 59.
- . *Bituminous Rock, California.*
Tenth Annual Report of the California State Mineralogist, 1890.
- E. W. HILGARD. *Report on the Asphaltum Mine of the Ventura Asphalt Company.*
Tenth Annual Report of the California State Mineralogist, 1890, p. 763.
- . *Asphalt and Petroleum in Mexico.*
Journal of the Society of Chemical Industry, IX, 1890, p. 426.
- GEORGE VALENTINE. *On a Carbonaceous Mineral or Oil Shale from Brazil: Its Formation and Composition. As a Key to the Origin of Petroleum.*
Proceedings of the South Wales Institute of Engineers, XVII, August 8, 1890, p. 20.
- S. DEUTSCH. *Ozokerite in Galicia.*
Journal of the Iron and Steel Institute, 1891, p. 311.
- A. N. SEARL. *Utah Ozokerite.*
Engineering and Mining Journal, LI, 1891, p. 441.
- HENRY WURTZ. *A Review of the Chemical Literature of the Mineral Waxes.*
Engineering and Mining Journal, LI, March 28, 1891, p. 326.
- CLARENCE LOWN; H. BOOTH. *Fossil Resins.*
New York, 1891, pp. 119.
- EDWARD ORTON. *Report on the Occurrence of Petroleum, Natural Gas, and Asphalt Rock in Western Kentucky.*
Geological Survey of Kentucky, J. R. Procter, Director, 1891.

- BOVERTON REDWOOD. The Galician Petroleum and Ozokerite Industries.
The Journal of the Society of Chemical Industry, XI, 1892, p. 93.
- E. T. DUMBLE. Note on the Occurrence of Grahamite in Texas.
Transactions of the American Institute of Mining Engineers, XXI, 1892, p. 601.
- HENRY M. CADELL. Petroleum and Natural Gas; their Geological History and Production.
Transactions of the Edinburgh Geological Society, VII, Pt. 1, p. 51, 1893-94.
- . Asphaltum and Bituminous Rock.
Twelfth Report of the California State Mineralogist, 1894, p. 26.
- S. F. PECKHAM. Petroleum in Southern California.
Science, February 9, 1894, p. 741.
- EDGAR B. GOSLING. A Treatise on Ozokerite.
The School of Mines Quarterly, XVI, 1894, p. 41.
- J. G. GOODCHILD. Some of the Modes of Origin of Oil Shales, with Remarks upon the Geological History of some other Hydrocarbon Compounds.
Transactions of the Edinburgh Geological Society, VII, 1895-96, p. 121.
- C. EG. BERTRAND; B. RENAULT. The Kerosene Shale of New South Wales.
Transactions of the North of England Institute of Mining and Mechanical Engineers, XLIV, 1895, p. 76.
- . Asphalt and Bitumen.
Journal of the Franklin Institute, September, 1895.
- S. F. PECKHAM. On the Pitch Lake of Trinidad.
American Journal of Science, L, 1895, p. 33. See also the Geological Magazine, II, 1895, p. 416.
- BOVERTON REDWOOD; GEORGE L. HOLLOWAY. Petroleum and Its Products.
2 Vols., London, 1896.
- . Asphaltum and Bituminous Rock.
Thirteenth Report of the California State Mineralogist, 1896, p. 35.
- OTTO LANG. Trinidad Asphalt.
Transactions of the North of England Institute of Mining and Mechanical Engineers, XLV, Pt. 3, March, 1896, p. 1.
- . Maracaibo Asphalt.
Scottish Geographical Magazine, April, 1897, p. 209. Abstract from Deutsche Geographische Blätter, XIX, Pt. 4.
- M. H. ENDEMANN. Sur la composition et l'analyse des asphaltes.
Moniteur Scientifique, L, 1897, 4th Ser., XI, p. 755.
- . The Uinta and the Uncompahgre Asphaltites of Utah.
Engineering and Mining Journal, LXIV, 1897, p. 10.
- WALTER MERIVALE. Barbadoes Manjak.
Engineering and Mining Journal, LXVI, 1898, p. 790.
- JOHN RUTHERFORD. Notes on the Albertite of New Brunswick.
Journal of the Federated Canadian Mining Institute, III, 1898, p. 40.
- F. NOETLING. Petroleum in Burma.
Engineering and Mining Journal, LXV, May 7, 1898, p. 555.
- A. S. COOPER. A Bituminous Rock Deposit in Santa Barbara County, California.
Engineering and Mining Journal, LXVI, 1898, p. 278.
- I. C. WHITE. Origin of Grahamite.
Bulletin of the Geological Society of America, X, 1899, pp. 277-284.

XIV. MISCELLANEOUS.

1. GRINDSTONES; WHETSTONES; AND HONES.

The custom of sharpening edge tools on pieces of stone has been practiced by barbarous and civilized nations ever since the adoption of cutting implements of any kind, however crude and of whatever materials.

With the first crude implements, it is safe to say almost any stone possessing the requisite grit would serve to produce the rough edge desired. With the improvement in the cutting implement there has, however, been necessitated a corresponding improvement in the character of the sharpening implement as well. Formerly, it may be safely assumed, every man used that which was most accessible and could be made to best answer its purpose. Now the grindstone and whetstone industry is as well organized as any other branch of manufacture, and forms no inconsiderable feature of the nation's trade. Localities are ransacked and material is brought from far and near, carried long distances, overland or across the ocean, to the workshops of the manufacturer to be cut into the desired shapes and sizes, classified and assorted according to quality, and sent abroad once more to meet the demands of the ever-increasing trade. The use of the grindstone, it should be noted, is not confined merely to sharpening edge tools, but, as will be noted later, they are made from a variety of materials and of an equal variety of sizes, from the 2-inch wheel of novaculite, used by jewelers, to a coarse grit monster of over 2 tons weight for the grinding of rough castings in machine shops.

A stone to be suitable for grinding purposes must possess a fine and even grain, free from all hard spots and inequalities of any kind. It is essential, too, that the various particles of which it is composed be cemented together with just sufficient tenacity to impart the necessary strength to the stone, and yet allow them to crumble away when exposed to friction, thus continually presenting fresh sharp grains and surfaces to act upon the material being ground. Simple as these essential qualities may seem they are in reality but rarely met with in perfection, and the majority of grindstones now on the market are quarried from a comparatively limited number of sources. If the stone be too friable it wears away too rapidly, and the grinding done is coarse and uneven; a sharp edge or polish is unobtainable. If too hard it glazes and loses its cutting qualities, or cuts so slowly as to be no longer desirable. If, moreover, the particles composing the stone adhere with too little tenacity, the stone, particularly if it be a large one, such as is used for grinding castings, is liable to burst, perhaps to the serious injury of workmen and machinery.

The requisite qualities as above enumerated are found mainly in

those stones that have originated as sandy deposits on sea bottoms and have undergone little if any metamorphism—in other words, in sandstones. For some particular reason, or rather owing to certain peculiar conditions, although sandstones were formed throughout a great number of periods in the earth's history, those formed during the Carboniferous age seem best adapted for the purpose, and from stone found somewhere in this formation are manufactured a large share of the grindstones now in use.

A majority of the grindstones now found in the markets of the United States are made from sandstones quarried from the Upper, Middle, and Lower Carboniferous formations of Ohio, Michigan, Nova Scotia, or New Brunswick, or England and Scotland. A few are, or have been, made from stone from Missouri and Kentucky. The Ohio stones are obtained nearly altogether from quarries in the sub-Carboniferous sandstones at or near Berea, Amherst, Bedford, Constitution, Massillon, Marietta, Independence, and Euclid. Few if any of the quarries are worked wholly for grindstones, but in the majority of cases the stone is sought for building purposes as well, and the grindstone output may be merely incidental, certain layers only being adapted for the latter purpose. This is well illustrated by the following section, as shown at one of the Amherst quarries and as described¹ by Professor Orton, the State geologist. The reader will understand that by section is meant the various layers exposed in the quarry wall, or that would be passed through in digging or boring from the surface downward.

At Amherst, then, the stone lies as follows, beginning at the surface:

	Feet.
Drift material (soil, sand, etc.)	1 to 3
Worthless shell rock	6 to 10
Soft rock used only for grindstones.....	12
Building stone.....	3
Bridge stone.....	2
Grindstone	2
Building and grindstone.....	10
Building stone.....	4 to 7
Building stone or grindstone.....	12

Commenting on the condition of affairs as here displayed, Professor Orton says:

As will be noticed in this section, the different strata are not applicable alike to the same purpose, and the uses for which the different grades of material can be employed depend principally upon the texture and the hardness of the stone. The softest and most uniform in texture is especially applicable for certain kinds of grinding, and is used for grindstones only, and the production of these forms an important part of the quarry industry. In its different varieties the material is applicable to all kinds of grinding, and stones made from it are not only sold throughout this coun-

¹ Geological Survey of Ohio, V, p. 586.

try, but are exported to nearly all parts of the civilized world. Some of the finest-grained material is also used in the manufacture of whetstones. There are various points in the system of the Berea grit where the stone is adapted to this use, but such a manufacture is best carried on when joined with a large interest in quarrying, so that the small amount of suitable material can be selected; and thus it happens that only at Amherst and at Berea are whetstones manufactured in large quantities.

Below are given in brief outline the sources and main characteristics of the principal grindstones now in the market, beginning with those of the United States. In speaking of the texture of any stone, that of Berea has been taken as the standard. This is the stone most used for grinding cutting tools, such as axes and scythes. It must be remarked here that the term Berea grit is applied not merely to the stone from the immediate vicinity of the town of Berea, but is rather a general name applied to this particular subdivision of the Subcarboniferous formation of Ohio and extending over a wide field.

Berea.—Medium fine; blue gray, light yellowish, or nearly white. For edge tools in general; the finer varieties also used for whetstones. Four quarries a few miles west of Berea produced alone upward of \$10,000 worth of grindstones during the last census year. (Specimen No. 25059, U.S.N.M.)

Amherst.—Medium fine, like the Berea, being a part of the same formation. Light gray, with small rust-colored spots due to iron oxides. For grindstones and whetstones for edge tools in general; the softer varieties for saws. (Specimens Nos. 25079, 25421, U.S.N.M.)

Independence.—Similar to the Amherst, and especially adapted for the manufacture of large grindstones for dry grinding; stones said not to glaze when used for this purpose. (Specimen No. 25080, U.S.N.M.)

Bedford.—Rather coarser, though of even texture and filled with brown spots of iron oxide. Especially adapted for grinding springs.

Euclid.—Fine, light bluish-gray; for wet grinding edge tools.

Massillon.—Medium to rather coarse; the microscope shows it to be an aggregate of rounded, colorless grains of quartz, with little, if any, cementing material. Not so finely compacted as the last, and small fragments can be readily broken from the sharp edges by means of the thumb and fingers. Color, light yellowish or pinkish; for edge tools, springs, files, and nail cutters' face stones, but mainly for the dry grinding of castings. (Specimens Nos. 25054, 25055, U.S.N.M.)

Constitution.—Medium; light gray and rather more friable than the last. A variety of textures, however, and all kinds of grits for wet grinding are furnished. (Specimens Nos. 25056, 25057, U.S.N.M.)

Huron, Michigan.—Fine; uniform blue-gray color, with numerous flecks of silvery mica. Smells strongly of clay when breathed upon. For wet grinding of edge tools; produces a fine edge. (Specimen No. 25076, U.S.N.M.)

The Joggins, Nova Scotia.—Fine gray; of uniform texture; used for wet grinding all kinds of edge tools; the larger stones for grinding

springs, sad irons, and hinges; extensively exported to the United States.

Bay of Chaleur, New Brunswick.—Fine dark bluish-gray; of firm texture; smells strongly of clay when breathed upon. Resembles the stone of Huron, Michigan, but contains less mica. Used in the manufacture of table cutlery; also machinists' tools and edge tools in general.

Newcastle, England.—Light gray and yellowish; with a sharp grit; rather friable, and texture somewhat coarser than that of the Berea stone, which it otherwise somewhat resembles. The finer grades used for grinding saws and the coarser and harder ones for sad irons, springs, pulleys, shafting, for head and face stones in nail work, and for dry grinding of castings; also used by glass cutters.

Wickersly, England.—A dull brownish or yellowish, somewhat micaceous stone of medium texture and rather soft. For grinding saws, squares, bevels, and cutlers' work in general.

Liverpool, or Melling, England.—Dull reddish; a somewhat loosely compacted aggregate of siliceous sand, so friable that the sharp angles are easily crumbled away by the thumb and fingers. A very sharp grit, used for saws and edge tools, particularly axes in shipyards.

Craigleith, Scotland.—Fine-grained and nearly white. A very pure siliceous sandstone with a sharp grit. Said to be the best stone known for glass cutting, though the Newcastle, Warrington, and Yorkshire grits are also used for a similar purpose.

Grindstones from France and Saxony find their way into our markets but rarely.

For whetstones the same qualities are essential as for grindstones, though as a rule the whetstones are designed for a finer class of work, and hence a finer grade of material is utilized. For sharpening scythes and other coarse cutting tools, however, the same stone is used as for grindstones, the same quarry producing stone for building, grindstones, and whetstones, as above noted. The so-called Hindostan, or Orange stone, from Orange County, Indiana, is a very fine-grained siliceous sandstone of remarkably sharp and uniform grit, and which for carvers and kitchen implements is unexcelled. (Specimens Nos. 38901-38905, 38910-38912, 38918-38924, 72896, 72899, etc., U.S.N.M.) The so-called Labrador stone is also a sandstone of a dark blue-gray color and of less sharp grit than that just mentioned. (Specimens Nos. 38957, 38959, 38963, 38964, 38968, 38974, 38980-38982, and 38985-38987, etc., U.S.N.M.) Many scythestones like "Indian Pond" (Specimen Nos. 38950, 38873, 38874, U.S.N.M.), "Chocolate," "Farmers' Choice," "Black Diamond," "Vermont Quinebaug," and the "Lamoille" (Specimens Nos. 38926 and 38878, U.S.N.M.), are fine-grained mica schists from New Hampshire and Vermont quarries (Specimens Nos. 38947 to 38951, etc., U.S.N.M.). These as a rule are very



Fig. 1.



Fig. 2.

MICROSECTION OF MICA SCHIST USED IN MAKING WHETSTONE.

Fig. 1, cut across foliation; Fig. 2, cut parallel to foliation.

fine-grained schistose dark-gray rocks, sometimes of a light chocolate color on a freshly fractured surface. The microscope shows them to consist of a compact and slightly schistose aggregate of quartz and mica in which are frequently included very abundant small octahedral crystals of magnetic iron and sometimes garnets. (See Plate 28.) So abundant are these magnetite granules in some of these rocks, especially those of Grafton, New Hampshire, as to constitute an important feature, and it is doubtless very largely to them that the stone owes its excellent abrasive qualities. Magnetite, it will be remembered, has a hardness of about 6.5 of the scale, and constitutes a very considerable proportion of the ordinary emery of commerce. We have here, then, what is almost a natural equivalent of the artificial emery stone, the compact groundmass of quartz and mica serving as a binding material for the magnetite grains while they perform their work in wearing away the implement being ground. A part of the abrading quality of these stones is, however, due to the abundant quartz and mica scales and their peculiar arrangement in relation to one another.

The well-known Water of Ayr, Scotch hone, or snake stone, as it is variously called, is also a very compact schist. It is said to come from Dalnour, in Ayrshire, Scotland. (Specimens Nos. 38931, 38937, 38946, 54146, U.S.N.M.)

The name novaculite is applied to a very fine-grained and compact rock consisting almost wholly of chalcedonic silica, and which, owing to the fineness of its grit, is used only in the finer kinds of work, as in sharpening razors, knives, and the tools of engravers, carpenters, and other artisans. The true novaculites are, so far as the writer is aware, at present quarried in America only in Montgomery, Saline, Hot Springs, and Garland counties, in Arkansas, and are known commercially as the Washita (or Ouachita, as the name is properly spelled) (Specimens Nos. 38955, 38966, 38969, 38977, 72900, etc., U.S.N.M.), and Arkansas stones (Specimens Nos. 38954, 38971, U.S.N.M.). Both varieties are nearly pure silica, the Ouachita being often of a yellowish or rusty red tint (Specimen No. 72900, U.S.N.M.), and the Arkansas of a pure snow whiteness, the latter variety being also the hardest, most compact, and highest priced. The analyses given below show the average composition of the two varieties:

Constituents.	Arkansas.	Ouachita.
SiO ₂	99.50	99.49
Al ₂ O ₃	0.20	0.13
Fe ₂ O ₃	0.10	0.06
CaO	0.10	0.04
MgO	0.05	0.08
K ₂ O	0.10	0.16
Na ₂ O	0.15	0.10
H ₂ O	0.10	0.14

According to Griswold stone suitable for the manufacture of whetstones occurs in quantity in two distinct horizons in the Arkansas novaculite series of rocks, both of which are now being worked. The principal quarries are in the massive white beds of the Hot Springs region, the material being mainly of the fine, compact white "Arkansas" type. Within a limited region, northeast of Hot Springs, the stone becomes more porous, owing in part to the existence of a larger number of the rhomboidal cavities, and passes over to the Ouachita type.

The microscopic structure of the Arkansas novaculite is shown in Plate 30, fig.1, the large white areas being angular granules of quartz.

Owen regarded the Arkansas novaculites as belonging to the age of the millstone grit formation; that is, to the lower part of the Carboniferous, and considered them as a sandstone metamorphosed and freed from impurities by the action of hot alkaline waters. State Geologist Branner, however, regards the finer grade of novaculite as a metamorphosed chert, a conclusion more in accordance with the microscopic structure of the rock, which is more that of chalcedony than of an altered sandstone. Griswold, on the other hand, regards the novaculite as a product of sedimentation of a fine siliceous silt, and of Lower Silurian age,¹ while Rutley² considers it as a product of chemical replacement by silica of the calcareous material of dolomite or dolomitic limestone beds.

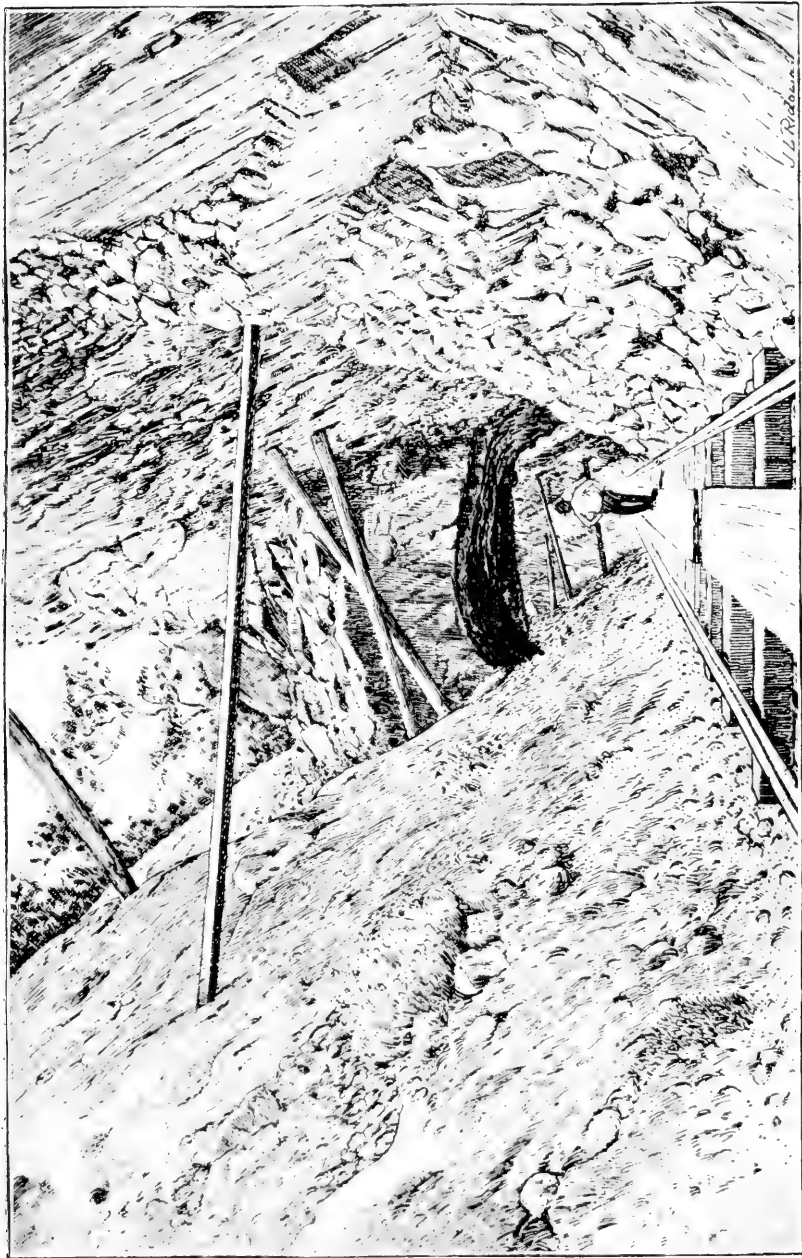
The view of Suttons quarry No. 7 in Plate 29 shows the novaculite beds dipping 60° to the southeast, the bed of good stone being some 12 or 15 feet in thickness. The rock is everywhere badly jointed, in one case mentioned by Griswold as many as six different systems being developed in a single quarry. The natural result is that pieces of only very moderate dimensions are obtainable even under the most favorable of circumstances. Fine veins of quartz intersecting the rock in various directions increase the difficulty of getting homogeneous material and thereby increase the cost of the output.

The Arkansas stone is now used for many purposes. The whetstones are used by engravers, surgeons, carvers, dentists, jewelers, cutlers, and other manufacturers of fine-edge tools, and by machinists and woodworkers of the more skilled class. Small whetstones for penknives are made in considerable quantity and some stones are sold for razor hones.

The stone is also used by wood carvers, jewelers, manufacturers of fine machinery and metal work, and by dentists in various forms of

¹See Whetstones and Novaculites, by L. S. Griswold, Annual Report of the Geological Survey of Arkansas, III, 1892. This report contains a very full discussion of the Arkansas novaculite in all its bearings.

²Quarterly Journal of the Geological Society of London, L, 1894, p. 377.



VIEW OF NOVACULITE QUARRY, ARKANSAS.
After Griswold, Annual Report of the Geology of Arkansas, III, 1890.

files and points. Dentists use particularly the "knife blade," a very thin, broad slip of stone, triangular in section, with one short side, the other two forming a thin edge as they come together (Specimens Nos. 38998, 53721, U.S.N.M.). They are used for filing between the teeth. Carvers use wedge-shaped, flat, square, triangular, diamond-shaped, rounded, and bevel-edged files for finishing their work. (Specimen No. 38996, U.S.N.M.). Jewelers, especially manufacturing jewelers and watchmakers, use all these forms of files and also points. These last are sometimes made the size of a lead pencil, having a cone-shaped end, and are about 3 inches long and $\frac{1}{4}$ inch square, tapering to a point. They are used chiefly in manufacturing watches to enlarge jewel holes (Specimens Nos. 38995, 53726-53727, U.S.N.M.).

Wheels of various thicknesses and diameter are also made from Arkansas stone. They are used chiefly by jewelers and dentists, but could be made of service in all workshops where an Arkansas whetstone is used (Specimens Nos. 38992, 38962, 53710, U.S.N.M.). The difficulty of obtaining pieces of clear stone large enough for wheels several inches in diameter makes the price very high, and the difficulty of cutting out a circular form increases the cost. Wheels are quoted at from \$1.10 to \$2.20 an inch of diameter.

Arkansas stone is used for finishing and polishing metal rolls, journals, cross-head slides, piston rods, crank pins, and all kinds of lathe work.

Fragments of the Arkansas stone are saved at the factories, and now and then sent away to be ground for polishing powder. In the manufacture of this powder millstones are worn out so rapidly that the process is rather expensive, but as waste stone is utilized, the powder can be sold by the barrel at 10 cents a pound. It makes a very fine, pure white powder of sharp grit, suitable for all kinds of polishing work; it is known as "Arkansas powder." A large amount of energy is wasted, however, in the manufacture of this powder, for the silica of the Ouachita stone is in every way identical with that of the Arkansas stone, and it would be much more easily reduced to powder than the Arkansas.

The so-called Turkish oilstone from Smyrna, in Asia Minor, is both in structure and abrasive qualities quite similar to the Arkansas novaculites. (Specimens Nos. 38956, 38967, 38997, U.S.N.M.) It, however, is of a drab color and carries an appreciable amount of free calcium carbonate and other impurities, as shown by the analysis given below, as quoted by Griswold:

TURKEY STONE.

Silica (SiO_2)	72.00
Alumina (Al_2O_3)	3.33
Lime (CaO)	13.33
Carbonic acid (CO_2)	10.33

According to Renard,¹ the celebrated Belgian razor hone quarried at Lierreux, Sart, Salm-Chateau, Bihau, and Recht is a damourite slate containing innumerable garnets, more than 100,000 in a cubic millimeter. Like the Ratisbon hone, this occurs in the form of thin, yellowish bands, some 6 centimeters wide ($2\frac{3}{8}$ inches) in a blue-gray slate (phyllade). The bands are essentially parallel with one another and with the grain of the slate, into which they at times gradually merge. The chemical composition of a sample from Recht is given as below. The microscopic structure of the stone as described and figured by Renard is essentially the same as that of the Ratisbon stone in the collection of the U. S. National Museum (see Plate 30, fig. 2), and the stones are practically identical in color and texture as well.

Silica (SiO_2)	46.5
Titanic oxide (TiO_2)	1.17
Alumina (Al_2O_3)	23.54
Ferric iron (Fe_2O_3)	1.05
Ferrous iron (FeO)	0.71
Manganese oxide (MnO)	17.54
Magnesia (MgO)	1.13
Lime (CaO)	0.80
Soda (Na_2O)	0.30
Potash (K_2O)	2.69
Water (H_2O)	3.28
Carbon dioxide (CO_2)	0.04
Phosphoric acid (P_2O_5)	0.16
Sulphur (S)	0.18
Organic matter.....	0.02
<hr/>	
Total	99.11

The cutting property of the stone would appear to be due to the presence of the small garnets above noted. (Specimens Nos. 38938-38940, U.S.N.M.)

The so-called holystone is but a fine, close-grained sandstone of the same nature as that used in grind and whet stones. The greater part of those made in this country are from the Berea sandstone of Ohio, though some are said to be imported from Germany. The stones are used mainly on shipboard, and the trade is small.

2. PUMICE.

The material to which the name pumice is commonly given is a form of glassy volcanic rock, which, by the expansion of its included moisture while in a molten condition, has become, like a well-raised loaf, filled with air cavities or vesicles. The cutting or abrasive quality

¹ Mémoires Couronnés et Mémoires des Savants Étrangers de L'Académie Royale des Sciences, etc., Belgique 1878, pp. 1-44.



FIG. 1.

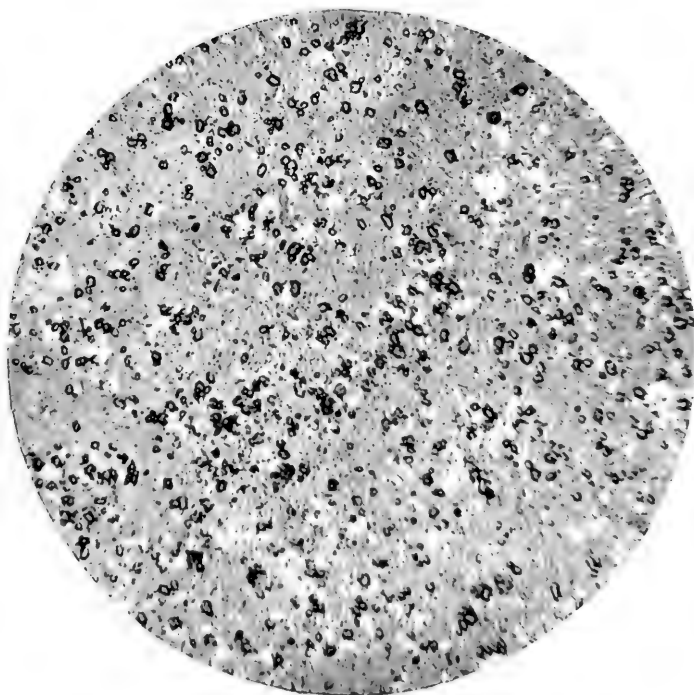


FIG. 2.

MICROSECTIONS SHOWING THE APPEARANCE OF (1) ARKANSAS NOVACULITE AND (2) RATISBON RAZOR HONE. THE DARK BODIES IN (2) ARE GARNETS.

of the material is due to the thin partitions of glass composing the walls between these vesicles. Any variety of volcanic rock, flowing out upon the surface of the ground, is likely to assume the vesicular condition known as pumiceous, but only certain acid varieties known as liparites seem to possess just the right degree of viscosity to produce a desirable pumice, and in this rock only in exceptional circumstances. Almost the entire commercial supply of pumice is now brought from the Lipari Islands, a group of volcanoes north of Sicily, in the Mediterranean Sea. (Specimen No. 60787, U.S.N.M.) The material is usually brought over in bulk and sold in small pieces in the drug and paint shops, or ground and bolted to various degrees of fineness and sold like emery and other abrasive materials. (Specimen No. 54155, U.S.N.M.) At times an inferior grade of pumice has been produced from volcanic flows near Lake Merced, in California. In Harlan County, Nebraska, and adjacent portions of Kansas, as well as in many other of the States and Territories farther west, have been found extensive beds of a fine, white powder, which was first shown by the present writer¹ to be pumiceous dust, drifted an unknown distance by wind currents and finally deposited in the still waters of a lake. Through a mistaken notion regarding its origin this material was first described in Nebraska as *geyserite*. So far as the writer is aware, these natural pumice powders have thus far been used only locally for polishing purposes and as a cleansing or scouring agent in soap. As the material exists in almost inexhaustible quantities, it would seem that a wider scope of usefulness might yet be discovered. (Specimens Nos. 53074, 60920, 37023, U.S.N.M., from Montana, Washington, and Nebraska.)

The analyses given below show (I) the composition of the pumice dust of Harlan, Orleans County, Nebraska,² and (II) a pumice from Capo di Costagna, Lipari Islands:

Constituents.	I.	II.
Silica	69.12	73.70
Alumina	17.64	12.27
Iron oxides		2.31
Lime	0.86	0.65
Magnesia	0.24	0.29
Potash	6.64	4.73
Soda	1.69	4.25
Ignition	4.05	1.22
Total	100.24	99.42

¹ See On Deposits of Volcanic Dust in Southwestern Nebraska (Proceedings U. S. National Museum, VIII, 1885, p. 99), and Notes on the Composition of Certain Pliocene Sandstones from Montana and Idaho (American Journal of Science, XXXII, 1886, p. 199).

² Rocks, Rock-weathering, and Soils, p. 350.

According to Dr. L. Sambon, as quoted by Dr. H. J. Johnston-Lavis:

All the best pumice of commerce is obtained from the northeast region of the island of Lipari, extending as far as the summit of Mte. S. Angelo on its northern slope. * * * It is excavated at the Fossa Castagna near M. Pelato, at M. Chirica, and on the shore of the Mosche.

I visited a quarry of M. Pelato on the outer southern side. The height was about 1.50 m. and 1 m. large. The entrance was sustained by poles, faggots of brushwood, and stones; at first one descended for 160 steps, then one ascended for about 50 m. where two naked men were digging in the dull light of an oil lamp. In descending I met some young men who were carrying up baskets full of pumice. They wore short coarse linen drawers, and on their naked breast hung the blessed scapulary. On my arrival at the works they made me sit down on an empty basket while I watched the men dig out the pieces of pumice, often the size of a human head, from the embedding matrix, which is composed of different sized fragments and dust of the same material, pressed together, and forming an incoherent tuff. They told me of their poor wages, and the dangers of their work in consequence of the frequent collapse of the workings, killing men and youths. It was horrible to hear those accounts of misery and misfortune at the bottom of these caves.

The low roof and narrow passage from which every moment fragments detached themselves seemed to threaten the collapse of the whole; and it was with great relief that I again reached the daylight. Only a few weeks previously a quarry of M. Pelato had collapsed and buried some workmen, and more than two days work were required to reach them. These unfortunate men, saved by a miracle, returned again to their work, for what else could they have done to obtain bread?

Prolonged and curious was at all times the discussion concerning the origin of pumice. It was believed to be amianthus decomposed by fire, by Pott, Bergman and Demeste; calcined lignite or schist, by Vallerio; scorified marl by Sage and granite that had become blown up and fibrous by the effect of fire and water by Dolomieu. The latter asserted having found inclosed in some pieces of pumice fragments of granite. He also declares that he had seen masses of granite which took on gradually the fibrous structure and other characters of pumice; so that he concluded that granite or granitoid schist was the primitive material which by the effect of the volcanic fire passed to the state of the pumice. Finally he declares he sent specimens to all the most learned geologists of the time. Spallanzani, who visited that same locality and hunted in every part of Campo Bianco in a most diligent manner but without being successful in finding the granite of Dolomieu, says wittily that probably the French geologist had carried them all away. Spallanzani himself, on the contrary, considers that pumice and obsidian are the result of fusion of great masses of intermediate lavas which one encounters on all parts of the mountain. Prof. J. F. Blake recently, probably ignoring the observations of Spallanzani, is satisfied in finding in that locality "Mother-pumice" as he has baptized it, from which also is derived the obsidian. But pumice, obsidian and all intermediate rock varieties more or less scoriaceous are but different forms of the same eruptive product. The whole history and modifications of pumice have been worked out by Dr. Johnston-Lavis, who has shown that by studying these eruptive products the whole mechanism of volcanic action in general is explained and the sequence of eruptive phenomena of any volcanic focus can be made out. * * *

When we descend to the shore of the Beja delle pomice by the gorge to the South East of the great obsidian flow, the slopes facing the lava are composed of immense deposits of pumice in which hundreds of holes are observable, marking the excavations made in search of the larger masses of this valuable rock, much of which could be seen in the numerous baskets standing at hand. The sight of the enormous

agglomeration of pumice and dust of a glaring white colour, cut by the action of rain and wind into fantastic shapes, stands out against the blue sky like the irregular crags, spurs and ridges of a great glacier.

Along the marina are quantities of pebbles of pumice, either rounded by the torrents that descend from above or by the waves that lap the shore. When the wind blows from N. E. a veritable fleet of floating masses reaches the port of Lipari. The pumice that has been excavated is carried to the beach, and stored and sorted in sheds or caves cut out of the same pumice tuff, protected in front by a breakwater of big stones to prevent heavy seas reaching and washing away the produce.

Pumice in commerce is classified as follows—*grosse* (large size), *correnti* (medium), and *pezzani* (small); the large and middle size are subdivided into *lisconi* (flat) and *rotondi* (round). The *lisconi* are filamentous and break less easily than the *rotondi*. They are also trimmed by the sorters. The *lisconi* and *rotondi* are again subdivided into white, black, and uncertain, according to their colour.

The price varies according to the quality from 50 to 2000 lire the ton. The common price for the assorted is 350 to 500 lire the ton. As much as 5000 tons a year are exported. The best pumice is that of Campo Bianco. It is also obtained at Perera, but it is in small quantity and was produced at the eruption of the Forgia Vecchia. It is a first class grey pumice and fetches from 600 to 750 lire the ton, and does not so easily break as the Campo Bianco. Also at Vulcano a grey pumice is found but the presence of included crystals render it useless for commercial purposes. At Castagna a commoner pumice is obtained called *Alessandrina*, of which brick shaped pieces are made and used for smoothing oil-cloth.¹

According to the Engineering and Mining Journal² a merchantable pumice has recently been found in Miller County, Idaho, but the demands for material of this nature is likely to be lessened by the putting upon the market of a German artificial product. In 1897 some 1,700 tons of pumice were mined near Black Rock, Millard County, Utah.

Ground and bolted pumice is quoted as worth from \$25 to \$35 a ton according to quality.

3. ROTTENSTONE.

The name rottenstone has been given to the residual product from the decay of silico-aluminous limestones. Percolating carbonated waters remove the lime carbonate from these stones, leaving the insoluble residue behind in the form of a soft, friable, earthy mass of a light gray or brownish color, which forms a cheap and fairly satisfactory polisher for many metals. Specimens Nos. 54150, 54153, 67390, 67791, U.S.N.M., show the material in its natural state and ground and bolted.

The chemical composition of rottenstone, as may well be imagined from what has been said regarding its method of origin, is quite variable, though alumina is always the predominating constituent. Analyses show: Alumina, 80 to 85 per cent; silica, 4 to 15 per cent;

¹ The South Italian Volcanoes, by H. J. Johnston-Lavis, Naples, F. Furchheim, 1891, pp. 67-71.

² Volume LXIV, July 24, 1897, p. 91.

5 to 10 per cent of carbon, and equal amounts of iron oxides and varying small quantities of lime. The material has little commercial value.

4. MADSTONES.

These need but brief notice here. The fallacy of the madstone dates well back into the dark ages and perhaps beyond, and strange as it may seem continues down to the present day. Not longer ago than December, 1898, the Washington newspapers chronicled the sale for \$450 of a madstone in Loudoun County, Virginia, and from year to year very many letters are received by the Smithsonian authorities making inquiries regarding such, or possibly offering one for sale at fabulous prices.

So far as the writer is able to learn, either from literature or from personal examination, stones of this class are almost invariably of an aluminous or clayey nature, and their supposed virtue is due wholly to their avidity for moisture—their capacity for absorption, which causes them to adhere to any wet surface, as the tongue or to a wound, until saturated, when they will drop away. It should not be necessary to state, at this late day, that their curative powers are purely imaginary. The ancient bezoar stone, used in extracting or expelling poisons, consisted of a calculus or concretion found in the intestines of the wild goat of northern India.¹

5. MOLDING SAND.

For the purpose of making molds for metallic casts, a fine, homogeneous argillaceous sand is commonly employed.

The physical qualities which go to make up a molding sand consist, according to Nason,² of elasticity, strength, and a certain degree of fineness. It must be plastic in order to be molded around the pattern; it must have sufficient strength to stand when unsupported by the pattern, and to resist the impact of the molten metal when poured into the mold. Too much clay and iron present in the sand will cause the mold to shrink and crack under the intense heat; too little will cause it to dry and crumple, if not to entirely collapse.

The peculiar virtues of molding sand, as outlined above, are ascribed to the fact that each of the sand grains is coated with a thin film of clay.

The accompanying table will serve to show the varying chemical character of sands thus employed, though, according to authorities

¹ W. J. Hoffman, *Folk Medicine of the Pennsylvania Germans*, Proceedings of the American Philosophical Society, XXVI, 1889, p. 337.

² Forty-seventh Annual Report of the Regents State Museum of New York, 1893, p. 469.

quoted by Crookes and Röhrig,¹ the "quality of the sand for molding depends less on its chemical composition than on its physical properties, namely, whether the grains are round, angular, scaly, etc., and whether they are of uniform size. The adhesiveness is dependent not alone on the quantity of clay, but upon the angularity of the grains, and by a mixture of smaller and larger grains. Reinhardt states that to the naked eye, a good sand should consist of particles seemingly uniform in size, with a sharp feel to the touch. When strewn upon dark paper it should show no dust, and when moistened with from 10 to 20 per cent of water it must be capable of being formed into balls without becoming pulpy or being too easily crushed.

Constituents.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
SiO ₂	92.083	91.907	92.913	90.625	79.02	86.68	87.6	90.25
Al ₂ O ₃	5.415	5.683	5.850	6.667	13.72	9.23	7.7	4.10
Fe ₂ O ₃ and FeO	2.498	2.177	1.249	2.708	2.40	3.42	3.6	5.51
CaO	Traces	0.415	Traces	Traces	.....	0.96	0.96	0.23
MgO .....	.....	.....	.....	.....	0.71	.....	.....	.....
K ₂ O .....	.....	.....	.....	.....	4.58	.....	.....	.....
	99.996	100.182	100.012	100.000	100.43	100.29	99.86	100.09

Of the above No. I is from Charlottenburg, Germany; No. II, a sand employed for bronze castings in Paris foundries; No. III, sand from Manchester, England; No. IV, from near Stromberg; No. V, from Ilsenburg, in the Hartz Mountains; No. VI, from Sheffield, England; No. VII, from Birmingham, England, and No. VIII, from Lüneburg.

The sand from Ilsenburg, the composition of which is given in column 5, is stated² to be prepared by mixing "common argillaceous sand, sand found in alluvial deposits, and sand from solid sandstone." In preparation the first two are carefully heated to dehydrate the clay and then mixed, equal proportions of each with the same amount of sandstone. The mixture is then ground and bolted, the product being as fine as flour and capable of receiving the most delicate impressions.

According to D. H. Truesdale,³ the four essential qualities in molding sand are, in the order of their importance, (1) refractoriness, (2) porosity, (3) fineness, and (4) bond. These qualities are dependent mainly upon the varying properties of siliceous sand and clay, the refractory nature being governed by the absence of such fluxing constituents as calcium carbonate, the alkalies, or of iron oxides. Since in nature it is not always possible to obtain the admixture of just the right proportion, artificial mixtures are often resorted to, as mentioned

¹ A Practical Treatise on Metallurgy, II, p. 626.

² Percy's Metallurgy, 1861, p. 239.

³ The Iron Trade Review, October, 1897, p. 24.

above. W. Ferguson gives¹ the following analyses of molding sand in actual use in his foundries:

Constituents	No. 1, fine sand for snap work.	No. 2, medium grade for medium class of work.	No. 3, coarse sand for heavy machine castings.	No. 4, for heavy machinery in dry-sand molds.
Silica.....	81.50	84.86	82.92	79.81
Alumina.....	9.88	7.03	8.21	10.00
Ferrie oxide.....	3.14	2.18	2.90	4.44
Combined water.....	3.00	2.20	2.85	2.89
Calcium carbonate.....	1.85	1.10	1.10	1.25
Magnesia.....	0.65	0.98	None.	0.88
Potassium.....	No estimate.	No estimate.	No estimate.	No estimate.
Manganese.....	Trace.	Trace.	Trace.	Trace.
Organic matter.....	Trace.	Trace.	Trace.	Trace.
Total.....	100.02	98.35	97.98	99.27

Sands containing lime or alkalis, that is those containing free calcite or feldspathic granules, are sometimes liable to fusion in the case of heavy castings. It is customary in such cases to coat the surface of the mold with graphite.

Sands suitable for ordinary castings are widespread, though the finer grades are often brought considerable distances, some of those used in bronze casting in America being imported from Europe. In the United States the beds are alluvial deposits of slight thickness. Large areas occur in New York State, in counties extending from the Adirondacks to New Jersey. At date of writing a very considerable proportion of the material used in the eastern United States is dug in Selkirk, Albany County, New York. (Specimen No. 61044, U.S.N.M.)

Nason states that these sands occur in beds varying from 6 inches to 3 feet or even 5 feet in thickness. They immediately underlie the surface soil and overlie coarser, well stratified sand beds more nearly allied to quicksands.

In gathering the sands for market, a section of land 1 or 2 rods in width is stripped of its overlying soil down to the sand, which is then dug up and carried away. When the area thus exposed is exhausted, a like area, immediately adjoining is stripped, the soil from the second being dumped into the first excavation. By this method the field, when finally stripped of its molding sand, is ready again for cultivation.

It is estimated that a bed of sand 6 inches in thickness will yield 1,000 tons an acre. The royalty paid the farmers from whose land it is taken varies from 5 to 25 cents a ton. Some 60,000 to 80,000 tons are shipped annually from Albany County alone.

The Selkirk molding sand is of a yellow-brown color, showing under the microscope angular and irregular rounded particles rarely more

¹ Iron Age, LX, December, 1897, p. 16.

than 0.25 mm. in diameter, interspersed with finely pulverulent matter which can only be designated as clay. The yellow-brown color of the sand is due to the thin film of iron oxide which coats the larger granules. When this film is removed by treatment with dilute hydrochloric acid, the constituent minerals are readily recognized as consisting mainly of quartz and feldspar fragments (both orthoclase and a plagioclase variety), occasional granules of magnetic iron oxide, and irregularly outlined scales of kaolin, together with dust-like material too finely comminuted for accurate determination. Many of the larger granules are white and opaque, being presumably feldspar in transition stages toward kaolin. An occasional flake of hornblende is present. The term *greensand*¹ is applied to the argillaceous molding sands, in an undried state, and which is employed in its native state, new and damp. The term *dry sand* is used in contradistinction, to indicate a sand that must be dried by heat before being fit for use. The dry sand is stated to be firmer and better adapted than the green for molding pipes, columns, shafts, and other long bodies of cylindrical form.

In England good molding sands are obtained from the Lower Mottled Sands of the Bunter (Trias) beds and from those of the Thanet (Lower Eocene).

6. MINERAL WATERS.

From a strictly scientific standpoint any water is a mineral water, since water is itself a mineral—an oxide of hydrogen. Common usage has, however, tended toward the restriction of the name to such waters as carry in solution an appreciable quantity of other mineral matter, although the actual amounts may be extremely variable.

Of the various salts held in solution, those of sodium, calcium, and iron are the more common, and more rarely, or at least in smaller amounts, occur those of potassium, lithium, magnesium, strontium, silicon, etc. The most common of the acids is carbonic, and the next probably sulphuric.

Classification.—The classification of mineral water is a matter attended with great difficulty from whatever standpoint it is approached. Such classification may be either geographic, geologic, therapeutic, or chemical, though the first two are naturally of little value, and the therapeutic, with our present knowledge, is a practical impossibility. The chemical classification is, on the whole, preferable, although even this, owing to the great variation of methods of stating results used by analytical chemists, is at present attended with some difficulty. Dr. A. C. Peale, the well-known authority on American mineral waters, has suggested the scheme given below,² and from his writings has been gleaned a majority of the facts here given.

¹ This must not be confounded with the Greensand marl, or Glauconitic sand used for fertilizing purposes, and mentioned on page 369.

² Annual Report of the U. S. Geological Survey, 1892-93, p. 64.

According to their temperatures as they flow from the springs the waters are divided primarily into (A) thermal and (B) nonthermal, a thermal water being one the mean annual temperature of which is 70° F. or above. Each of these groups is again subdivided according to the character of the acids and their salts held in solution as below:

Class I. Alkaline.	
Class II. Alkaline-saline.	{ Sulphated.
	{ Muriated.
Class III. Saline	{ Sulphated.
	{ Muriated.
	{ Sulphated.
Class IV. Acid.....	{ Muriated.
	{ Silicious .. { Sulphated.
	{ Muriated.

Any spring of water may be characterized by the presence or absence of gas when it is designated by one of the following terms: (1) Nongaseous (free from gas). (2) Carbonated (containing carbonic-acid gas). (3) Sulphureted (containing hydrogen sulphide). (4) Azotized (containing nitrogen gas). (5) Carbureted (having carbureted hydrogen).

In cases where there is a combination of gases such is indicated by a combination of terms, as sulphocarbonated, etc. The classes may be further subdivided according to the predominating salt in solution, as (1) sodic, (2) lithic, (3) potassic, (4) calcic, (5) magnesian, (6) chalybeate, (7) aluminous.

The alkaline waters, Class I above, include those which are characterized by the presence of alkaline carbonates. Generally such are characterized also by the presence of free carbonic acid. Nearly one-half the alkaline springs of the United States are calcic-alkaline, that is, carry calcium carbonate as the principal constituent. The saline waters include those in which sulphates or chlorides predominate. They are more numerous than are the alkaline waters. The alkali-saline class includes all waters in which there is a combination of alkaline carbonates with sulphates and chlorides; the acid class includes all those containing free acid, which is mainly carbonic, though it may be silicic, muriatic, or sulphuric.

The character of the salts held in solution is the same for both thermal and nonthermal springs, though as a general rule the amount of salt is greatest in those which are classed as thermal. Thus at the Hot Springs of Virginia one of the springs, with a temperature of 78° F., has 18.09 grains to the gallon of solid contents, while another, with a temperature of 110° F., has 33.36 grains to the gallon.

Source of mineral waters.—Pure water is a universal solvent and its natural solvent power is increased through the carbonic acid which it takes up in its passage through the atmosphere, and by this same acid and other organic and inorganic acids and the alkalis which it acquires in passing through the soil and rocks. The water of all springs is

meteoric, that is, it is water which has fallen upon the earth from clouds, and gradually percolating downward issues again in the form of springs at lower levels. In this passage through the superficial portion of the earth's crust it dissolves the various salts, the kind and quantity being dependent upon the kind of rocks, the temperatures and pressure of the water, as well as the amount of absorbed gases it contains.

Both the mineral contents and the temperature of spring waters are dependent upon the geological features of the country they occupy.

As a rule springs in regions of sedimentary rocks carry a larger proportion of salts than those in regions of eruptive and metamorphic rocks. Thermal springs are as a rule limited to regions of comparative recent volcanic activity, or where the rocks have been disturbed, crushed, folded, and faulted, as in mountainous regions. Occasional thermal springs are met with in undisturbed areas, but such are regarded as of deep-seated origin, and to owe their temperatures to the great depths from which they are derived.

Distribution.—Mineral springs of some sort are to be found in each and all of the States of the American Union, though naturally the resources of the more sparsely settled States have not as yet been fully developed. For this reason the table given herewith is to a certain extent misleading:

Production of mineral waters in 1899 by States and Territories.

State or Territory.	Springs report- ing.	Product.	Value.
		<i>Gallons.</i>	
Alabama	4	38,900	\$19,917
Arkansas	5	48,602	17,442
California	38	1,464,075	698,493
Colorado	11	642,850	172,970
Connecticut	12	338,017	50,685
District of Columbia	2	168,500	10,275
Florida	2	17,000	7,250
Georgia	6	128,040	21,770
Illinois	18	858,950	101,090
Indiana	12	162,475	25,255
Iowa	3	40,200	3,320
Kansas	6	36,175	2,718
Kentucky	4	63,500	7,032
Maine	26	1,850,132	179,450
Maryland	11	100,380	13,045
Massachusetts	39	4,439,041	230,704
Michigan	21	3,045,400	368,235
Minnesota	4	2,078,700	54,704
Mississippi	6	271,500	48,292
Missouri	12	551,876	262,705
New Hampshire	6	469,800	190,990
New Jersey	7	332,000	171,380
New Mexico	5	46,800	7,770

Production of mineral waters in 1899 by States and Territories—Continued.

State or Territory.	Springs reporting.	Product.	Value.
		<i>Gallons.</i>	
New York	46	4,454,057	\$809,056
North Carolina	7	103,150	20,715
Ohio	15	2,494,473	171,135
Oregon	2	45,500	9,700
Pennsylvania	25	1,542,800	340,254
Rhode Island	4	195,000	15,000
South Carolina	5	322,564	33,450
South Dakota	2	138,645	44,073
Tennessee	6	346,700	55,658
Texas	15	4,729,950	155,047
Utah	3	7,850	1,955
Vermont	6	53,917	15,869
Virginia	39	954,689	341,769
Washington	3	54,000	7,002
West Virginia	7	32,220	18,305
Wisconsin	30	4,089,329	701,367
Other States <i>a</i>	4	263,782	75,847
Total	479	37,021,539	5,484,694
Estimated production of springs not reporting sales	62	2,540,597	1,463,336
Grand total	541	39,562,136	6,948,030

a The States in which only one spring for each has made a report are included here. These States are Idaho, Louisiana, Montana, and Nebraska.

Uses.—The mineral waters are utilized mainly for drinking and bathing purposes, the thermal springs being naturally best suited for bathing, and the nonthermal for drinking purposes.

For exhibition purposes the following waters have been selected, kind and geographic distribution being the controlling factors in making up the collection. In all cases the samples are exhibited in the original bottles as put upon the market.

ALKALINE WATERS.

Poland Natural Spring Water, Poland Springs, Maine.
 Ballardvale Lithia Spring Water, Ballardvale, Massachusetts.
 Londonderry Lithia Spring Water, Londonderry, New Hampshire.
 Otterburn Lithia Water, Amelia, Virginia.
 Capon Springs Mineral Water, Capon Springs, West Virginia.
 Jackson Lithia Spring Water, Jackson County, Missouri.
 Algonquin Spring Water, Prince George County, Maryland.
 Manitou Natural Mineral Water, Manitou, Colorado.
 Rock Mineral Water, Jeffress, Virginia.
 Massanetta Spring Water, Harrisonburg, Virginia.
 Bethesda Natural Mineral Water, Waukesha, Wisconsin.
 Clysmic Natural Mineral Water, Waukesha, Wisconsin.
 White Rock Lithia Water, Waukesha, Wisconsin.
 Idanha Natural Mineral Water, Soda Springs, Idaho.
 Missisquoi Mineral Water, Sheldon, Vermont.

ALKALINE SALINE WATERS.

1. *Sulphated.*

Takoma Springs Water, Takoma Park, Maryland.
 Fonticello Lithia Water, Chesterfield County, Virginia.
 Tredyffrin Lithia Water, Chester County, Pennsylvania.
 Charnian Natural Mineral Water, Franklin County, Pennsylvania.
 Harris Antidyspeptic and Tonic Water, Burkeville, Virginia.
 Crockett's Arsenic Lithia Water, Shawsville, Virginia.
 Thompson's Bromine and Arsenic Springs Water, Ashe County, North Carolina.
 Harris Lithia Water, Laurens County, South Carolina.
 Stafford Mineral Water, Jasper County, Mississippi.
 Bladensburg Spa Mineral Water, Bladensburg, Maryland.
 Healing Springs Lithia Water, Bath County, Virginia.
 Fairchild's Potash Sulphur Water, Garland County, Arkansas.
 Buffalo Lithia (Spring No. 2) Mineral Water, Buffalo Lithia Springs, Virginia.
 Geneva Red Cross Lithia Spring Water, Geneva, New York.
 Wright's Epsom Lithia Water, Mooresburg, Tennessee.
 Veronica Natural Mineral Water, Santa Barbara, California.

2. *Muriated.*

Como Lithia Water, Henrico County, Virginia.
 Powhatan Natural Mineral Water, Alexandria County, Virginia.
 Blackistone Island Mineral Water, St. Marys County, Maryland.
 Columbia Natural Lithia Water, Washington City.
 Saratoga Natural Vichy Water, Saratoga Springs, New York.
 Lincoln Spring Water, Saratoga Springs, New York.
 The Hathorn Mineral Water, Saratoga Springs, New York.
 High Rock Springs Water, Saratoga Springs, New York.
 Congress Water, Saratoga Springs, New York.
 Houston Lithia Water, Houston, Virginia.

SALINE WATERS.

1. *Sulphated.*

Indian Spring Water, Sligo, Maryland.
 Rockhill Spring Water, Rockville, Maryland.
 Pluto Spring Water, French Lick Springs, Indiana.
 Excelsior Mineral Water, Excelsior Springs, Michigan.
 Greenbrier White Sulphur Water, Greenbrier County, West Virginia.
 Geneva Lithia Water, Geneva, New York.
 Blue Ridge Springs Water, Botetourt County, Virginia.

2. *Muriated.*

Anipa Spring Water, Rome, Georgia.
 Deep Rock Spring Mineral Water, Oswego, New York.
 Blue Lick Water, Blue Lick Springs, Kentucky.

ACID WATERS.

1. *Sulphated.*

Shenandoah Alum Springs Water, Shenandoah County, Virginia.
 Rockbridge Alum Springs Water, Alum Springs, Virginia.
 Wallawhatoola Sulphated-aluminous Chalybeate Water, Millboro Springs, Virginia.

7. ROAD-MAKING MATERIALS.

Roadways subject to any considerable amount of traffic demand almost invariably some sort of stone bedding to prevent their becoming soft or badly cut up and rutted by wheels and hoofs of horses. Until within a comparatively few years it has been the general custom to pave the streets of cities and towns with rectangular blocks of granite, trap, or other hard rock, forming thus the well-known Belgian block and Telford pavements. Such are set in regular rows and the interspaces filled with sand and sometimes with tar or asphalt. For suburban and country roads a pavement of broken stone, the invention of a Mr. L. Macadam about 1820, and known by his name, is at present the most extensively used. The invention is based upon the property possessed by freshly broken stone of becoming compacted and to a certain degree even cemented when subject to heavy rolling and the impact of wheels. The finer particles, broken away by the action of the wheels, fill the interstices of the larger, and gradually bring about an induration forming a roadbed hard, smooth, and durable.

Not all materials are equally good for macadamizing purposes. If the rock is too hard ordinary travel is not sufficient to produce the desired amount of fine material, and satisfactory cementation does not ensue. If too soft it grinds away too rapidly. If the material is decomposed, it is stated, it does not become sufficiently indurated—refuses to set, as it were.

Obviously the bulk matter of any roadbed must be built up of materials from near-by sources, owing to cost of transportation. For surfacing, however, materials are often carried long distances. For this purpose a hard, dense rock, such as the finer grades of trappean rocks, are now most generally used.

Macadam is laid with or without a foundation of larger stones. When such is used a thickness of from 6 to 12 inches is recommended and over this is laid from 4 to 6 inches of the broken stone or "metal."

Taking all points into consideration, it is probable that the best size for macadam, for hard and tough stones, such as basalt, close-grained granite, syenite, gneiss, and the hardest of primary crystallized rocks, is from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches cube, according to their respective toughness and hardness, while stones of medium quality ought to be broken to gauge of from $1\frac{1}{2}$ to $2\frac{1}{4}$ inches, and the softer kinds of stone might vary between the limits of 2 and $2\frac{1}{2}$ or $2\frac{3}{4}$ inches, but the latter is a size which should seldom be specified.

On roads for light driving it is customary to place a final surfacing of smaller stone, such as will pass a 1-inch mesh.

Considerable importance is attached to the manner in which the macadam is prepared for use. Machine-broken stone is not considered of the same value as that broken by hand. The stones are not so regular a size and shape, and there is a greater proportion of inferior stuff. A mechanical crusher is apt to stun the material, and does not leave the edges so sharp for binding as they are when the stone is broken with a small hammer.¹

¹ Circular No. 12, U. S. Department of Agriculture, Office of Road Inquiry, 1896.

The cost of macadamized roads from necessity varies almost indefinitely. The primary factors are (1) cost of labor, (2) accessibility of materials, and (3) character of country. From \$2,000 to \$2,500 a mile is perhaps an average figure for localities where materials are available close at hand.

The collections are intended to show only the average sizes employed and the varying nature of materials.



A PRIMITIVE FRAME FOR WEAVING NARROW
FABRICS.

BY

OTIS TUFTON MASON,

Curator, Division of Ethnology.

A PRIMITIVE FRAME FOR WEAVING NARROW FABRICS.

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“Tela jugo vineta est; stamen secernit arundo;
Inseritur medium radiis subtemen acutis;
Quod digiti expediunt, atque inter flamina ductum
Percusso feriunt infecti pectine dentes.”
(OVID—*Pallas and Arachne*, lines 55-58.)

INTRODUCTION.

The textile art among savage and barbarous peoples, as well as in the hands of country folk in civilization, consists in the joining of flexible materials in filaments—straw, splints, threads, etc. The simplest of these activities is twisting or twining. The making of sennit or braid comes next. After that will follow basketry, matting, netting, lace work, and even fabrics, all made, out and out, with the fingers.

The second step in the textile art, as in all others, will be taken with the aid of some kind of device which hastens or perfects the operation of the hand. There will be knives to split the material, gauges to replace the finger nail, spindles, bobbins, frames, and shuttles, of very humble structure, forsooth, but all of them containing the working principles of the most advanced apparatus having the same functions. Omitting all other textile processes, attention will be directed here to weaving proper, or the use of mechanical appliances to this end among primitive peoples.

In any style of mechanical weaving, however simple or complex, even in darning, the following operations are performed: First, raising and lowering alternately different sets of warp filaments to form the “sheds;” second, throwing the shuttle, or performing some operation that amounts to the same thing; third, after inserting the weft thread, driving it home and adjusting it by means of the batten, be it the needle, the finger, the shuttle, or a separate device.

In the modern power loom the parts by which these operations are performed are very intricate and rapid in their composition and action; but in the simplest form of apparatus, from which the power loom was originally derived, a few sticks and strings and the cunning hand of the operator take the place of machinery, and time is no object. A careful examination of any power loom will demonstrate the oft-repeated fact that most of the machinery, after all, is a substitute for the human fingers.

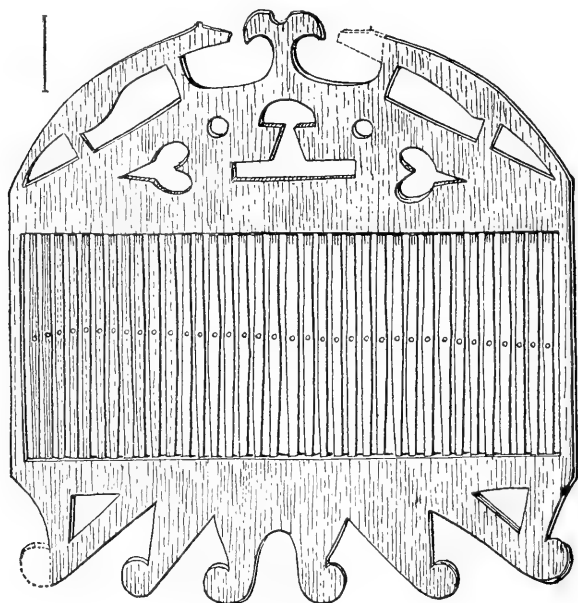


Fig. 1.

CHIPPEWA HEDDLE FRAME, CARVED FROM A SINGLE PIECE OF WOOD.

Cat. No. 3648, U.S.N.M. Collected by Henry R. Schoolcraft.

DEFINITION OF HEDDLE FRAMES.

There are in the U. S. National Museum a collection of heddle frames, and photographs of others from different parts of Europe and America, each one of which was designed to form the "sheds" in weaving belts and garters—that is, to raise or lower different sets of warp filaments in the manner to be now described. A series of healds are attached to or form parts of a heddle frame, which sometimes hangs free on the warp threads, as in the frontispiece, and sometimes is attached solidly to a frame or box, or to the body of the operator. (Compare fig. 16 with Plate 3.) In the former of these classes the "sheds" are opened by the weaver, who lifts or lowers the heddle with the hand. In the second class, the "sheds" are formed by raising or lowering the inner ends of the warp itself, half of its filaments being

entangled in the stirrups of the healds, the other half passing up and down between the healds.

A still simpler style of making "sheds" may be seen in a Chinese device employed in weaving rush matting. A block of wood like a piece of studding, as long as the matting is to be wide and $\frac{1}{4}$ inches square in section, has a series of triangular saw cuts through it. Each cut has an upright opening on one side and terminates with a small hole on the opposite side. The next saw cut alternates with the preceding, its long opening being on the side of the small perforation in the other cut. In rocking the heddle block by means of two handles on top, backward and forward, "sheds" are formed in the twine which constitutes the warp of the matting.

The specimens to be herein described came to the Museum from the Zuñi and other pueblos of the Southwest; from the Masquakee or Sauks of Iowa; from the Chippewa Indians; from Finland, Germany, and Italy in Europe; and, finally, from the English settlements in the New England States and New York, and the Dutch settlements in Lancaster County, Pennsylvania. To complete the round this ingenious mechanism, having traveled through many lands and some centuries, emerges from the U. S. Patent Office as patent No. 334320 (Plate 4), and adapted forms are used for illustrating technical instruction in the Teachers' College, New York.

HEDDLE FRAME OF THE ALGONQUIN TRIBES.

The first of these objects brought to the notice of the ethnologist, belonging to the first class above described, in which the operator raises and lowers the heddle frame, was a Chippewa specimen figured in Schoolcraft, but no description of it is there given (fig. 1).

The Chippewa Indians (belonging to the Algonquin family) about Lakes Michigan, Huron, and Superior were in an excellent area of food supply, contiguous to Iroquoian and Siouan tribes, and were also brought into close industrial relationship with the French explorers and priests; later the English settlers became their teachers.¹

The very object described by Mr. Schoolcraft was in the possession of the United States Government before the U. S. National Museum was founded, and is here figured; but there is on the specimen and in the catalogues no allusion to the distinguished ethnologist and none to the function of the apparatus. It is carved from a single block of beech wood one-eighth of an inch thick. The upper margin is rounded and cut into patterns as with a jig saw, representing two animals, two hearts, and a symmetrical pattern in the middle. The lower margin is treated in the same way, only the designs are such as might be seen on old-fashioned furniture. The working part of this apparatus is

¹ Information respecting the Condition and Prospects of the Indian Tribes of the United States, Philadelphia, 1852, II, pl. 77.

the rectangular space constituting the middle portion. There are thirty-seven upright healds or "heddle dents" and thirty-eight spaces. The healds are not inserted into the wooden frame, but are a part of it, and are about the twenty-fourth of an inch in thickness, the material having been cut away on both sides so as to leave these as thin as safety would allow. Each heald or upright piece is wider in the center than at the ends and is there perforated with a small hole. The whole frame is just $7\frac{1}{2}$ inches wide and the healds about 3 inches in length. The points to be especially noticed in this example are, first, that the apparatus is made from a single piece of wood; second, that the Indians of the upper Great Lakes were taught by the early settlers from Europe to be weavers; and third, that the method of ornamentation, shown at the top and bottom of this specimen, is common enough in Germany (figs. 8 and 9), but it is not common elsewhere among American aborigines on such heddle frames. The healds and spaces, together seventy-five in number, make provision for seventy-five warp threads in all.

Mr. W J McGee, of the Bureau of American Ethnology, calls attention to similar heddle frames in use among the Masquakee, or Sauks and Foxes, an Algonquin tribe in Iowa, and presents to the U. S. National Museum an excellent example of a weaving frame from that tribe (fig. 2).

Mr. W. H. Jackson says that the Sacs, Sauks, Saukies, or Osaukees, as it has been variously written—a word meaning yellow clay—and the Foxes, or Outagamies, or more properly the Musquakkink (red clay) are now as one tribe. They were first discovered settled about Green Bay, Wisconsin (after residence on the north shore of Lake Ontario), but their possessions extended westward, so that the larger part was beyond the Mississippi. They partly subdued and admitted into their alliance the Iowa, a Dakota tribe. By 1804 they had ceded all their lands east of the Mississippi and settled on the Des Moines River, moving subsequently to the Osage (in Kansas) and, after 1842 [in 1845], the most of these finally to the Indian Territory. In 1822 the united bands numbered 8,000, but are now [1875] reduced to a little more than 1,000, of whom 341 are still in Iowa, 430 in the Indian Territory, 98 in Nebraska, and about 200 in Kansas. The Sauks and Foxes of the Mississippi in the Indian Territory have a reservation of 483,840 acres.¹

The frame is made of walnut and is in its general structure similar to the foregoing, but is much heavier and more elaborately finished. It has forty-two healds, making provision for eighty-three warp threads in all. The ornamentation, at the top especially, has been evidently under the influence of whites in quite recent times. In this

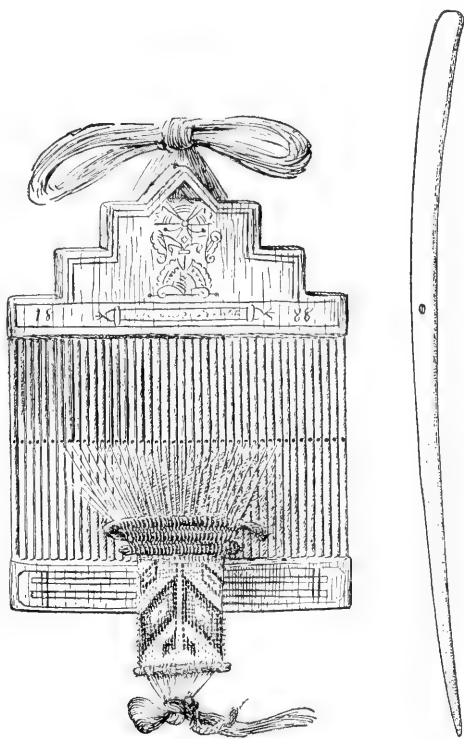
¹ Report U. S. National Museum, 1885, p. 37.

specimen, as it is set up, the healds are not all used, only a sufficient number to enable the weaver to form a texture having fifty-five warp threads. Especial interest attaches to this piece of work, which is an example of transparent weaving and beadwork. The warp consists of fifty-five white threads. The shuttle is a steel needle threaded with fine cotton on which beads of different colors are strung. The figures are produced by counting off the beads and arranging them so that one will fall in each of the interstices of the weaving.

Accompanying this frame (fig. 3) is a shuttle for mat weaving, having an eye near the center of its body. In forming the beadwork a steel needle was employed; but in ordinary garter weaving on the same loom the shuttle was employed both for placing the weft and beating it home.

The general method of operation in both heddles just described and in all others of this type was as follows: Warp threads of the healds and spaces, or a smaller number, were cut into the length of the intended garter, or belt, or band to be woven. If they were all of the same color one filament was drawn through the stirrup in each heald and one passed between each pair

of healds. If there were to be various colors in the warp, filaments of different shades were passed through the stirrups and between the healds according to the taste of the weaver. At one end, which will be called the outer or farther end, the filaments were gathered together into a knot and made fast to some fixed object answering to the yarn beam of a loom. The other end, which will be called the inner or proximal end, answering to the cloth beam of a loom, contained that portion of the fabric which, when finished, was rolled on a stick that lay against the breast of the weaver and was secured by a strap passing around the body and buttoned to the ends of the cloth beam. Sometimes the inner ends of the warp were merely held in the left



Figs. 2 and 3.

MASQUAKIE HEDDLE FRAME AND SHUTTLE.

Cat. Nos. 265262 and 176680, U.S.N.M. Collected by W J McGee.

hand of the weaver. In any case, they were secured to some movable object which allowed the weaver to increase or decrease the tension at will.

THE PUEBLO HEDDLE.

There is among the Zuñi Indians a style of setting up the warp of a belt or garter for heddles of this class, which relates the frame to the Indian blanket loom. The warp is one continuous yarn wound round and round two cylinders, one resting against the soles of the weaver's feet, the other attached to her body by a strap which passes behind her back, its ends buttoning over the ends of the inner cylinder. In the use of this device the warp is loosened or tightened by moving the feet or inclining the body, the most pliant, delicate, and responsive tension device.¹ (Plate 1.)

When the woman and her loom apparatus were set up for work, she raised or lowered the heddle with one hand. The warp filaments which passed through the stirrups in the healds, being fixed in their places, were by this movement raised or lowered with the frame, but the alternate threads which passed between the healds remained steadfast and straight. Whether the frame was raised or lowered, a "shed" was formed in the warp; the weaver then passed through this "shed" a simple bobbin or shuttle, often a rod with the weft woven on it, after the manner of a kite string, containing the weft or woof filaments, usually of white thread and quite fine. When the weft had been passed through this "shed" between the heddle frame and the body of the weaver it was beaten home by means of the shuttle or with a separate tool, as among the Zuñi, or by the weaver's finger. This completed one weft.

The alternate warp series were then brought to the top or depressed, and a second "shed" formed. The shuttle was passed back through this "shed" and the weft again beaten home. If a pattern was to be wrought, the shuttle was not passed through the "shed" as described, but worked, as in darning, through a certain number of the upper warp threads each time before a new "shed" was made.

THE FINLAND HEDDLE.

In 1893, Consul-General John M. Crawford sent to the U. S. National Museum, from Helsingfors, in Finland, two specimens of this type of heddle, one of which resembles in general features those described, while the other (fig. 4) is very suggestive of the type found in the pueblos of southwestern United States, to be later studied (fig. 5).

¹ Washington Matthews, *Navajo Weavers*. Third Annual Report of Bureau of Ethnology (1884), pp. 371-378.

Each of these specimens is carved out of a single piece of wood, and in each one the framework above and below is much thicker than the healds. Fig. 4 has eighteen healds in all and seventeen long slits between them. The specimen is 8 inches long and $5\frac{1}{2}$ wide. The upright bars are whittled into a roundish shape, so as to present no sharp corners to the work. The top of the framework is carved out into the form of a ring used both in handling the apparatus and for suspending it when out of use. In fig. 5 the upper and lower margins are cylindrical in form, like the back of a comb, the middle parts corresponding to the teeth. In outline this example is nearly square, being about $5\frac{1}{2}$ inches broad and high. Accompanying this specimen of Consul-General Crawford's was a shuttle for carrying the weft. It is a thin piece of wood, parallel-sided, except a slight constriction at the middle, with a wide notch at either end for holding the weft filament; the edges are sharpened for driving home the lay. It also has a perforation through one end for the purpose of suspension.

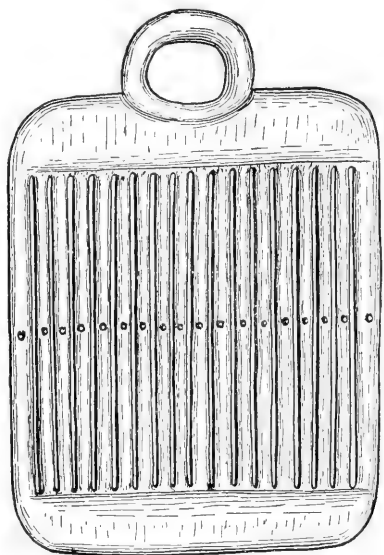


Fig. 4.

HEDDLE FROM HELSINGFORS, FINLAND.

Cat. No. 167839, U.S.N.M. Collected by Consul-General John M. Crawford.

With these frames were a number of belts and garters woven in such apparatus, which exhibit in their patterns the manner of producing diaper effects on the surface. In plain weaving, it will be recalled, the shuttle is passed backward and forward on the "shed" produced by the vertical motion of the heddle, and as soon as the weft is passed the shuttle becomes a batten for driving it home. But whenever the weaver desires to produce other effects than plain weaving, it is necessary to count off from the upper threads at each excursion of the shuttle such numbers of warps as are necessary, and to use a batten stick or her fingers in forming the secondary "shed" and in driving home the weft. This custom also appears in other places, to be mentioned farther on. In each instance, the patterns on Plate 2 are in pairs, showing the two sides of the fabric and the effects of the special secondary treatment of the warp by counting. There is thus to be seen in these patterns a good example of primitive arithmetic (Plate 2). Attention is especially called to the fact that along with this type of heddle in the Crawford collection there came a loom for weaving

coarse hemp cloth. This apparatus coincides precisely with the common hand loom seen over Europe and the United States. Just as in New England and in New York the country folk were making cloth and tape with primitive apparatus only a generation back, so in Finland the same practices yet survive. Helsingfors lies at the northern end of the Baltic Sea, and it is only a short journey thence to northern Germany, where the little heddle frame will next be found. It doubt-

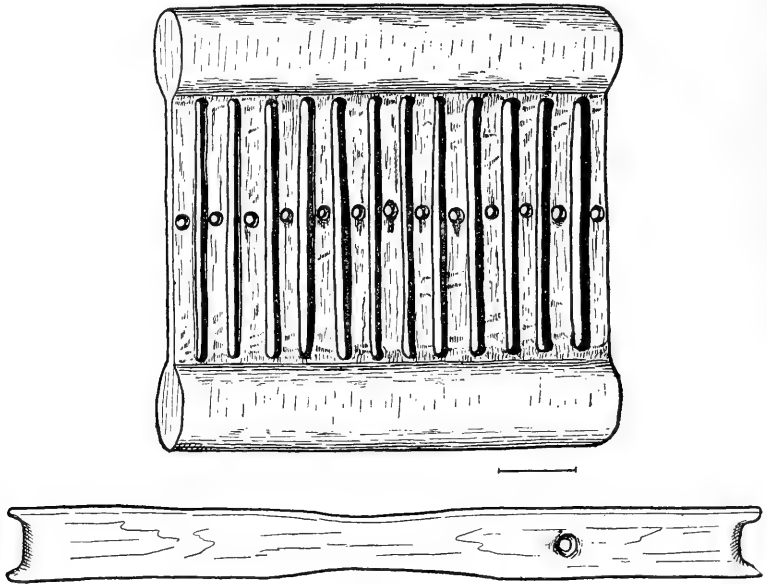


Fig. 5.

HEDDLE FROM HELSINGFORS, FINLAND, WITH SHUTTLE.

Cat. No. 167837, U.S.N.M. Collected by Consul-General John M. Crawford.

less traveled northward, acquiring a new name at every landing, but its structure and function have undergone little change. The patterns at Helsingfors are more primitive.

GERMAN HEDDLE FRAMES.

The next example takes the student to the town of Saalfeld, Königsberg, in east Prussia. It was presented to the U. S. National Museum by Mrs. Elizabeth Lemke, who says that it is a common apparatus among the people. There are twenty bars or healds in this example, and nineteen slits between. The frame is $14\frac{5}{8}$ inches long, and $8\frac{1}{4}$ inches wide. The healds are $8\frac{3}{4}$ inches long, giving to the warp thread a wider excursion up and down. This specimen is made from a thin pine board finished in a planing mill, and is three-eighths of an inch

thick, without ornaments. The upper part is rounded and has a projecting handle, as in old-fashioned school slates.

The shuttle is of hard wood and resembles the form of a netting needle which has a deep, rectangular notch at one end and a slitted point at the other end opening into an eye, in the middle of which stands a pointed spindle. This specimen, like all those before mentioned, hangs free on the warp, and the "sheds" are made by moving the heddle up and down while the warp is stationary at both ends (fig. 6).

Example No. 176321, in the U. S. National Museum, is also from Saalfeld. It is made of a thin piece of plain board, and there are sixteen healds and fifteen slits or spaces between the healds. The apparatus is $19\frac{1}{4}$ inches long, 8 inches wide, and nearly one-half an inch thick, rounded at the upper end, and cut out to form a hand hold or grip. The saw cuts are roughly made, and the holes have been burned through with hot wire.

The shuttle is a small seine needle, not slitted at the point, but having a projecting spindle in the eye at the pointed end and a deep notch in the other, as in the common seine needle. In this example the shuttle contains white weft thread or twine; the warp filaments are alternating brown, blue, white, and red threads. The shuttle serves also for a batten to beat the weft in place.

Accompanying this apparatus is a device used in winding off the warp and giving to its filaments the correct length (fig. 7). It is a piece of hard wood, heart-shaped, with a pointed base to fit in a socket and a pointed spool above to hold the yarn.

In the Museum of the Society for Pomeranian History and Antiquities, in Stettin, are three heddles or weaving boards of the type now being considered. Each was collected in Further Pomerania, where the apparatus is called the "deska," as it is also known in Cassubisch dialect. It is in use up to the present day, but among the surrounding German population throughout the whole of Pomerania, so far as information goes, it is unknown. The oldest one (fig. 8) measures 4 inches in width and 7 inches in length, is carved out of a single piece of wood, and has nine long openings between the healds which, through many years of use, have become worn away. These openings or slits are 3 inches long and 0.2 inch broad. There are ten perforations for warp

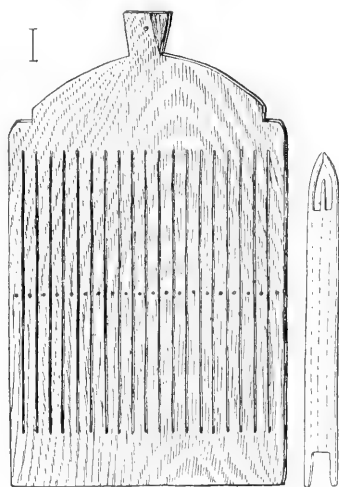


Fig. 6.

HEDDLE AND SHUTTLE, FROM SAALFELD,
EAST PRUSSIA.

Cat. No. 175642a, U.S.N.M. Collected by
Elizabeth Lemke.

threads, the outer two being through the sides of the frame itself. The upper margin of the board is cut out in figures or patterns quite similar to those on the Schoolcraft specimen. In addition to these openings, the surface is covered with carvings.

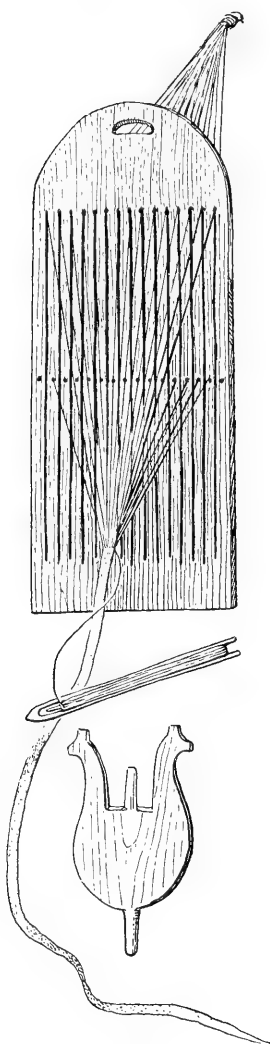


Fig. 7.

HEDDLE AND SHUTTLE, SET UP FOR WEAVING, ALSO WARP HOLDER.

Saalfeld, East Prussia.

Cat. No. 176321, U.S.N.M. Collected by Elizabeth Lemke.

The second example (fig. 9) is rather rudely made of board. It is 5 inches broad and 8 inches long. Counting the sides of the apparatus, there are fourteen beads, perforated in the middle, through which warp threads pass, and thirteen slits or openings between these, all $4\frac{1}{2}$ inches long and 0.2 inch broad. The upper part of the board has three heart-shaped perforations, a serrated border, and a loop, used for moving the heddle up and down or for hanging it up when not in use.

A third example, having no ornamentation, is $5\frac{1}{2}$ inches long and 8 inches broad. It has eighteen openings, $\frac{1}{4}$ inches long.¹

The lack of definite information concerning the precise origin of the Schoolcraft specimen (fig. 1) and that of the Sauk or Masquakie Indians of central Iowa, collected by Mr. W J McGee, makes it difficult to inquire into the German origin of the Algonquin specimens. It must be noted, however, that the ornamental carvings at the top are alike in the two types. Furthermore, it must not be assumed that the specimens in the U. S. National Museum exhaust the geographic distribution of this type of apparatus. Quite the contrary. It would be surprising to find that it had no use in England and France in the Colonial period.

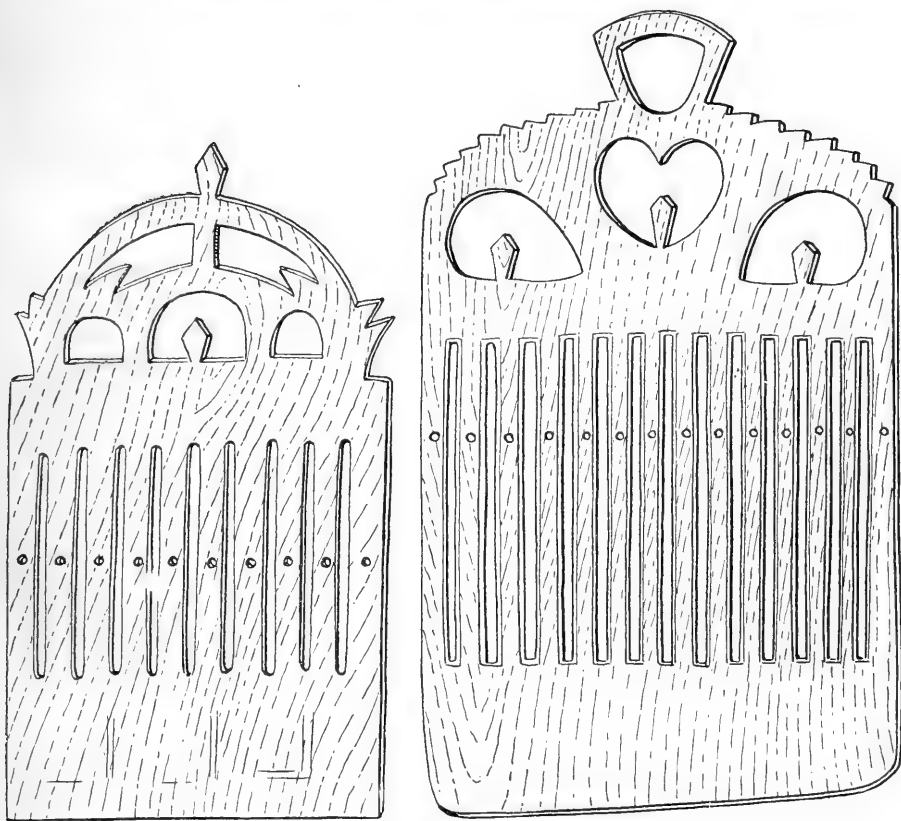
ITALIAN HEDDLE FRAMES.

In the U. S. National Museum is a heddle frame from the town of Siena, south of Tuscany, Italy, collected by Dr. G. Brown Goode. Unfortunately, material is lacking in all the area between east Prussia and Tuscany.

Furthermore, it will be seen that the inventor has been at work more than once to transform the Cassubisch into the Tuscan specimen

¹Upon the Cassubic population of Farther Pomerania see *Baltische Studien*, by Dr. C. A. Hass, pp. 33-368, and *Blätter für Volkskunde*, IV, pp. 51-81.

(fig. 10). It consists of eleven strips or healds of walnut wood $5\frac{1}{4}$ inches long, one-fourth inch wide, and one-twelfth inch thick, each perforated in the middle for a warp filament. These slats are set into grooves in a rectangular frame $6\frac{1}{2}$ inches long and $5\frac{5}{8}$ inches wide; the frame itself is three-fourths inch wide and five-sixteenths inch thick. It accommodates twenty-three warp filaments and belongs to the second class of heddles before mentioned, in which the heddle



Figs. 8 and 9.

HEDDLES FROM STETTIN, NORTH GERMANY.

In Museum of the Society for Pomeranian Antiquities.

is stationary and the weaver raises and lowers the inner end of the warp. This specimen is set up, with considerable mechanical accompaniment, on one end of a box that is $7\frac{1}{2}$ inches long and $5\frac{1}{4}$ inches wide. On the other end is an upright frame in which works a revolving yarn beam, a feature copied from the ordinary hand loom.

There is also in the U. S. National Museum a facsimile of this example, from Lancaster, Pennsylvania, the center of the Teutonic

population called the Pennsylvania Dutch. The framework, or heddle frame, has thirty-one healds or upright bars, perforated, and thirty-two slits, in all accommodating sixty-three warp threads of various colors. The ordinary yarn beam is replaced in this example by a reel, on which the warp is distributed. This reel is held fast by a stick pushed through between the spokes of the reel and resting against the upright posts which support the shaft. By removing the stick additional warp may be unwound (fig. 11). Still more rude is another example in the U. S. National Museum, probably from Pennsylvania, consisting of a heddle frame cut out of a thin piece of board one-eighth inch thick. Provision is made for twenty warp threads, by means of ten healds and ten slits. On one margin of the frame the outer portion is perforated and on the other side it is not. This upright is nailed in the end of a very rude box, having a bottom and two sides but no ends. The box is 2 feet long. At the rear portion, on either side, a post is fastened, and in this a reel, on which the yarn is wound. The structure is similar to that of the Italian specimen and to others from Pennsylvania, but this is the rudest example of the kind in the Museum.

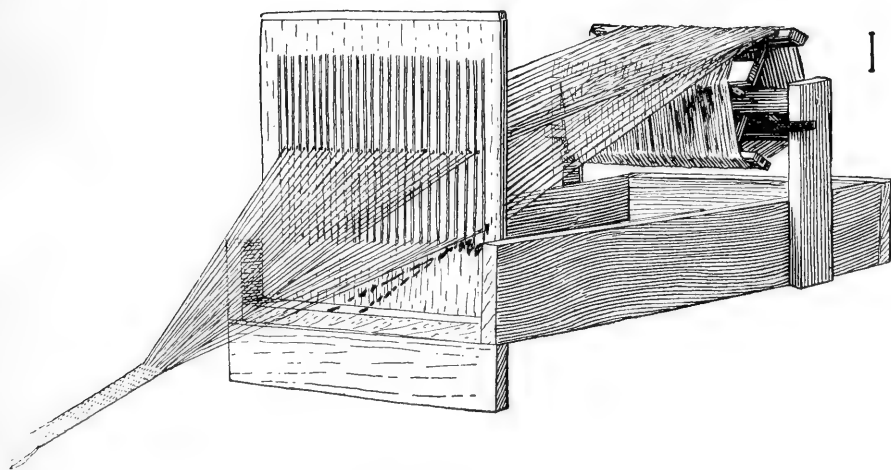
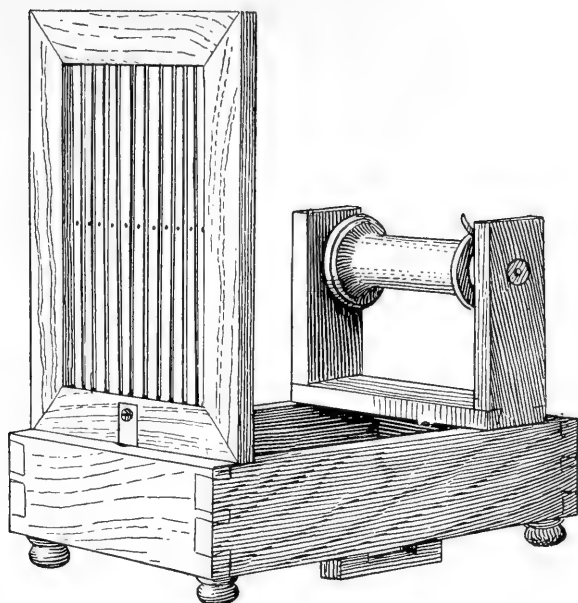
NEW ENGLAND HEDDLE FRAMES.

The writer is greatly indebted to Mrs. Alice Morse Earle, author of the charming work on *Life in Colonial Days*, for a photograph of a loom belonging to this stationary type for making silk braid, from Long Island, set up and in operation. The furniture of the room and the costume of the weaver are all in harmony with the instrument itself, and reproduce, as nearly as possible, the time in which these heddle frames were in common use throughout New England and the Eastern States. There is room for thirty-three warp threads, though it is possible to weave with a smaller number. Mrs. Earle, after speaking of the large, home-made looms seen in all thrifty New England houses, makes the following observation on the heddle frames:

Smaller looms, called tape looms, braid looms, belt looms, garter looms, or "gallus frames," were seen in many American homes, and useful they were in days when linen, cotton, woollen, or silk tapes, bobbins, and webbings or ribbons were not common and cheap, as to-day. Narrow bands, such as tapes, none-so-pretty's, ribbons, caddises, ferretings, inkles, were woven on these looms for use for garters, points, glove ties, hair laces, shoe strings, belts, hatbands, stay laces, breeches suspenders, etc.¹

In 1894 the author visited the town museum in Bristol, Connecticut, and saw two specimens of the second type of heddle apparatus, one of which was given to the U. S. National Museum, and is here figured (fig. 12). It will be recalled that in this type the heddle is fixed and the weaver moves the inner or cloth end of the warp up and

¹ Alice Morse Earle, *Home Life in Colonial Days*. New York, 1898, p. 225.



Figs. 10 and 11.

HEDDLES FROM SIENA, ITALY, AND LANCASTER, PENNSYLVANIA.

Set up in a box, with yarn beam and other loom attachments.

Cat. Nos. 164841 and 175639, U.S.N.M. Collected by G. Brown Goode.

down to form the sheds. A note with reference to these specimens was inserted the next day in the Hartford Courant, and as a result replies were received from various quarters, calling attention not only to the existence of other examples, but mentioning the names of women who in their early days had practiced weaving tape, fanciful hat-bands, garters, and other narrow ornamental fabrics on them. It became evident that a device which at first seemed to have been invented by American Indians was not known to them prior to Columbus, but had crept into savage hands from the folk craft of early white settlers.

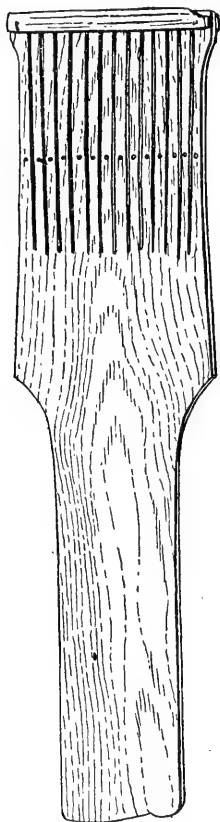


Fig. 12.

HEDDLE FRAME FROM BRISTOL, CONNECTICUT.

Cat. No. 169078, U.S.N.M. Presented to the National Museum by Roswell Atkins.

Specimen No. 169078, in the U. S. National Museum, is a heddle frame presented by Roswell Atkins, of Bristol, Connecticut, of the seventh generation of this family in the United States. It is made of a piece of pine board three-fourths of an inch thick. The upper end is sawed into fourteen healds, and each of them is pierced for a warp thread, making room for twenty-seven warp threads. At the top, the healds are held in place by two battens which clamp the upper ends. The bottom is chamfered to be held between the knees by a person sitting in a chair (fig. 12). This is a very primitive specimen of this class of heddles, and serves to illustrate their popularity in folk industry. There is nothing about this piece that is above the skill of the untutored farm boy with a common saw and awl and hammer; the lower portion is not even rounded out to fit the limbs of the operator as seen in other figures.

Specimen 175641 in the U. S. National Museum is a heddle frame from Bristol, Connecticut, made from a thin board of maple wood. The upper portion consists of twenty-two healds $8\frac{1}{4}$ inches long, sawed out from the top as in fig. 14 (fig. 13). These, together with twenty-one spaces, provide for forty-three warp filaments, and this portion of the apparatus is 9 inches wide. The tops of the healds fit in a groove of a rectangular block of oak which furnishes a framework to the upper border. On opposite sides, at the bottom of the healds, are riveted semicylindrical strips of the same material, strengthening the apparatus at that point. The continuation downward of this upper or working part forms a base 17 inches long, cut out in a pattern resembling a vase or lamp stand. This stand is inserted in a groove

at the end of a piece of oak wood and held fast by wooden pegs. Finally, the oak piece is firmly set in and mortised into a heavy block of wood which acts as a foot to the apparatus.

This specimen belongs to the class of stationary heddle frames as in the example from Siena, Italy, and from Lancaster, Pennsylvania. The specimens from Maine and Connecticut, held between the knees of the operator, really belong to the same type.

Mrs. F. R. Post, of Hebron, Connecticut, has one of these heddle frames cut out of a single piece of wood, on which her grandmother when young used to weave garters, etc., for her mother and her sisters, and her mother has also used it.

The warp was laid off in proper lengths by being wound around chairs, run through the holes in the healds and between slats; the outer ends were tied together and fastened to some object and the inner ends were held in the hand of the weaver. The weaver held the heddle between her knees by means of the projecting lower part or handle, and taking the inner ends of the warp in one hand, she raised and lowered it alternately. The slats allowed the warp to spring the same as the harness in a loom. The filling was put in with her other hand by means of a simple shuttle, and beat up with one finger. (Compare fig. 14.)

Mrs. Louise G. Strong, of Colchester, Connecticut, also sent to the U. S. National Museum models, in cardboard, of these primitive hand looms, and with them two specimens of work done thereon. The first specimen is tough white linen tape one-fourth of an inch wide, used in old country houses for making loops on towels and other fabrics to hang them up. The other example is in worsted; the warp is a series of black, green, red, olive, and blue worsted thread; the woof is a salmon-colored worsted thread, but it is invisible on the surface of the fabric, the warp having been driven hard home, so as to give a twilled effect.

Mrs. Strong says that the loom on which these were woven was used in her family eighty years ago for making substantial fabrics, but more especially as a pastime for young women.

Mrs. O. D. Nott, of New York, writes that her grandmother, living in the little village of Milton, Litchfield County, over sixty years ago, used a loom to make tape for apron strings. It was a very simple affair, operated as follows: One end of the warp threads was fastened to some stable object to hold them firm; the other ends were held in the left hand, and by raising and lowering them the "shed" was formed, through which the filling or weft was inserted. In a cardboard model given to the U. S. National Museum are five healds and six spaces. The woof in this example is not even wound on a shuttle. The fabric being very narrow, a small reel or bobbin was sufficient for the work, the lay being beaten home with the forefinger.

Specimen 175640 in the U. S. National Museum is a heddle frame

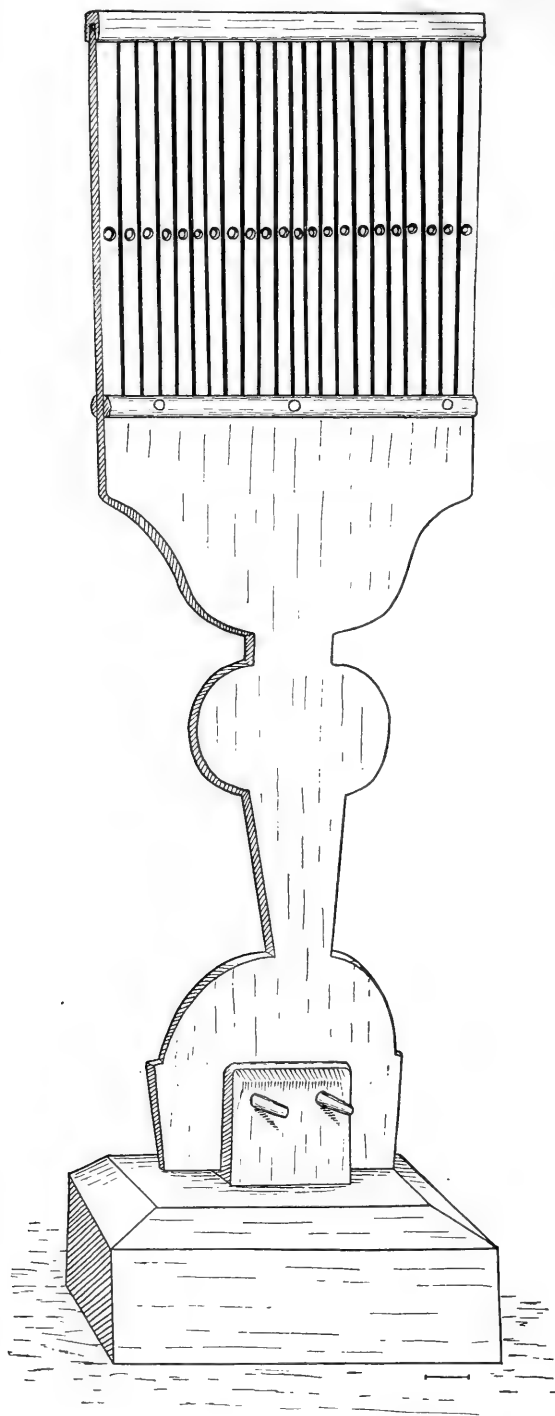


Fig. 13.

HEDDLE FRAME FROM BRISTOL, CONNECTICUT.

On solid base connected by an ornamental leg.

Cat. No. 175641, U.S.N.M. Collected by A. W. Williams and G. F. Richards.

from Auburn, Maine, collected by Mr. H. C. Merrill. It is formed from a piece of white pine board one-half inch thick, and has eighteen heddle dents. There is no crosspiece at the top, the working portion being formed by seventeen saw cuts 10 inches long, dividing the upper portion into parts like the teeth of a comb, each part one-half inch wide. On both sides the angular edges of the upright parts have been whittled away so as to facilitate the passing of the threads. The holes for the warp threads have been rudely perforated and their outer extremities whittled. The lower part of the apparatus, $8\frac{1}{2}$ inches long, has concave sides to facilitate holding it between the knees of the operator (fig. 14).

It is quite possible that examples might be found in northern New England States. The form in which the heddle made of a single piece of board is prolonged to be held between the weaver's knees or to be set in a block of wood on the floor is peculiar to New England, so far as the U. S. National Museum collection testifies.

PATENTED HEDDLE FRAMES.

As the climax of this type of the stationary heddle frame, attention is now called to the United States patent No. 334320, granted in 1886 to Eugenia Wernicke, a subject of the King of Prussia, residing at 7 Bes-selsstrasse, Berlin.

In the Wernicke patent the heddle frame, in the drawing, shows twenty-seven healds made of wire or cord, with stirrups in the middle.

The shuttle for holding the thread is a seine needle lenticular in cross section, tapering at its extremities, and provided at each end with an eye. Other attachments to this device form part of the patent, namely, for holding the warp in good shape, so as to secure uniformity of width in the textile; clamp for holding the apparatus to the table, etc., all unimportant in this place, the principle of operation being the same as in those previously described from Germany and other parts of Europe.

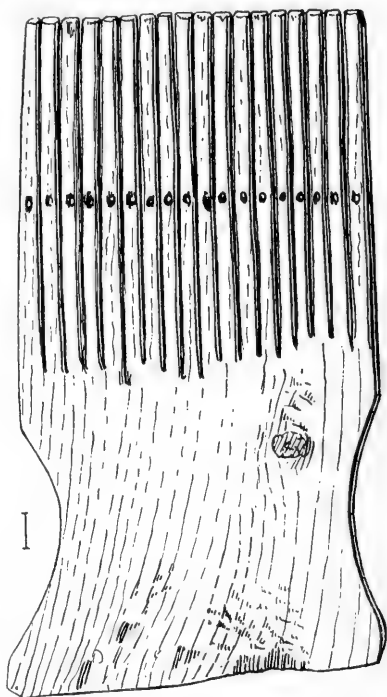


Fig. 14.

HEDDLE FROM MAINE, WITH HEALDS DISCONNECTED AT THE TOP.

At the bottom a footing is cut in to fit the knees of the operator.

Cat. No. 175640, U.S.N.M. Collected by H. C. Merrill.

The language of the claim is as follows (Plate 4):

I claim as new:

(1) The combination, with a holder for one end of the warp threads, a clamping device for securing said holder to a fixed support, and a holder for the other end of the warp threads, of one or more bars adapted to be inserted in the warp, to serve as a guide against which the weft is beaten up, a heddle frame constructed to be held in and operated by hand, and a shuttle, also constructed to be operated by hand, said devices constituting a hand-weaving apparatus, substantially as described.

(2) The combination, with a fixed support for one end of the warp threads and a free support for the other end of said warp threads, of one or more bars adapted to be inserted in the warp, to serve as a guide against which the weft is beaten up, a heddle frame constructed to be held in and operated by the hand, substantially as and for the purpose specified.

(3) The combination, with a fixed support for one end of the warp threads and a free support for the other end of said threads, of one or more bars adapted to be inserted into the warp and to serve as a guide against which the weft is beaten up, a heddle frame constructed to be held and operated by hand, and a shuttle of lenticular form in cross section, operated by hand to pass the weft thread through the warp and for beating up the lay, substantially as described.

(4) The holder or clamping device for one end of the warp thread, consisting of the clamping bars 1, 2, 3, the latter being provided with a screw clamp or clamping bracket (B), and the screws (s), said parts being constructed for operation substantially as and for the purpose specified.

(5) The heddle frame consisting of a rectangular frame (H), the upper crossbar (h^1) of which is provided with a groove in its under side, and the lower crossbar (h^2) with an offset in combination with the rack bars (h), rectangular in cross section, the healds (H^1), the stirrups (e), the locking bar (L), and locking latches (l) substantially as and for the purpose specified.

(6) The herein described shuttle (S), the body of which is of lenticular form in cross section, having slitted points (s^1), the slit of which terminates in an eye (s^2), substantially as and for the purpose specified.

HEDDLE FRAMES FROM THE PUEBLO REGION.

This interesting region occupies the valley of the upper Rio Grande, the Territories of New Mexico and Arizona, and also portions of southern Utah, southern Colorado, southern California, and northern Mexico. It was first invaded by Spaniards when Cabeza de Vaca crossed it in 1536, and visited by Francisco Vasquez de Coronado in his expedition to search for the Seven Cities of Cibola in 1540. After this the region was occupied by Spanish settlers, sheep were introduced, and weaving in machines began. Some of the rude mechanical appliances of this class existed there doubtless before of Mexican type, since in the ancient ruins and cave dwellings textile fabrics of excellent quality are found. But no relic has, up to this time, been exhumed which connects the heddle frame here described with anything earlier than the Spanish occupation, nearly 400 years ago.

The most interesting part of this study, however, is a large collection of heddle frames from the pueblo region of the United States for weaving garters, belts, and other narrow ceremonial fabrics, sometimes in plain color, more commonly in stripes and diaper effects in

different colored warps, quite similar to those of the Finlanders (Plate 5). A number of sections of reed or split mesquite sticks are laid parallel, as in the batten of the ordinary loom. These are fastened at their ends on two parallel sticks, which constitute the framework, whose length depends upon the number of warp threads to be inserted in the garter or belt.

An interesting feature in the structure of many of these pueblo heddles is the occurrence of the wooden cross piece at the upper part, on the opposite side from the cross piece at the bottom. When one of these heddles is held perpendicularly in the hand, if the upper cross stick is on the side next to the eye, the lower one will be on the outside away from the eye (fig. 15).

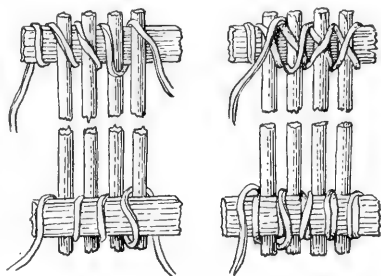


Fig. 15.

SKETCHES SHOWING METHOD OF ATTACHING THE
HEADS TO THE CROSSBARS IN PUEBLO HEDDLES.

The Algonquin Indians sit upon the ground at their work; so do the pueblo tribes. Hence the free-swinging heddle is more convenient for them. The same may be true of the east German types. Fig. 16



Fig. 16.

PUEBLO WOMAN SITTING ON THE GROUND AND WORKING HEDDLE IN WEAVING A BELT.

shows the attachment of the warp to the cylindrical stick in front of the weaver, which by courtesy may be called the primitive "cloth beam." It is held in place by a strap around the back, buttoned on the end of the roller, serving also as a roller for the finished work. The method of administering the heddle and the batten is clearly exhibited (fig. 16).

This pueblo series is of such importance that the typical forms will be more minutely described, and a table given of all the specimens so as to bring out the characteristics which they have in common and those which serve to differentiate them.

Specimen No. 176704 in the U. S. National Museum is a rude heddle frame from Zuñi, New Mexico, collected by Frank Hamilton Cushing (fig. 17). The crossbars of twig are $6\frac{3}{4}$ inches long, and there are sixteen healds, $4\frac{1}{2}$ inches long, laid parallel, with their ends on the same side of the crossbars; these are made of little sticks rudely whittled out, notched at their ends and fastened to the crossbars by

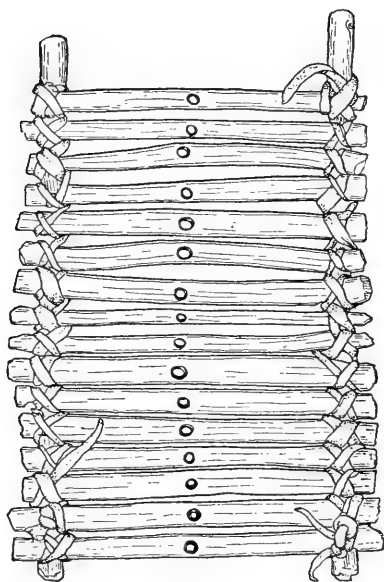


Fig. 17.

RUDE ZUÑI HEDDLE FRAME FOR NARROW
GARTER.

Cat. No. 176704, U. S. N. M. Collected by F. H. Cushing.

means of a rawhide lashing. The holes, or dents, or stirrups in the healds are rudely gouged out and punched through. The whole apparatus is so clumsily put together that it gives the impression of a child's heddle for practicing. It is inconceivable that good work could be done with such a utensil, and yet the Zuñi have no better. Only thirty-one warp threads could be used in this heddle. One can not always be sure that the objects obtained from modern Indian tribes have seen actual service. As soon as things are known to be desirable, they are forthcoming. In the best made Zuñi heddles the crossbars are on alternate sides.

Specimen No. 41666 in the U. S. National Museum is a heddle frame from Zuñi, New Mexico, collected by Maj. J. W. Powell. The crossbars, of wood, are 28 inches long. There are ninety-four healds of small reed, $5\frac{3}{4}$ inches long, and these are attached to the crossbars by the usual lashing of rawhide thong, supplemented by wrappings of yellow yarn. The excursion of the loose warp filaments is $4\frac{1}{4}$ inches up and down. The holes or stirrups through the healds have been bored with hot wire; indeed, in all of the old specimens this seems to have been the method of piercing the healds or of finishing off the stirrups (fig. 18).

It is noteworthy that in the examples presented from the different States of the Union, from Finland, Germany, and Italy, the heddle frame, with its healds, is carved or sawed out of a single piece of wood, or the healds are set in a groove which corresponds with the crossbar

of the Zuñi loom, but in all the looms of the Southwest the healds are lashed to crossbars.

Specimen No. 165534 is a small batten frame or reed from Guadalajara, Mexico, collected by P. L. Jouy. It consists of sixty-four "reeds" made of bits of flat iron, somewhat like those of a small clock spring. These are set at the top and bottom between two semicylindrical bits of wood and held in place by half-hitches of twine, which not only hold fast the reeds, but also give uniform spacing for the warp. The collector says that "it is used for separating the threads of the warp in weaving the 'rebozos' or ornamental head shawls," universal throughout Latin America (fig. 19).

At the side of this frame upright pieces are set in between the ends of the crosspiece and held in place by lashing. There are no dents or stirrups in this piece, so that it could not in any way have been used as a heddle or harness, but simply as a reed in beating home the weft. The noticeable feature is the method of attaching the upright iron portions to the crossbars, which is very similar to that used by the Zuñi in attaching the healds to their heddle frames.

Example No. 166694 in the U. S. National Museum is a heddle frame labeled Moki or Tusayan, collected by Mr. James Mooney. The frame sticks are $22\frac{1}{4}$ inches long. There are eighty-two healds of reed and eighty-one spaces, so that there is in all provision for one hundred and sixty-three warp threads. The healds are $8\frac{3}{4}$ inches long, giving an excursion to the warp threads of 7 inches; at their upper and lower ends they are laid on different sides of the crossbars, so that in looking at the apparatus the crossbar will be on the side of the eye, and the other will appear behind the ends of the healds.

As before remarked, there are a great many specimens made in this way, although there are others in which the crossbars are both on the same side of the healds as in a gate. The ends of the healds are attached to the crossbars by a peculiar kind of lashing, in which the twine or filament crosses itself over the healds and lies in somewhat parallel lines on the sides of the crossbars (Plate 6).

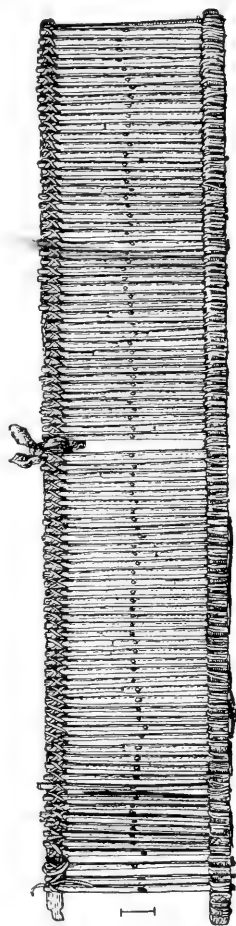


Fig. 18.

HEDDLE FROM ZUÑI.

Showing the healds on alternate sides of crossbars.

Cat. No. 41666. U.S.N.M. Collected by J. W. Powell.

PUEBLO HEDDLES OF VARIOUS SIZES.

Collection of heddles from pueblos, marked Zuñi in the catalogue, but the location is not definitely known. The apparatus is more common at Moki.

Plate 7, fig. 1. Crossbars, rectangular strips of wood with notches cut on the flat side to receive the ends of the healds. This characteristic should be noted in this specimen, since it is very rare; in most examples it will be seen that the healds are laid against the

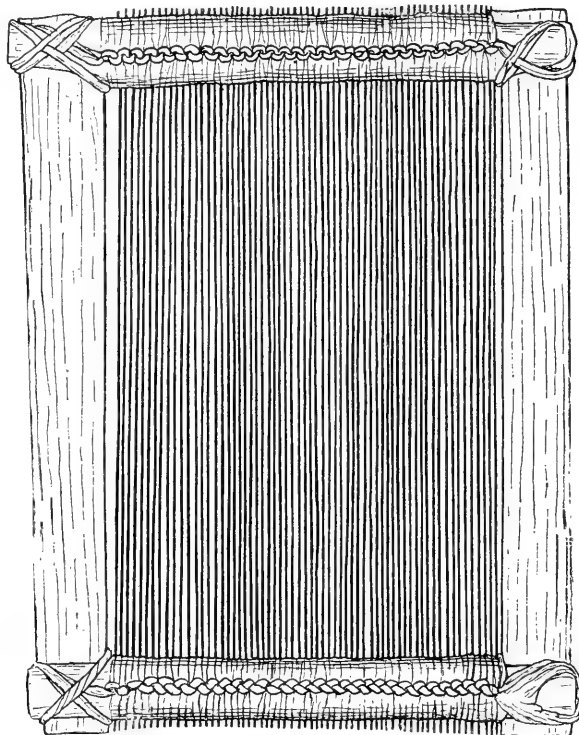


Fig. 19.

BATTEN FROM GUADALAJARA, MEXICO, ON THE PLAN OF THE PUEBLO HEDDLES.

Cat. No. 165534, U.S.N.M.

frame. In this specimen there are sixteen healds made of bits of split cane or splints of wood one-fourth of an inch wide and very thin. The ends are notched to fit into the notches cut into the crossbars and are held in place by a continuous winding or wrapping of sinew filament. The holes or stirrups, in the healds, are coarse and rudely excavated.

The healds are 4 inches long between the crossbars; the whole length of healds is 5 inches, and of crossbars $9\frac{1}{2}$ inches.

Cat. No. 127688, U.S.N.M. Collected by Bureau of Ethnology.

PLATE 7.—Collection of Pueblo heddles, marked Zuñi, but they are quite as likely to be Moki. U.S.N.M.

FIG. 2.—Crossbars of willow twigs; sixteen healds, $5\frac{1}{2}$ inches long, made of splints of wood, rudely whittled and fastened to the crossbars by wrapping of rawhide and rags. This is a very rude specimen. Length of crossbars, $7\frac{1}{2}$ inches. Zuñi, New Mexico. Cat. No. 75732, U.S.N.M. Collected by James Stevenson.

FIG. 3.—Crossbars of twig; forty healds of cane splints, $5\frac{1}{2}$ inches long, notched at either end to be fastened against the crossbars on alternate sides by rawhide string and rags. It is specially noteworthy that the ends of the bars are not opposite to each other. Zuñi, New Mexico. Cat. No. 75731, U.S.N.M. Collected by James Stevenson.

FIG. 4.—Crossbars of splints of wood, rectangular in cross section and regularly notched in on the broad side for securing the thirty-five healds which are made of thin splints of wood, $6\frac{3}{4}$ inches long, and notched at the ends and fastened to the crossbars by a lashing of leather. This specimen has the appearance of having been much used. Moki pueblo. Cat. No. 127688, U.S.N.M. Collected by James Stevenson.

FIG. 5.—Crossbars of sticks of wood rectangular in cross section; forty-four healds, the shorter ones $6\frac{3}{4}$ inches long, are fastened to the crossbars by wrapping of leather string. On either side of the middle are three groups of healds rising above the upper crossbars by a series of steps. Moki pueblo, New Mexico. Cat. No. 127688 (a), U.S.N.M. Collected by James Stevenson.

PLATE 8.—Figures of two heddles from Moki Indians, New Mexico. Collected by Mrs. Stevenson.

FIG. 1.—Crossbars of sticks, perforated for the fastening of the forty-eight healds, of split cane, 6 inches long, which are attached to the crosspieces by means of a leather string rove through the holes in the ends of the healds and through the crossbars. Both ends of each heald are on the same side of the crossbars.

This specimen is unique in the manner of attachment, since most of the healds are fastened to the crossbars by wrapping, but in this case they are sewed together by means of leather thong. Moki Indians, New Mexico. Cat. No. 127688 (b), U.S.N.M. Collected by James Stevenson.

FIG. 2.—Crossbars, one of stick, the other a flat piece of wood resembling a bow. There are eighty-nine healds, consisting of small reeds not split, $7\frac{1}{2}$ inches long, neatly wrapped at their ends with fine thread attaching them to the crossbars. The two ends of these healds, as in other best examples, are on different sides of the crossbars. The great number of healds, their neat lashing, and the position of the crossbars on different sides of the healds, mark this as a well-used and genuine example. Two reeds are broken out, and their places have been filled by woollen yarn with knotted stirrups in the middle to take the place of the holes in the healds. Moki Indians. Cat. No. 166695, U.S.N.M. Collected by James Mooney.

It has been seen already, from the plates and descriptions, that among the Zuñi and other Pueblo Indians a special batten is used for beating home the weft. In the simple tape-weaving devices in Connecticut the forefinger of the weaver is used as a batten, the shuttle serving merely to carry the warp thread back and forth through the "sheds." In the Finland examples, in those of Germany, and perhaps elsewhere, a wooden bobbin with open ends carries the warp filament, while in other examples either one or both ends of the bobbin are carved into the shape of the shuttle used in net making, and the edges of this wooden bobbin in all cases are made in the form of a knife

blade, so as to be utilized also as a batten in pushing the weft thread into place. Now, in the Pueblo examples the bobbin is a little stick on which the weft thread is wound, very much as a boy winds his kite string, into a spindle-shaped package, the ends of which pass easily into and through the "sheds." This bobbin is not used at all in beating the weft thread home, but a separate sword or batten is employed, which performs several functions. First, it takes the place of fingers in separating different series of warp threads when figure weaving is in view. After running the batten underneath those warp threads that are to appear in the figure it is revolved 90° on its axis and in this way becomes a special harness for making "sheds." Second, as a batten for beating home the weft. Third, as a help to the heddle, which does not always separate the two series of warp threads. The longer specimens are used for precisely the same purposes by blanket weavers in their looms, and in the U. S. National Museum there is, in the Ainu collection, a weaving in bark in which a very broad batten of this kind with a handle similar to some of those found in the Pueblo region is exhibited.

The specimens shown in Plate 9 are of mesquite wood (*Prosopis juliflora*) or of oak (*Quercus gambelii*). The upper example is made from a branch split and smoothed and shaped as little as possible. In the others it will be seen that there is an increasing effort on the part of the maker to secure a handle and a wider, thinner, and smoother blade.

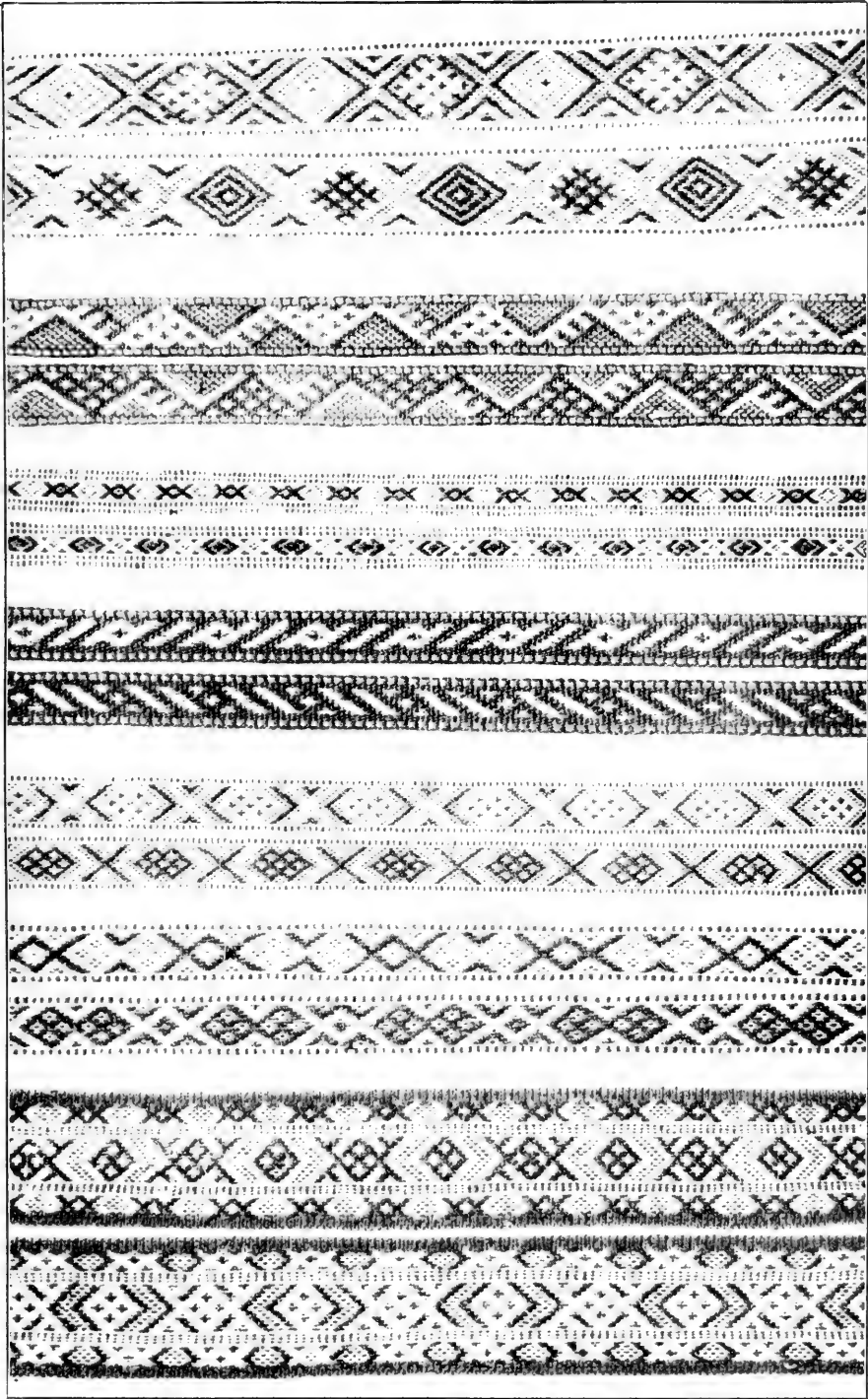
It is regrettable that the author has not been able to extend his inquiries into France and Spain. Hypothetically, the heddle frame came from Europe or southwestern Asia. The Finns, the Germans, the Sauks, and the Pueblo tribes have the free-swinging heddle frame. The New England women, who sit in chairs at their work, the Pennsylvania Dutch, and the Italians used the stationary frame, making the "sheds" by raising and lowering the inner or cloth ends of the warp.

Those weavers that sat on the ground and employed the free-swinging heddle could use a sword or paddle batten, serving to make the "sheds," to separate certain warp filaments for figure working, and for beating home the weft. Only rich patterns occur where the free-swinging heddle frame is employed. Not enough is known of the spread of this last apparatus in Europe to show the definite manner of its introduction into Iowa and the Pueblo region. On weaving with little boards in Bagdad and Mesopotamia, see C. F. Lehmann.¹

¹ Verhandl. d. Berliner Gesellsch. f. Anthrop., etc., May 19, 1900, p. 299.



ZUNI WOMAN WEAVING CEREMONIAL BELT.



PATTERNS OF GARTERS AND BELTS MADE IN HEDDLE FRAMES IN HELSINGFORS.



LOOM WITH HEDDLE FRAME FOR WEAVING SILK BRAID.

(No Model.)

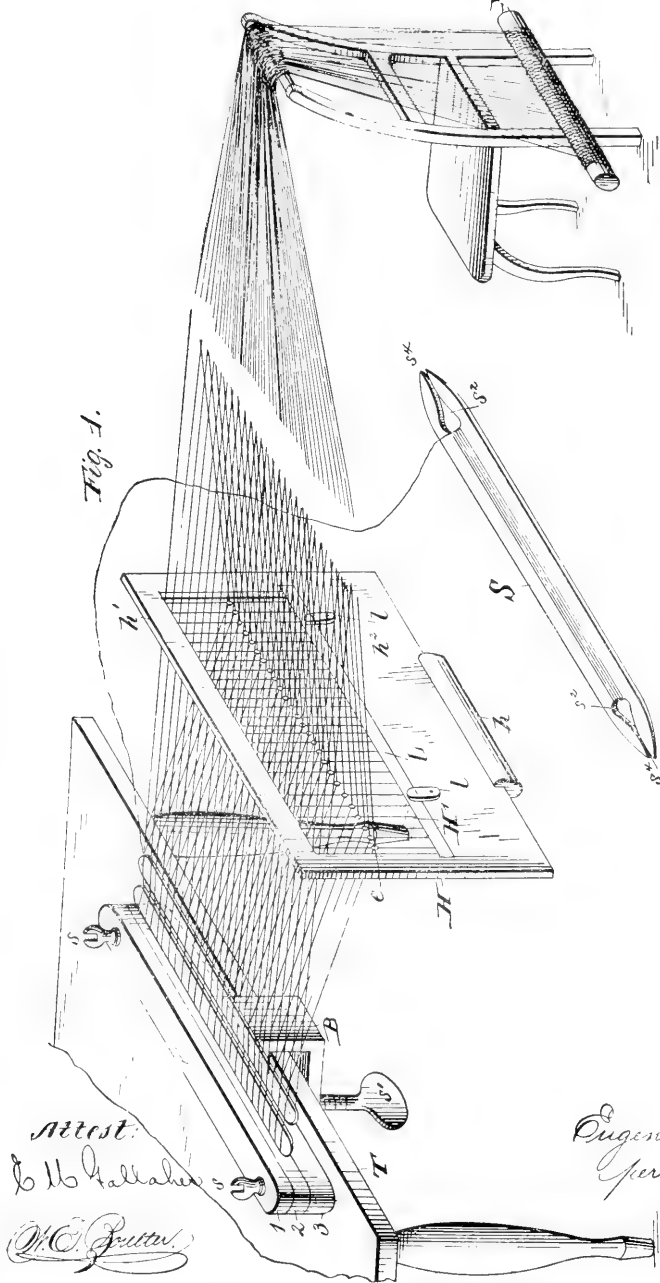
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E. WERNICKE.

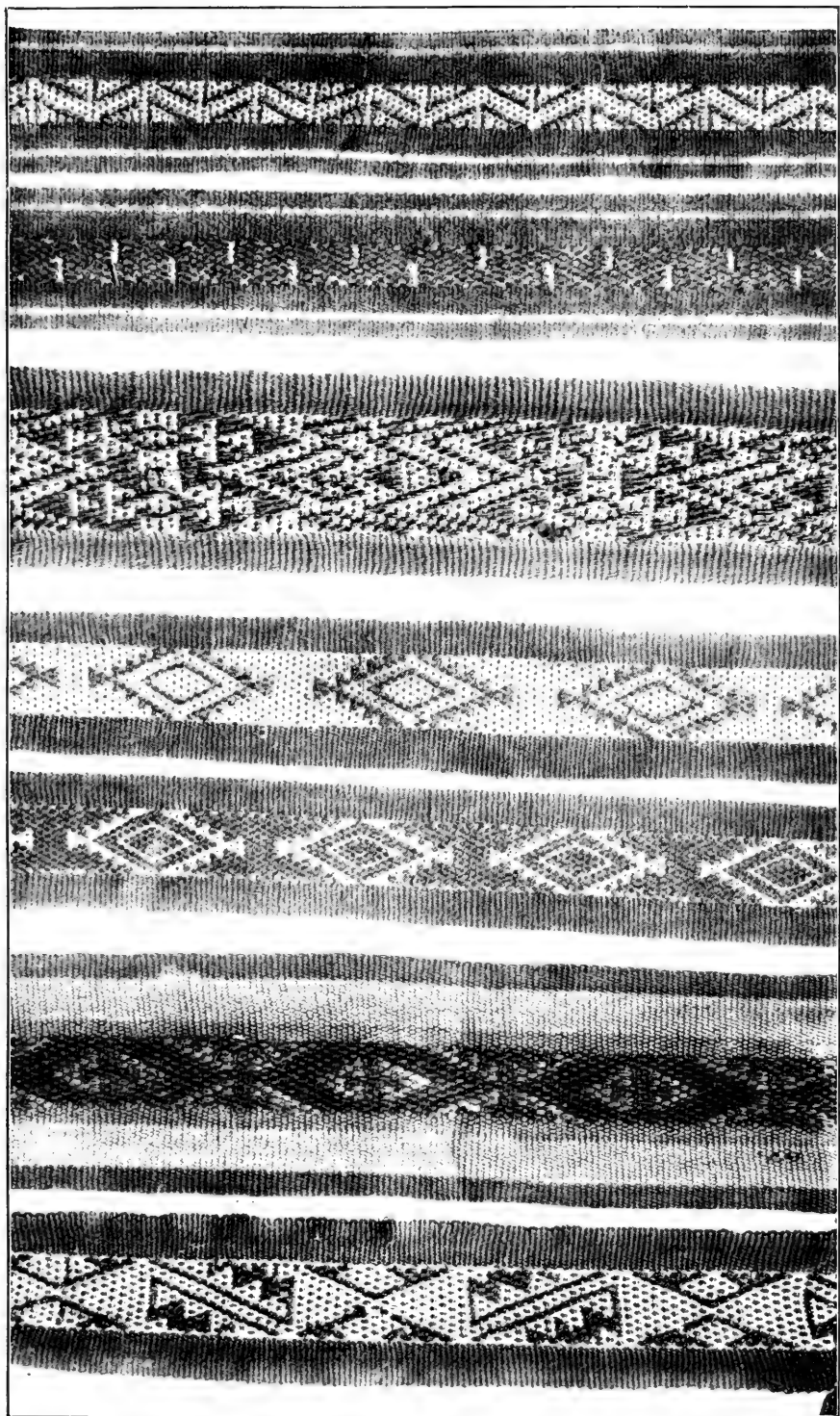
HAND WEAVING APPARATUS.

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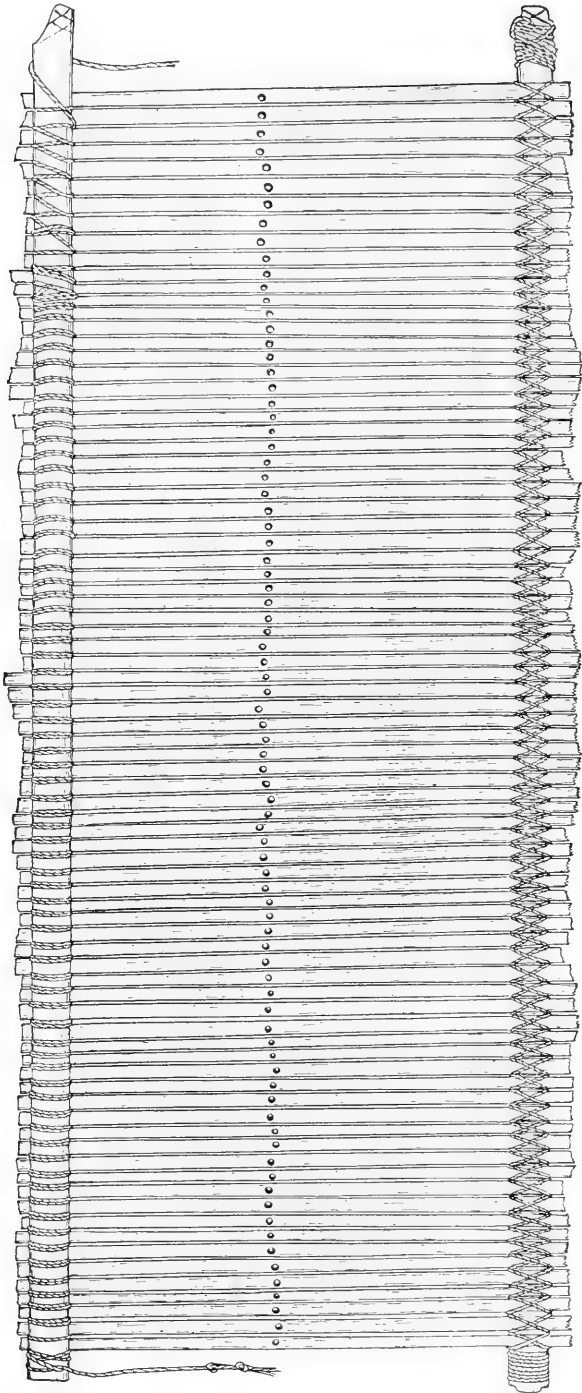
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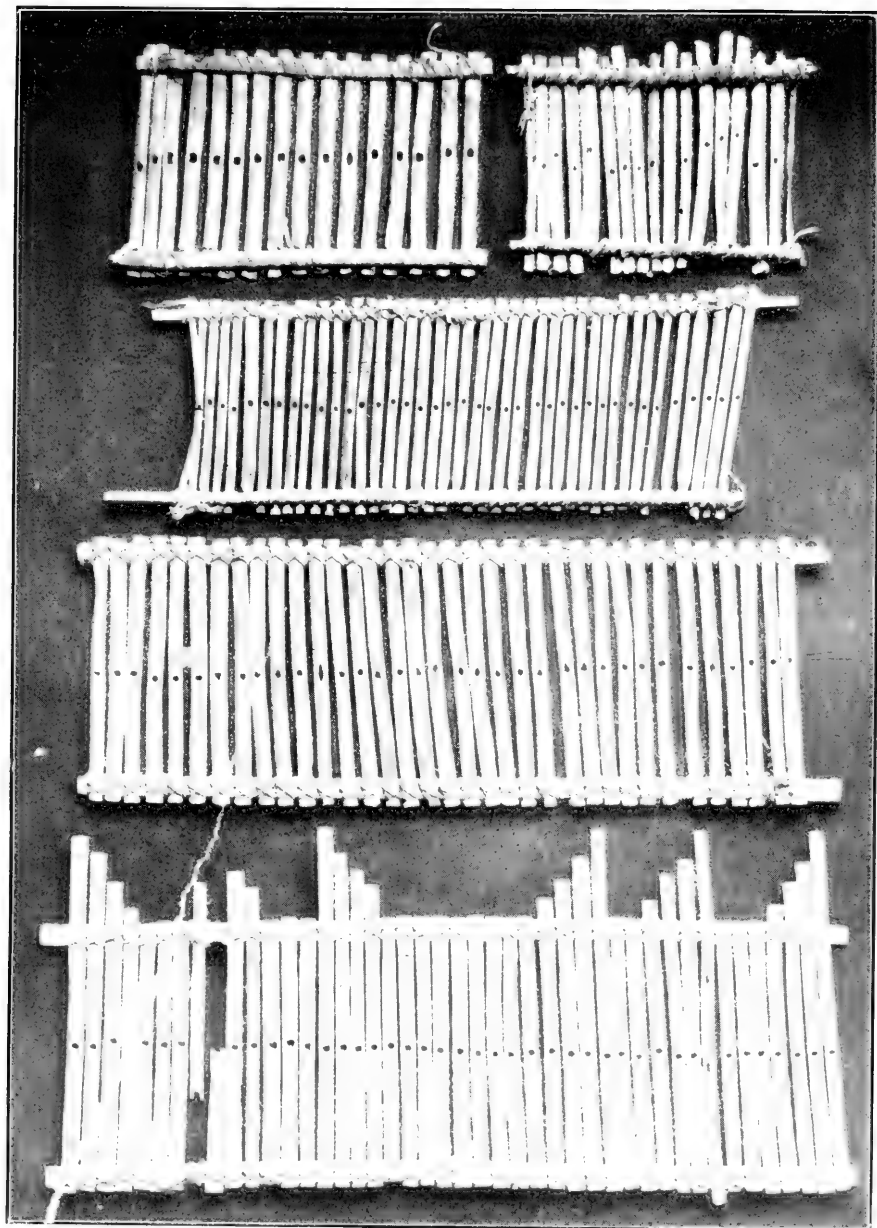
Inventor:
Eugenie Wernicke
per Henry C. W. Co.
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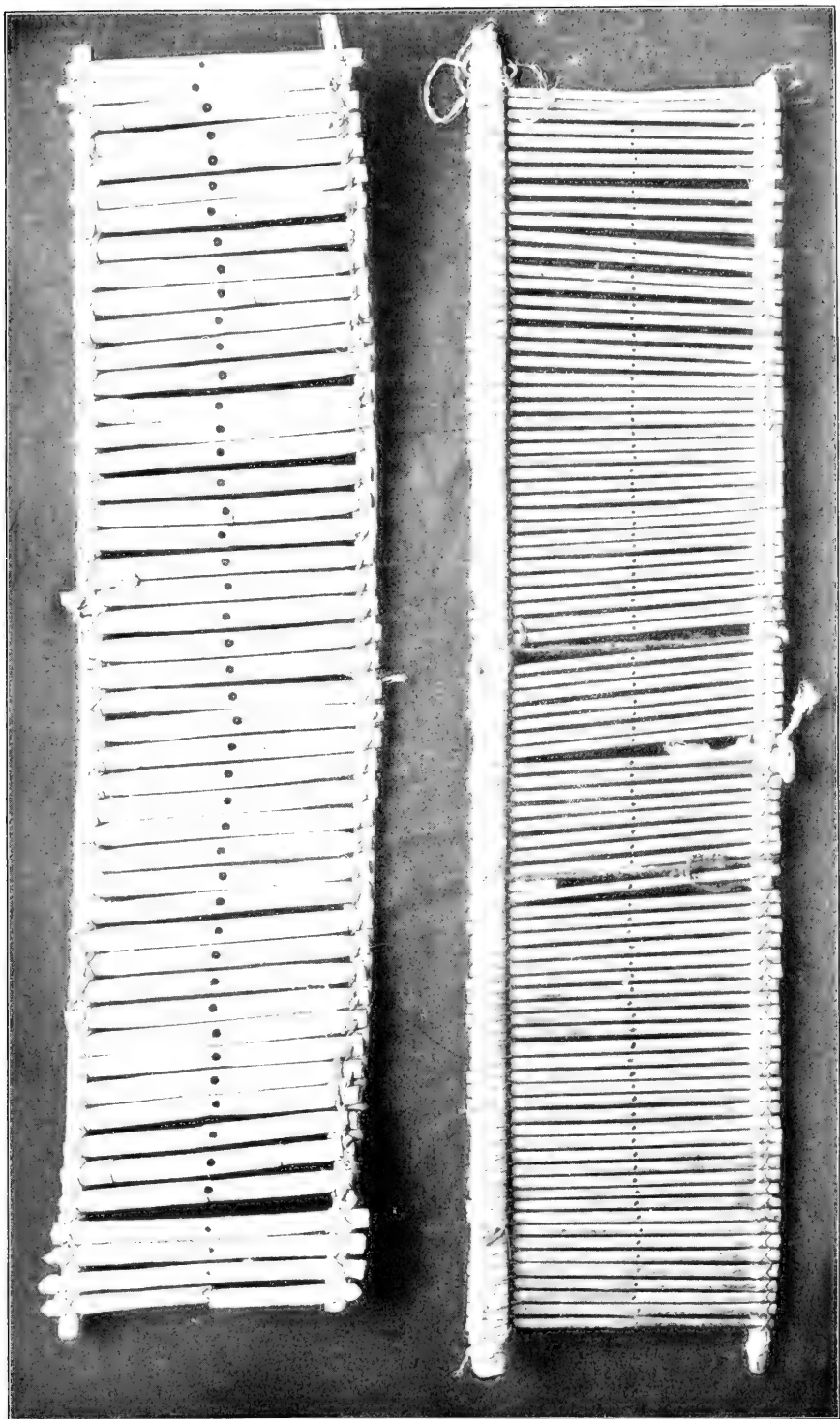
BELT AND GARTER PATTERNS FROM PUEBLOS.



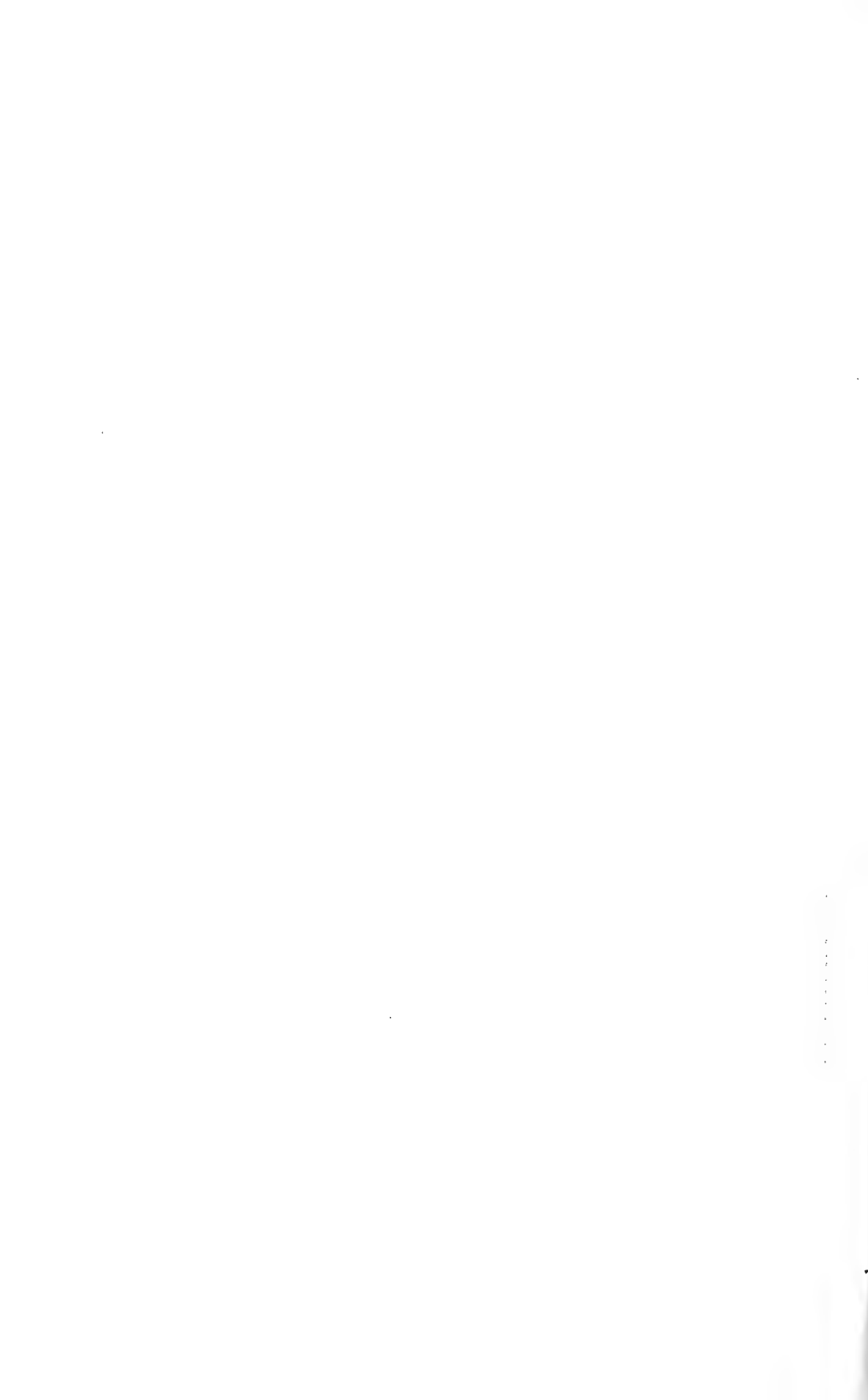
CONSTRUCTION OF PUEBLO HEDDLE FRAME.



TYPES OF PUEBLO HEDDLE FRAMES.



TYPES OF PUEBLO HEDDLE FRAMES.





PUEBLO BATTEN KNIVES FOR BEATING HOME THE WEFT.



AN EARLY WEST VIRGINIA POTTERY.

BY

WALTER HOUGH,

Assistant Curator, Division of Ethnology.

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The first potter at Morgantown, after the Indians, whose shards are scattered in the rich alluvium of the valley of the Upper Monongahela, was called by his apprentices "Master" Foulk. Of him nothing more can be learned, nor can the date of his enterprise be fixed beyond that it was before 1785, neither do any of his wares exist at the present day.

In the period of settlement between 1758, when Thomas Decker arrived at the mouth of the creek that bears his name, and 1786, when Morgantown was incorporated, there is little to chronicle beyond the events incident to the early frontier, such as the establishing of forts and the fights with the Indians, in which David Morgan stands out prominently as a remarkable figure in border warfare.

About the year 1785, James Thompson, with his son, John W. Thompson, then 4 years old, came from Bel Air, Maryland, to Morgantown. They settled near the Dorsey fort, several miles south of the town, because in those days of Indians, panthers, wildcats, and bears, everyone wanted to be near the fort. Later they moved to Morgantown, and, as family tradition has it, built the fifth house in the place. John was apprenticed to "Master" Foulk, the potter, learning the trade and succeeding to Foulk's business.

This pottery was probably the first established west of the mountains, and arose from the increasing needs of the settlements growing around the frontier forts, so remote from the seacoast markets and almost without roads and transportation. Early in the nineteenth century, domestic pottery, which had been hauled all the way from Baltimore, sold on the frontier at 3 levys a gallon, equivalent at this day to 72 cents. This was another inducement to supply the demand on the spot. Moreover, the extensive deposits of Quaternary clays on the

terraces of the Monongahela, shown by Dr. I. C. White to be coincident in geological time with the formation of the great glacial dam across the Ohio near Cincinnati, furnish abundant and superior material for pottery making.¹

There was also an early market for the wares of Morgantown, and a great part of the product of the pottery was sent in keel boats and flat-boats to various points down the Monongahela above Pittsburg and into the "wilderness."

The stoppage of intercourse between the United States and England during the Administration of Thomas Jefferson worked hardship upon the growing country, as yet depending largely upon foreign nations for manufactured articles. However, the restrictions on trade and intercourse of the embargo act of 1807 paved the way for independent manufactures in the United States to supply home demand and mark the beginning of that industrial energy which has led to industrial supremacy. At this period many small manufactories were started, as the glass factory (1807) of Albert Gallatin and the pottery of Alex. Vance at Greensboro, Pennsylvania (1809).

During the war of 1812, as William Boughner, of Greensboro, Pennsylvania, informs me, the yellow glazed ware was in good demand and brought a high price. He instances that cups and saucers sold at a dollar the set. It will be seen that again the cessation of commerce with England cut off the supplies of wares of the quality not made in America and stimulated the small potteries to manufacture articles for table use. Previously the wares were of the commoner forms for domestic use, such as milk pans, preserve jars, jugs, etc. Unfortunately, no examples of the tableware of 1812 survive, but fragments from the site of the old pottery show that it was a good quality of earthenware covered with a lustrous yellow glaze.

The Vance-Boughner pottery at Greensboro, Pennsylvania, continued to produce lead-glaze earthenware up to 1849; one of the latest specimens being shown in Plate 3. The manufacture of stoneware, principally in the form of jugs and milk crocks, still continues at that place. The earliest specimen of salt glaze stoneware from Greensboro, turned by Alex. Boughner in 1850, is shown in Plate 6.

One can hardly realize the difficulties that beset the potter on the frontier in the early days. His materials for glazes were secured only by the greatest exertions, and their compounding taxed his patience. His colors were ground on stones by hand. Sheet lead secured from

¹I. C. White, *American Geologist*, XVIII, December, 1896, pp. 368-379.

Recent investigations seem to show that the clay deposits are due to local dams of ice. The writer, when a boy, discovered fossil plants in these clays and brought them to the attention of geologists. Dr. F. H. Knowlton, of the U. S. Geological Survey, has determined the plants to be of the Quaternary glacial period.

chests of tea and oxidized over the fire in an iron pan formed the basis of his lead glaze; other materials had to be brought long distances over the mountains.

On every hand there was call for the inventive spirit in the potter and skill in handling all sorts of tools and doing odd jobs. If a tool was needed there was nothing to do but to make it; brushes of human hair served for decorating the ware; bits of stick were whittled into modeling tools, or objects from various sources, if they had the proper form, were pressed into service. Clay was to be dug and worked in the rude mill of the potter's manufacture, the masonry kiln was to be laid up, and wood hauled and chopped with which to burn the ware. In the "shop" abounded evidences of the potter as jack of all trades; the wheel, the pieces of wood held in the hand for forming the vessels (Plate 8), the slip pump, carriers for removing the green ware, molds, stamps (Plates 9-18), and many other things that he had made with his own hands. A picture of the resourceful handicraftsman's laboratory and workshop in the period of independent trades is full of interest. Also the products have an individuality that is denied to the products of cooperative labor, though the latter be more in touch with art ideas diffused at the present time.

The first ware made at Morgantown was porous terra-cotta covered with a yellow lead glaze. Teapots, cups and saucers, dishes, and other tableware were turned out. Unfortunately, no specimens of this ware remain, but fragments from the site of the old pottery show its character.

Following this came "red ware," or terra-cotta, covered with transparent lead glaze. At this period (1800) a number of glazes began to be used, such as dark-brown lead glaze, black iron or manganese glaze, gray "china glaze," greenish-gray and white, the surviving specimens being interesting and beautiful. They show decided artistic merit in the glaze and a quaintness of form that is pleasing and well worth the study of modern ceramists.

Lead glaze wares went into disuse on account of a belief that such glazes are unwholesome, which is true. It was observed, also, that the preparation and firing of lead glazes had a bad effect on the health of the potter.

With the disappearance of the ware having a lustrous glaze there ended a most interesting period of the pottery at Morgantown. The traditions and training that had given form and character to the art during more than fifty-five years and produced results that were commendable could not survive the introduction of heavy, unresponsive material like stoneware, which was produced in the second period.

In the second period, by the mixture of clays, securing the fusible and infusible elements which stand high heat in the kiln, stoneware

began to be made. This ware was rudely decorated with blue on the paste, slipped in the interior with "Albany clay,"¹ and glazed in the kiln with salt.

The method of glazing by salt was introduced into Staffordshire in 1690 by two Germans from Nuremburg, named Elers. It was experimented with by Wedgewood, but proved unavailable, and fell to use for common ware. It is probable that the first salt glaze made in this country was at Marcus Hook, New Jersey.

On the close of the first period of the Morgantown pottery and the death of the aged potter, John W. Thompson, following a few years after, his son Greenland Thompson took charge of the work.

Greenland Thompson was a singularly retiring but well-informed man. Under better material conditions and surroundings he might have advanced to the manufacture of finer wares under the demands of modern taste. Within his limitations his temperament was artistic and appreciative.

The idea which he carried out in stoneware was the application of natural forms in relief to the exterior of vessels. The specimens of his work in the U. S. National Museum consist of a small cream pitcher with an ornamentation of rose stems, leaves, and buds; a flower vase covered with impressions from the shell of the Brazil nut, all of heavy ware, soft gray in color, and glazed with salt (Plates 6, 7). More pretentious pieces were made by this potter, consisting of large garden-flower vases, the holder decorated with rose and other floral designs, and the base representing rounded river pebbles, or cylinders imitating tree trunks with vines clinging to them.

Vases of this character were not made for sale, but may be considered as the pastime of the potter, and were intended as presents to friends. A small trade was, however, carried on in children's banks, pipes, fat-lamps, etc., but the standard product of the pottery was crocks, jars, jugs, and other desiderata for the housewife. The only decoration applied to the salt glaze ware consisted of rude floral ornamentations in cobalt.

One of the most interesting specimens of early salt glaze ware of Morgantown belongs to Mrs. Linnie Dille, of that place. It is a jar, bearing the following brush-work inscription in cobalt blue: "Home manufacture. Independence. High tariff. William Crihfield. August, 1844." Crihfield or Chrichfield was an employee of the Thompson pottery.

The work of Greenland Thompson was not appreciated at its value and was scarcely known outside of Morgantown. In consequence, there are very few specimens in existence, those pieces which have

¹ Albany slip clay is a fusible silicate of aluminium mined at Albany; New York. It fires to a sublustrious enamel of dark purple color.

escaped destruction being lost in the limbo of "old things" which exists in or around every human habitation.

The pottery ceased operation on the death of Mr. Thompson in 1890.

The writer is much indebted for the historical information in the above paper to Mrs. Dorcas Haymond, a daughter of Mr. John W. Thompson.

DETAILED CATALOGUE OF THE WARES OF THE FIRST PERIOD.¹

WHISKY FLASK. Terra-cotta with brown lead glaze; heavy ware. Such flasks were in use on the frontier before glassware was common. Plate 1, fig. 1.

Height, 6½ inches.

Morgantown, West Virginia. 178460.

Gift of Mrs. Dorcas Haymond.

OINTMENT JAR. Terra-cotta with greenish-gray glaze showing mottlings of pink. The vessel has one of the most beautiful glazes produced by the old pottery at Morgantown. Plate 1, fig. 2.

Height, 4 inches; diameter, 2½ inches.

Morgantown, West Virginia. 205346.

Gift of Mrs. Dorcas Haymond.

PITCHER. Terra-cotta, unglazed. On one side is the impression of a large mold in relief representing a house surrounded with trees, a favorite device of the early potter. The spout was formed from the pattern figured on Plate 16, fig. 7. The handle has been broken off. Plate 1, fig. 3.

Height, 9 inches; diameter, 8 inches.

Morgantown, West Virginia. 205345.

Gift of Mrs. Dorcas Haymond.

PRESERVE JAR. Terra-cotta body covered with dark brown lustrous glaze. Sealed by tying oiled paper over the mouth, as in the old form of preserve jar. Plate 1, fig. 4.

Height, 6½ inches; diameter, 5½ inches.

Morgantown, West Virginia. 205344.

Gift of Mrs. Dorcas Haymond.

SPICE BOTTLE. Terra-cotta body covered with transparent lead glaze giving the beautiful clear red of the earliest pottery made at Morgantown. The word "peper" in dark brown decorates one side. The shoulder of the bottle bears a slip decoration in white, the motive being the name D. Thompson. Plate 1, fig. 5.

Height, 5½ inches; diameter, 3 inches.

Morgantown, West Virginia. 203343.

Gift of Mrs. Dorcas Haymond.

SUGAR PURIFIER. Terra-cotta covered with glaze giving the reddish-brown color which is said to have been the color of the earliest ware made at Morgantown. In form the vessel is conical, open at the top, and having an orifice at the bottom. It was set up over another jar and was filled with the rather crude maple sugar manufactured in the early days, which would drain through the orifice, leaving the upper layer white and dry. The initials "J. F. C.," of an unknown potter, are scratched through the glaze. Date, 1800. Plate 2, fig. 2.

Height, 13½ inches; diameter, 9 inches.

Morgantown, West Virginia. 96595.

Gift of Mrs. Dorcas Haymond.

¹ The wares described are exhibited in a wall case on the south side of the ceramic gallery in the U. S. National Museum.

MOLASSES JAR. The sugar purifier was placed above the molasses jar in order to catch the drips from the soft sugar. For description of the jar see page 518 and explanation of Plate 4, fig. 2.

PRESERVE JAR. Terra-cotta body, straight sides, sloping shoulders, and short straight neck. The glaze is opaque, lustrous, and gray-green in color, with cloudings of brown blended into the glaze. This specimen is one of the most artistic and pleasing of the objects remaining from the early pottery at Morgantown. It dates from the last quarter of the eighteenth century. Plate 3, fig. 1.

Height, 8 $\frac{1}{2}$ inches; diameter, 6 $\frac{1}{2}$ inches.

Morgantown, West Virginia. 178456.

Gift of Mrs. Dorcas Haymond.

SPICE BOTTLE. Terra-cotta body, sloping sides, fluting around bottom. Lead glaze, dark brown, heavy and lustrous, with obscure mottling or spotting that gives a pleasing broken color. Such bottles were used for containing spices. Date, about 1800. Plate 3, fig. 2.

Height, 4 $\frac{1}{2}$ inches; diameter, 4 inches.

Morgantown, West Virginia. 178455.

Gift of Mrs. Dorcas Haymond.

MOLASSES JAR. Terra-cotta body, covered with dark brown mottled glaze; amphora shape. For containing molasses and apple butter. Date, about 1820. Plate 3, fig. 3.

Height, 11 inches; diameter at top and bottom, 5 and 5 $\frac{1}{2}$ inches; at middle, 8 inches.

Morgantown, West Virginia. 178459.

Gift of Mrs. Dorcas Haymond.

JUG. Red body, pear shape. Glaze red brown, highly lustrous, and with uniform, spirally arranged crackle. Turned in 1849 by William Boughner, at Greensboro, Pennsylvania. Plate 3, fig. 4.

Height, 8 $\frac{1}{16}$ inches; diameter, 6 inches.

Greensboro, Pennsylvania. 178454.

Gift of William Boughner.

PRESERVE JAR. Terra-cotta body of usual shape covered with dark-brown lead glaze, with imperfections, giving light brown and yellow effects. Plate 3, fig. 5.

Height, 8 inches; diameter, 6 $\frac{1}{2}$ inches.

Morgantown, West Virginia. 178452.

Gift of Hon. J. M. Hagans.

PITCHER. Terra-cotta body glazed outside and within with a speckled glaze resembling Flemish gray. This glaze was called "china glaze" by the potter; its composition is not known at present. Horizontal rows of alternate green and black circles have been painted on over the glaze and fused, forming a bizarre ornamentation. The body of the vessel is ovoid, the spout bent in the neck; the handle is very broad, and the pitcher presents a quaint, old-fashioned appearance. Plate 4, fig. 1.

Height, 9 $\frac{3}{4}$ inches; diameter, 7 $\frac{1}{4}$ inches.

Morgantown, West Virginia. 96594.

Gift of Mrs. Dorcas Haymond.

MOLASSES JAR. Terra-cotta body covered with a greenish semitransparent glaze. Where the glaze is thicker the greenish hue predominates, where it is thinner the orange hue of the body shows through. The handle and sides of the jar between the handles are decorated in brown. The handles are lugs for lifting the jar. Plate 2, fig. 1, and Plate 4, fig. 2.

Height, 13 $\frac{3}{4}$ inches; diameter, 10 $\frac{1}{2}$ inches.

Morgantown, West Virginia. 96590.

Gift of Mrs. Dorcas Haymond.

PRESERVE JAR. Terra-cotta body covered outside and within with a brown (near sienna) transparent lead glaze speckled with minute dark-brown spots. The sides of the jar are decorated with a conventional flower, possibly a tulip, in white, green, and brown. The colors have blended into the glaze. The jar is of quaint shape, the sides having a long, concave sweep, the shoulders bended with turned grooves, and the rim low, suited for tying on the cover. This excellent specimen is of the first period of the pottery of Morgantown. Plate 4, fig. 3.

Height, 10½ inches; diameter, 6½ inches.
Morgantown, West Virginia. 96588.
Gift of Mrs. Dorcas Haymond.

CHURN. Terra-cotta body covered with an uneven semitransparent greenish-yellow glaze known as "china glaze," decorated with a leaf design in black. The churn is a truncated cone, the rim hollowed for the reception of the churn lid. It is related that churns were made as presents to children, but also were found useful for small churnings in the household. Plate 4, fig. 4.

Height, 9½ inches; diameter, 8½ inches.
Morgantown, West Virginia. 96592.
Gift of Mrs. Dorcas Haymond.

SPICE BOTTLE. Terra-cotta, unevenly covered with a glaze varying from gray to brownish yellow, rough and spotted. The word "Cinnamon," in brown, is written on the bottle, and the signature of D. G. Thompson is scratched on the paste. The sides slant to the bottom from the shoulder, which slopes upturned to the neck. The latter is ridged. Plate 5, fig. 1.

Height, 5½ inches; diameter, 3¾ inches.
Morgantown, West Virginia. 96593.
Gift of Mrs. Dorcas Haymond.

PRESERVE JAR. Terra-cotta body, burned rather hard. Speckled brown lead (near sienna) transparent glaze, with large feathery clouded splotches of lighter greenish buff "china glaze" over brown glaze, but melted in. Ornamental band stamped with rolling die around the shoulder of the jar. Almost straight, slightly bulged sides, sloping shoulder, flaring rim, inside of which is a collar to hold the lid for sealing. Glazed brown inside, no glaze on bottom. No marks. Plate 5, fig. 2. This jar is of the variety first made in Morgantown, where a pottery was in existence about 1785. It dates from about the beginning of the present century.

Height, 9¾ inches; diameter, 6½ inches.
Morgantown, West Virginia. 96587.
Gift of Mrs. Dorcas Haymond.

JAR OR CADDY. Terra-cotta body covered with black, lustrous, obscurely-crackled glaze made with lead. A band of three horizontal grooves in the paste goes around the middle of the jar. A relief stamp representing a coat of arms is placed above the band. The sides of the jar are slightly concave, the shoulder is square, and the neck is upright without flange, the general shape being that of the old-fashioned glass candy jar. This jar is a very excellent example of the "black" ware of the early pottery. Date, about 1792. Plate 5, fig. 3.

Height, 8½ inches; diameter, 6½ inches.
Morgantown, West Virginia. 96589.
Gift of Mrs. Dorcas Haymond.

FAT-LAMP. Terra-cotta, unglazed; in shape, that of a North African lamp, but with larger reservoir. It is probable that this is a potter's lamp. In it waste fat was burned by means of a wick formed of cotton cloth. Plate 5, fig. 4.

Height, 5 inches; diameter, 5 inches.
Morgantown, West Virginia.
Gift of Dr. Walter Hough.

WARES OF THE SECOND PERIOD.

JUG. Old form in stoneware, with salt glaze of grayish-brown shade. Employed for holding oil, etc. Date, 1845. Plate 6, fig. 1.

Height, $8\frac{1}{2}$ inches; diameter, 4 inches.
Morgantown, West Virginia. 178464.
Gift of Mrs. Dorcas Haymond.

PRESERVE JAR. Gray salt glaze stoneware, slipped inside with "Albany clay," the slip giving a smooth, dark-purple enamel. The jar shows mark of the turning. Sealed by settling a convex tin cover in a slot at the mouth of the jar and securing with sealing wax. Date, 1872. Plate 6, fig. 2.

Height, $11\frac{1}{2}$ inches; diameter at base, $5\frac{1}{2}$ inches; at top, $3\frac{1}{2}$ inches.
Morgantown, West Virginia. 178461.
Gift of Mrs. Dorcas Haymond.

PRESERVE JAR. Fine specimen of the best type of salt glaze stoneware, carefully thrown and finished. The color is uniform and pleasing. The clay from which it is made is said to be the best ever discovered at Greensboro, but has been exhausted for many years. Turned by Alex. V. Boughner, at Greensboro, Pennsylvania, in 1860. Plate 6, fig. 3.

Height, 7 inches; diameter, $4\frac{1}{4}$ inches.
Greensboro, Pennsylvania. 178453.
Gift of Alex. V. Boughner.

PRESERVE JAR. Brownish-gray salt glaze stoneware resembling the Flemish ware. Sealed in the old style by tying oiled paper around the mouth. This is one of the earliest pieces of stoneware made at Morgantown, West Virginia. Date, 1850. Plate 6, fig. 4.

Height, 6 inches; diameter, $3\frac{3}{8}$ inches.
Morgantown, West Virginia.
Gift of Mrs. Dorcas Haymond.

MUFFIN RINGS. Rings of salt glaze stoneware used for baking gems or "popovers." Date, 1849. Plate 6, fig. 5.

Diameter, $3\frac{1}{2}$ inches; height, $1\frac{1}{4}$ inches.
Morgantown, West Virginia. 96596.
Gift of Mrs. Dorcas Haymond.

FLOWERPOT. Gray stoneware with salt glaze. The outer surface is overlaid with clay representations of Brazil-nut shells in low relief, forming an effective decoration. Made by Greenland Thompson about 1870. Plate 7, fig. 1.

Height, 3 inches; diameter, $7\frac{1}{2}$ inches.
Morgantown, West Virginia. 95933.
Deposited by Miss Clara Hough.

CREAM PITCHER. Gray stoneware with salt glaze. Decoration, the branch of a rose-bush in leaf and flower applied in relief to surface of pitcher. Made by Greenland Thompson about 1873. Plate 7, fig. 2.

Height, $3\frac{3}{8}$ inches; diameter, $2\frac{1}{2}$ inches.
Morgantown, West Virginia. 95131.
Deposited by Miss Clara Hough.

FLOWERPOT. Gray salt glaze stoneware. The outer surface is overlaid with clay representations of pine cones in low relief, taken from molds made from the subjects. Made by Greenland Thompson about 1873. Plate 7, fig. 3.

Height, $5\frac{1}{2}$ inches; diameter, $7\frac{3}{8}$ inches.
Morgantown, West Virginia. 95932.
Deposited by Miss Clara Hough.

FLOWER POT. Salt glaze stoneware. Decorated with impressions from molds of pine cones. Date, 1880. Made by Greenland Thompson. Plate 7, fig. 4.

Height, $3\frac{1}{2}$ inches; diameter, $5\frac{1}{2}$ inches.

Morgantown, West Virginia. 205341.

Gift of Mrs. Dorcas Haymond.

BOTTLE FOR SLIP PAINTING. Terra-cotta, with brown glaze. The vessel has been turned in the shape of a low bottle, and while green flattened on one side, concavities pressed in the opposite sides for the thumb and forefinger, a hole made in the top for the cork, and a quill thrust in the neck. In painting, the bottle was filled with slip and the perforated stopper inserted. By the closing and opening of the aperture in the cork with the forefinger the slip was made to flow at the pleasure of the operator. Slip painting was prevalent in England in the last century, and some remarkable pieces are still in existence. The slip vessel may have been brought from England at the close of the last century. Plate 12, fig. 1.

Length, 4 inches; height, $2\frac{1}{2}$ inches.

Morgantown, West Virginia. 96597.

Gift of Mrs. Dorcas Haymond.

BOTTLE FOR SLIP PAINTING. Similar in form to No. 96597, but of unglazed terra-cotta, and having two holes. Two small feet in front allow the bottle to stand in slanting position, preventing the leakage at the quill when not in use. Plate 12, fig. 4.

Length, $5\frac{1}{2}$ inches; height, $3\frac{1}{2}$ inches.

Morgantown, West Virginia. 96598.

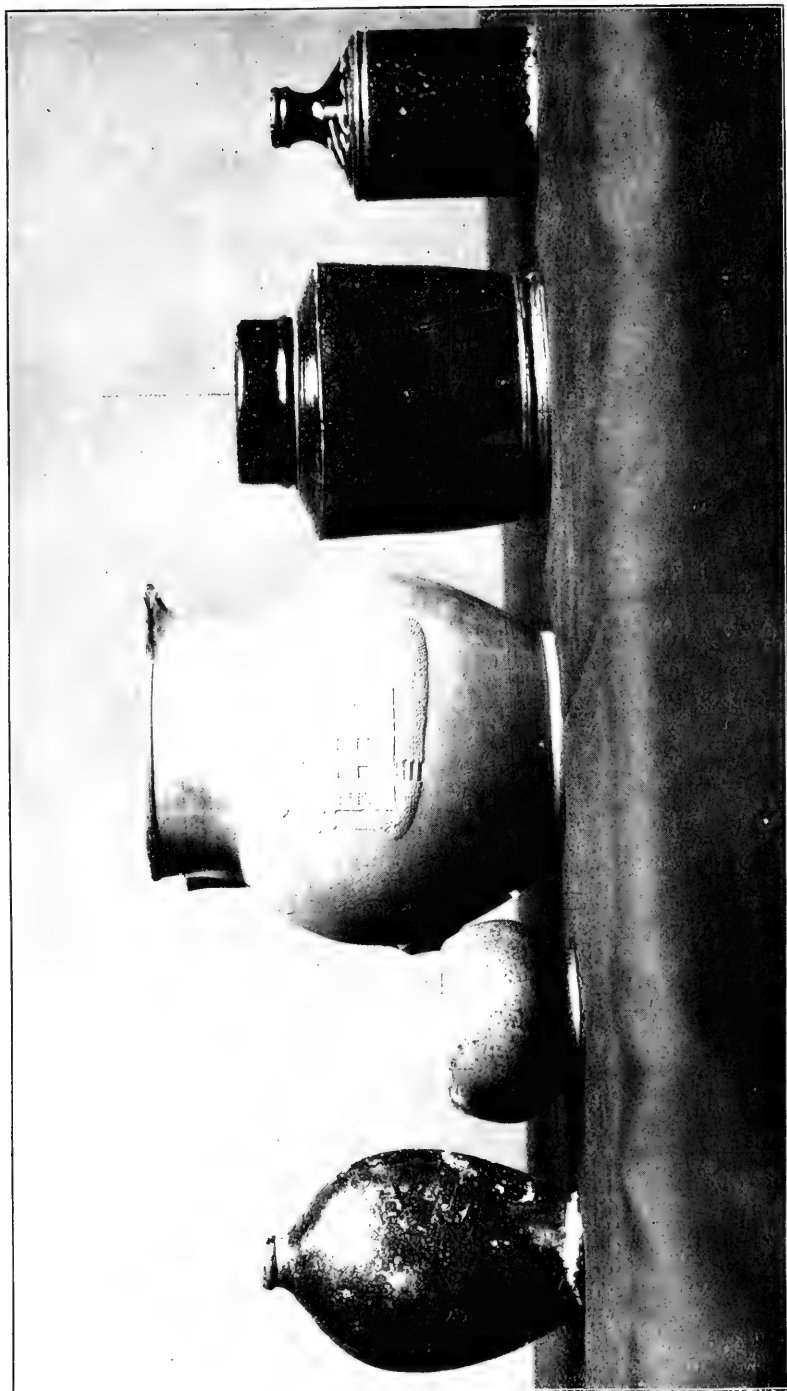
Gift of Mrs. Dorcas Haymond.



EXPLANATION OF PLATE 1.

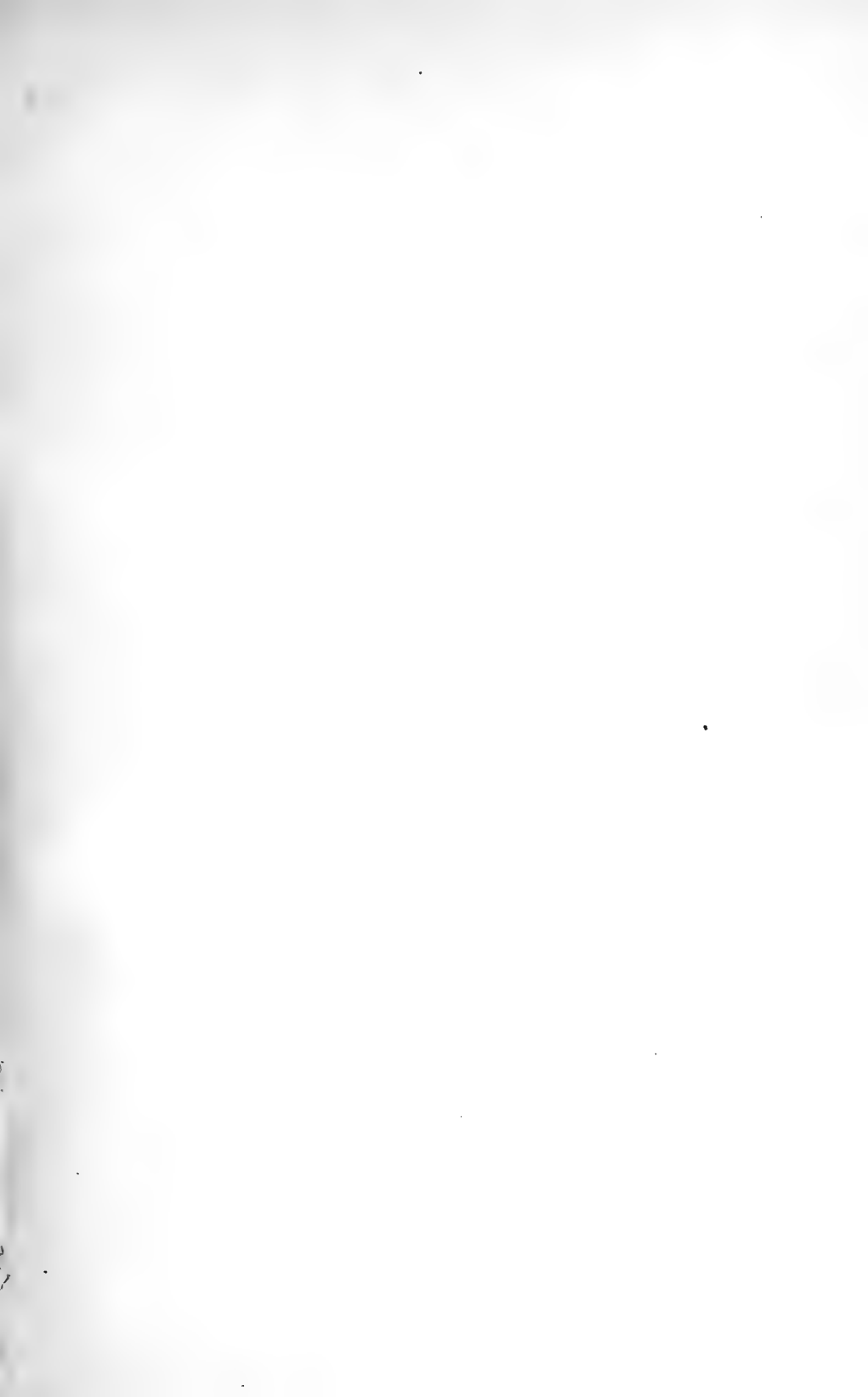
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- FIG. 1. "Tickler," or pint flask. Red body; rough surface, glazed thinly with brown lead glaze. Date, 1790. Height, $6\frac{1}{2}$ inches; breadth, $4\frac{1}{2}$ inches; thickness, $2\frac{1}{2}$ inches. Cat. No. 178460.
- FIG. 2. Ointment jar. Red body, with mottled greenish glaze. Date, 1800. Cat. No. 205346.
- FIG. 3. Unglazed pitcher. Baked red ware, showing use of large stamp on side. Date, about 1790. Cat. No. 205345.
- FIG. 4. Preserve jar. Red body; dark-brown lustrous glaze. Old form of preserve jar, sealed by tying oiled paper over the mouth. Cat. No. 205344.
- FIG. 5. Spice bottle. Red body; transparent glaze. Cat. No. 203343.



WARE OF THE FIRST PERIOD.





EXPLANATION OF PLATE 2.

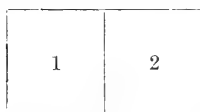


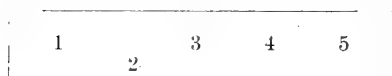
FIG. 1. Molasses jar. Thin, greenish glaze on terra-cotta. Brush decorations in brown on lugs and sides. Cat. No. 96590.

FIG. 2. Sugar purifier. Terra-cotta, with yellow glaze, giving an orange-red color. Cat. No. 96595.

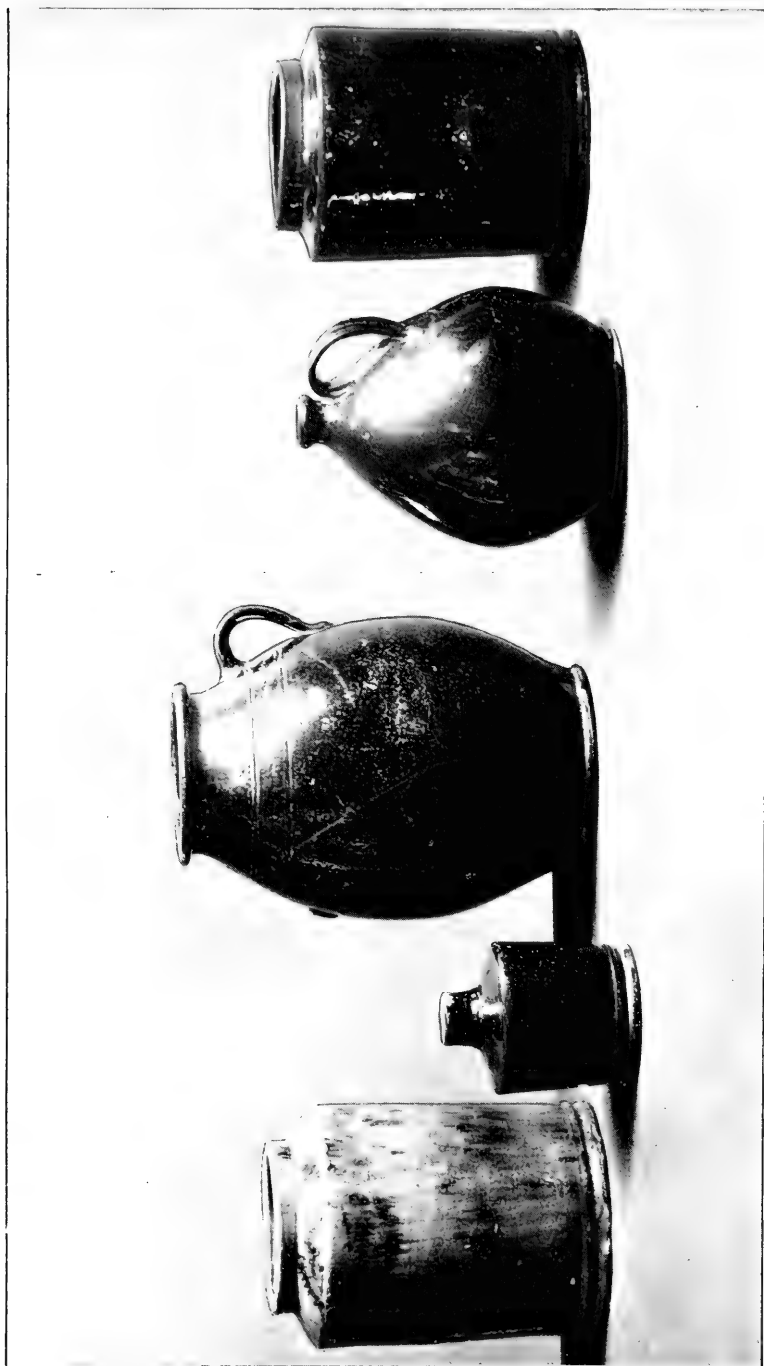


WARE OF THE FIRST PERIOD.

EXPLANATION OF PLATE 3.



- FIG. 1. Preserve jar. Red body, covered with gray-green glaze, with cloudings of brown fused into the glaze, giving delicate shaded effect. Beautiful specimen, probably the highest product of the pottery. Date, 1820. Height, $8\frac{1}{2}$ inches; diameter, $6\frac{1}{2}$ inches. Cat. No. 178456.
- FIG. 2. Spice bottle. Dark-brown lead glaze on red body. The glaze is heavy and lustrous, and a close examination shows mottling of lighter color, giving a variety to the general effect. Date, 1800. Height, $4\frac{3}{4}$ inches. Cat. No. 178455.
- FIG. 3. Molasses jar. Dark-brown mottled glaze on red body. One handle broken off. Height, 11 inches; diameter at top and bottom, 5 and $5\frac{1}{2}$ inches; at middle, 8 inches. Cat. No. 178459.
- FIG. 4. Jug. Red-brown lustrous glaze, with uniform spiral crackle. Body, red ware. Turned in 1849 by William Boughner at Greensboro, Pennsylvania. Height, $8\frac{1}{8}$ inches; diameter, 6 inches. Cat. No. 178454. Gift of William Boughner.
- FIG. 5. Preserve jar. Dark-brown glaze, with mottlings of yellow, the shadings giving good color effect. Height, 8 inches; diameter, $6\frac{1}{2}$ inches. Date, 1820. Cat. No. 178452. Gift of Hon. J. M. Hagans.



WARE OF THE FIRST PERIOD.

EXPLANATION OF PLATE 4.

1	2	3	4
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- FIG. 1. Pitcher. Terra-cotta, glazed with an opaque glaze resembling "Flemish gray." Spotted alternately black and green. Cat. No. 96594.
- FIG. 2. Molasses jar. Terra-cotta, with semitransparent green glaze. Cat. No. 96590.
- FIG. 3. Preserve jar. Terra-cotta, covered with lustrous brown glaze. Decoration, a conventional tulip in white, green, and dark brown. Fine specimen of old ware. Cat. No. 96588.
- FIG. 4. Churn. Terra-cotta, with uneven, semitransparent, greenish-yellow glaze. Decoration, a leaf design in black. Cat. No. 96592.

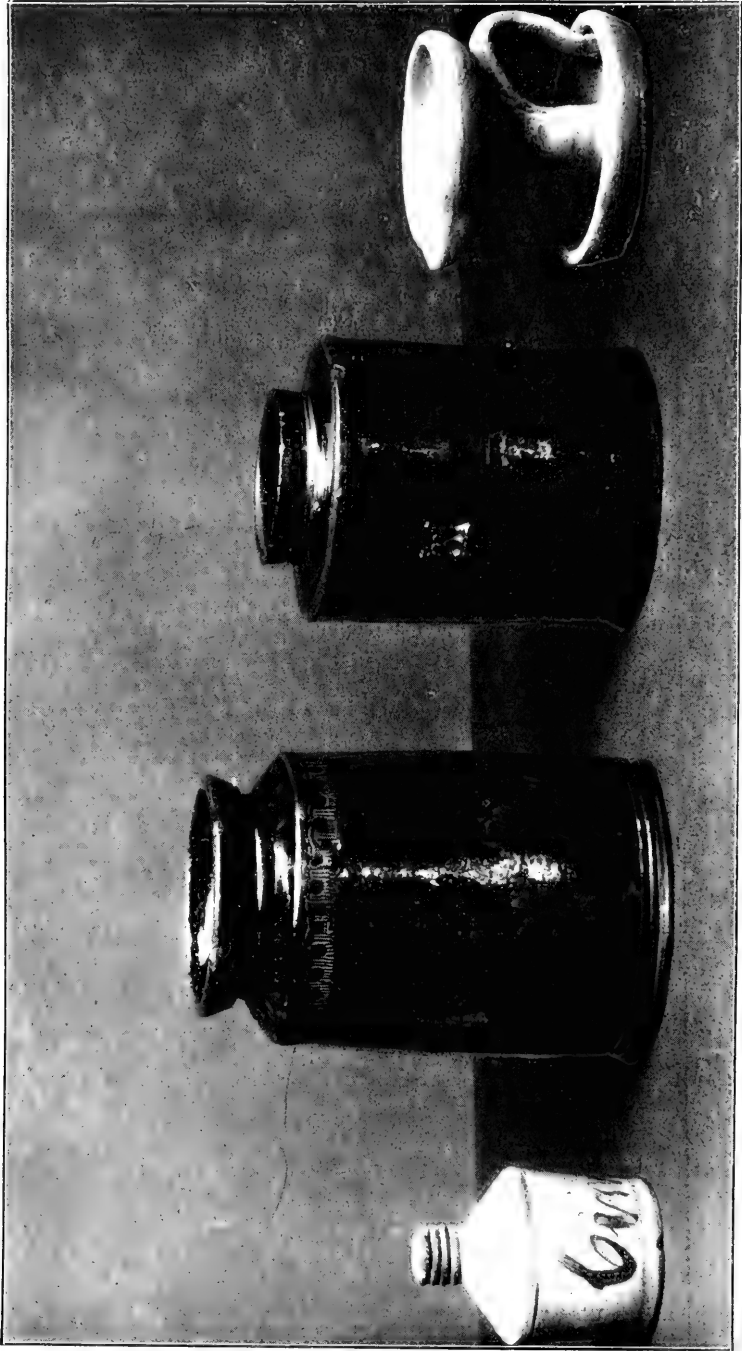


WARE OF THE FIRST PERIOD.

EXPLANATION OF PLATE 5.

1	2	3	4
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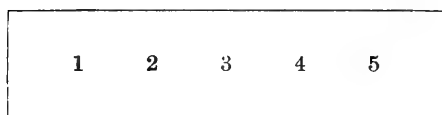
- FIG. 1. Spice bottle. Terra-cotta, covered thinly with opaque white glaze. Neck fluted. The word "Cinnamon" is painted on the side in brown. Height, $5\frac{1}{8}$ inches; diameter, $3\frac{3}{4}$ inches. Cat. No. 96593.
- FIG. 2. Preserve jar. Terra-cotta body, brown glaze, with light cloudings. Height, $9\frac{7}{8}$ inches; diameter, $6\frac{1}{2}$ inches. Cat. No. 96587.
- FIG. 3. Jar or caddy. Terra-cotta body, covered with very dark-brown, lustrous glaze. Height, $8\frac{1}{2}$ inches; diameter, $6\frac{5}{8}$ inches. Cat. No. 96589.
- FIG. 4. Fat-lamp. Terra-cotta, unglazed and rudely finished. This form of lamps was one of the early products of the pottery at Morgantown. Height, 5 inches; diameter, 5 inches. Cat. No. 178464.



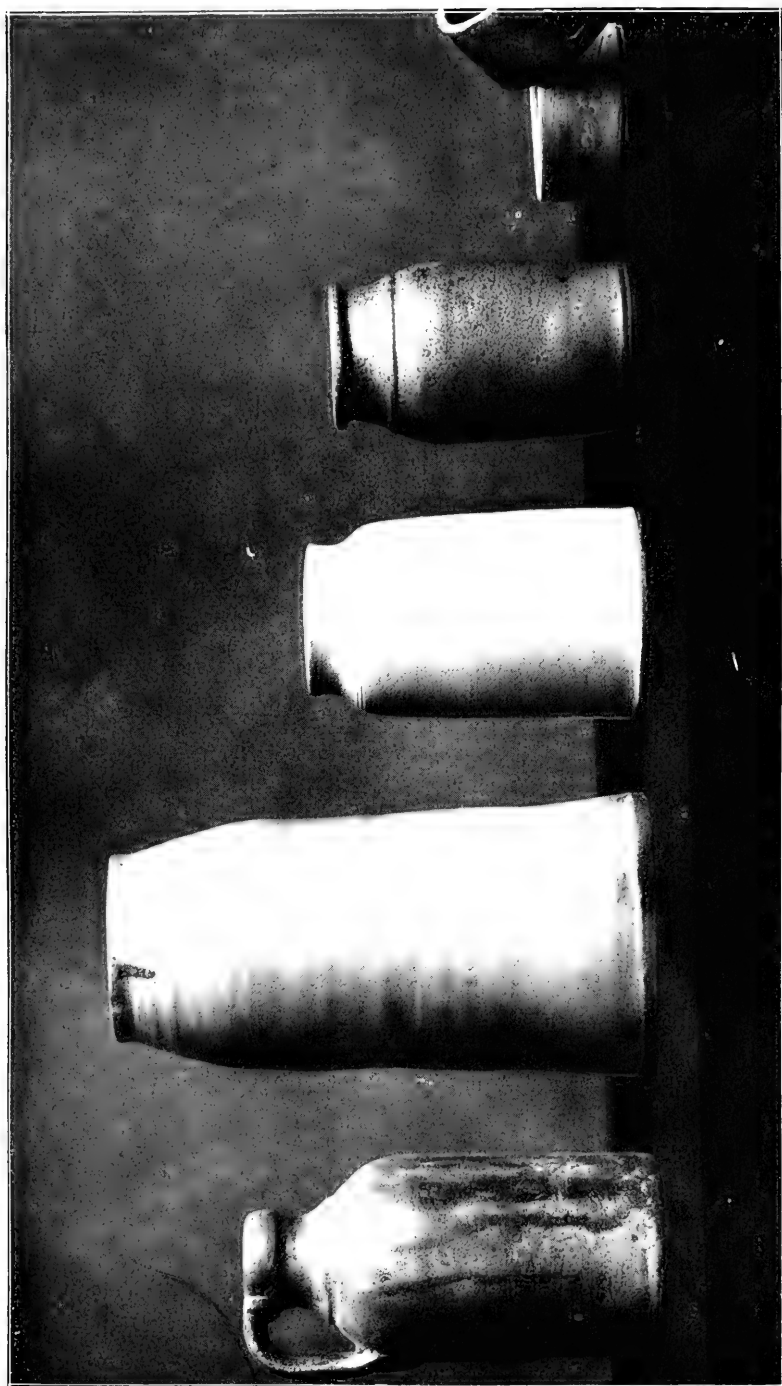
WARE OF THE FIRST PERIOD.



EXPLANATION OF PLATE 6.



- FIG. 1. Jug. Half-gallon jug in grayish-brown, salt glaze stoneware, used for oil. Date, 1845. Height, $8\frac{1}{2}$ inches; diameter, 4 inches. Cat. No. 178464.
- FIG. 2. Preserve jar. Gray, salt glaze stoneware, slipped inside with "Albany clay;" not carefully finished. Slot in lip for sealing with tin cover and sealing wax. Date, 1872. Height, $11\frac{1}{8}$ inches; diameter, $5\frac{1}{8}$ inches—at top, $3\frac{1}{8}$ inches. Cat. No. 178461.
- FIG. 3. Preserve jar. Best type of salt glaze ware, carefully thrown and finished. Turned by Alex. Boughner, at Greensboro, Pennsylvania, in 1860. Height, 7 inches; diameter, $4\frac{1}{2}$ inches. Cat. No. 178453. Gift of Alex. V. Boughner.
- FIG. 4. Preserve jar. Brownish-gray, salt glaze stoneware, having the appearance of old Flemish. Sealed in old style by tying oiled paper around the mouth. Date, 1850. Cat. No. 200342.
- FIG. 5. "Popover" or muffin mugs. Stoneware, covered with Albany slip. Date, 1849. Height, $1\frac{1}{8}$ inches; diameter, $3\frac{1}{2}$ inches. Cat. No. 96596.



WARE OF THE SECOND PERIOD.





EXPLANATION OF PLATE 7.

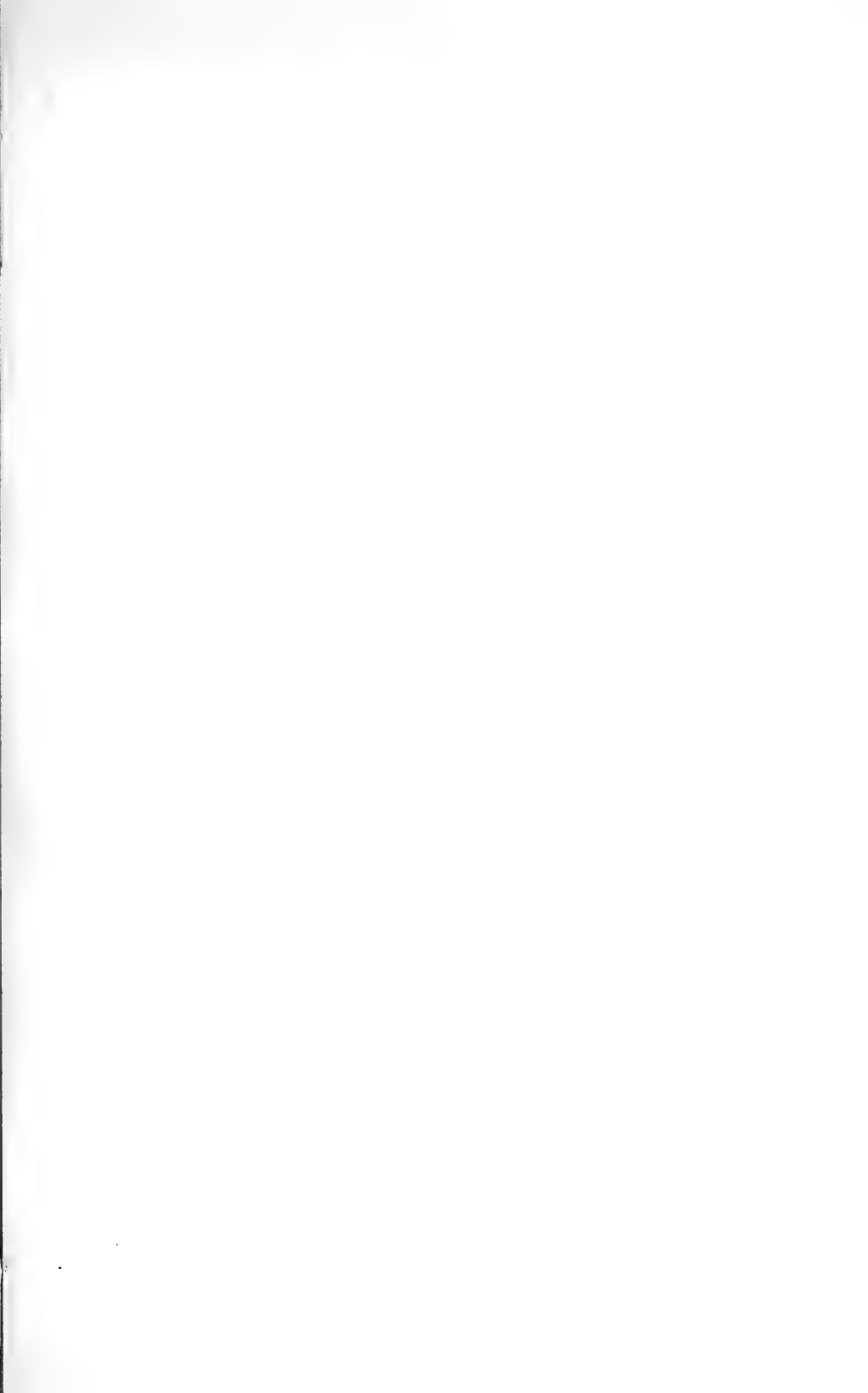
1	2	3	4
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- FIG. 1. Flowerpot. Gray stoneware; salt glaze. Decoration, casts from molds taken from Brazil nuts. Made by Greenland Thompson, 1884. Height, $3\frac{1}{2}$ inches; diameter, $7\frac{1}{2}$ inches. Cat. No. 95933.
- FIG. 2. Cream pitcher. Gray stoneware; salt glaze. Decoration, rose leaves and buds. Made by Greenland Thompson, 1870. Height, $3\frac{1}{2}$ inches. Cat. No. 95931.
- FIG. 3. Flowerpot. Gray stoneware; salt glaze. Decoration, pine cones. Made by Greenland Thompson, 1882. Height, $5\frac{1}{2}$ inches; diameter, $7\frac{1}{2}$ inches. Cat. No. 95932.
- FIG. 4. Flowerpot. Brownish-gray stoneware; thin salt glaze. Decoration, pine cones. Made by Greenland Thompson, 1885. Cat. No. 205341.



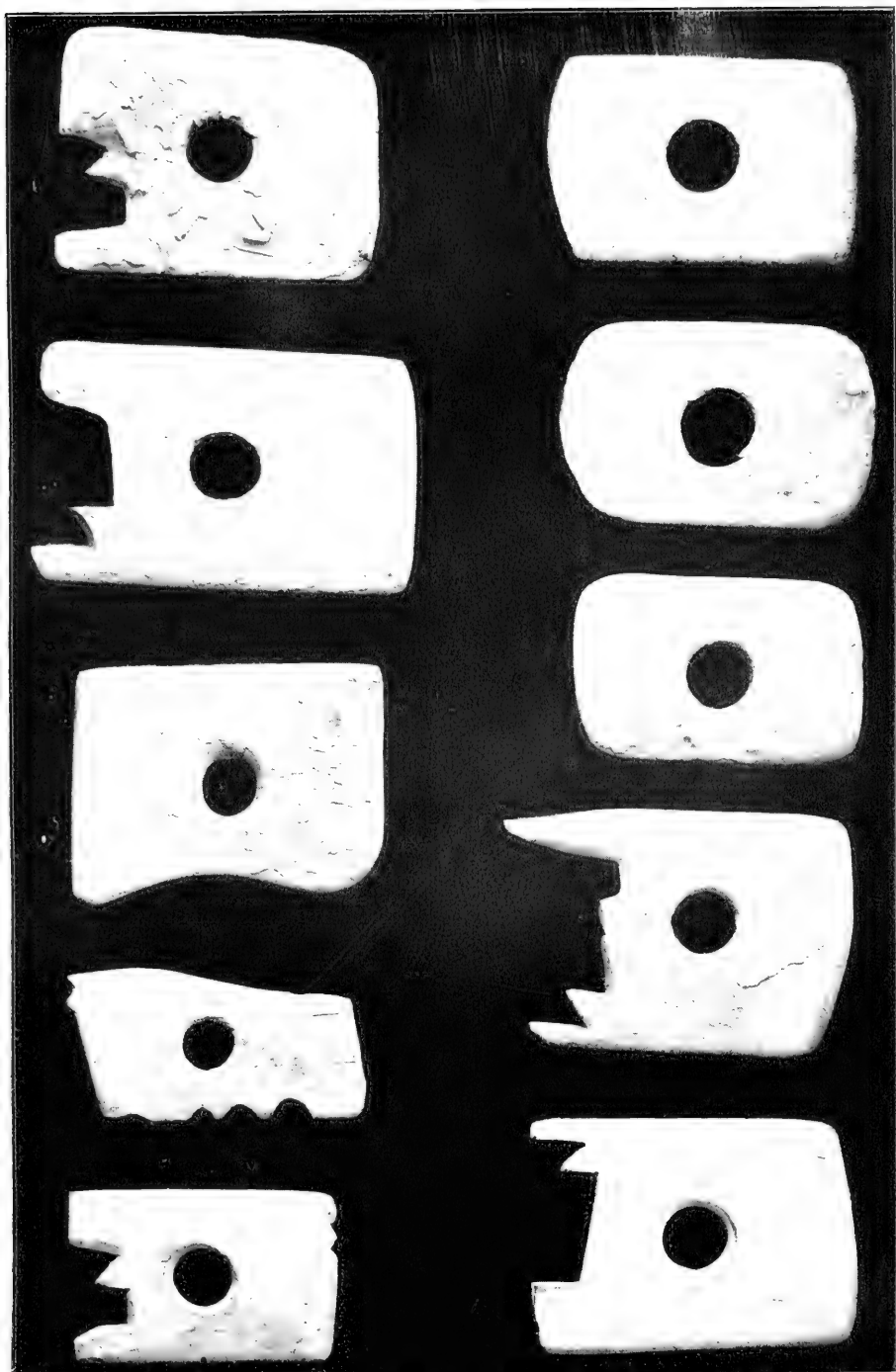
WARE OF THE SECOND PERIOD.





EXPLANATION OF PLATE 8.

FIGS. 1-10. Formers of wood held in the hand by the potter while "throwing" ware on the wheel, giving shape to the vessel by dexterously applying the bit of wood to the revolving clay. The notches on the formers are for the purpose of securing certain shapes and for finishing lips of jars, etc. The formers were made of apple or pear wood. Morgantown, West Virginia. Cat. No. 178502. Gift of Miss Jennie Thompson.

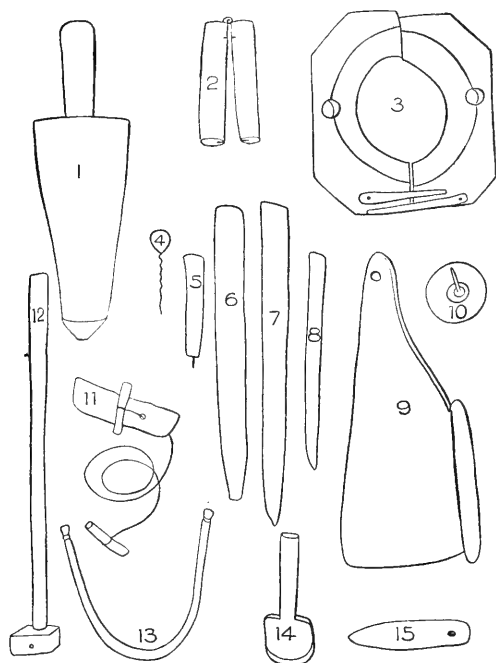


TOOLS OF THE POTTER.





EXPLANATION OF PLATE 9.



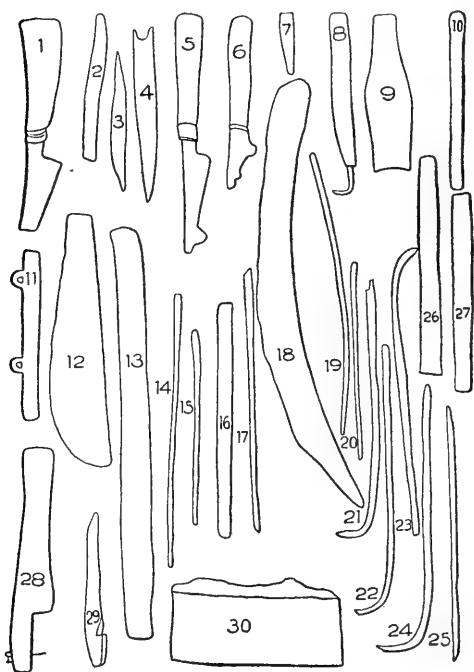
- FIG. 1. Former of wood. Cat. No. 178496.
 FIG. 2. Hinged mold for tubular spouts. Cat. No. 178499.
 FIG. 3. Lifters for handling green ware. Cat. No. 178497.
 FIG. 4. Plumb bob of clay and string. Cat. No. 178510.
 FIG. 5. Awl. Cat. No. 178505.
 FIG. 6. Former for mouths of jugs, etc. Cat. No. 178513.
 FIG. 7. Wooden spatula. Cat. No. 178512.
 FIG. 8. Wooden spatula. Cat. No. 178512.
 FIG. 9. Arm rest. In use fastened by a bolt at the side of the wheel-box and covered with sheepskin as a cushion. Cat. No. 178495.
 FIG. 10. Gauge for jar mouth. Lid of preserve jar fitted with handle to allow of placing it over the mouth of the jar being thrown to ascertain gauge. Cat. No. 178500.
 FIG. 11. Wire for cutting ware from the wheel. Copper wire with wooden handle and leather guard. Cat. No. 178498.
 FIG. 12. Gauge for height of ware. Planted in a lump of clay in the wheel-box. Cat. No. 178504.
 FIG. 13. Bow for wire used in cutting ware from the wheel.
 FIG. 14. Scraper for removing clay.
 FIG. 15. Former for mouths of jugs, etc.



TOOLS OF THE POTTER.



EXPLANATION OF PLATE 10.



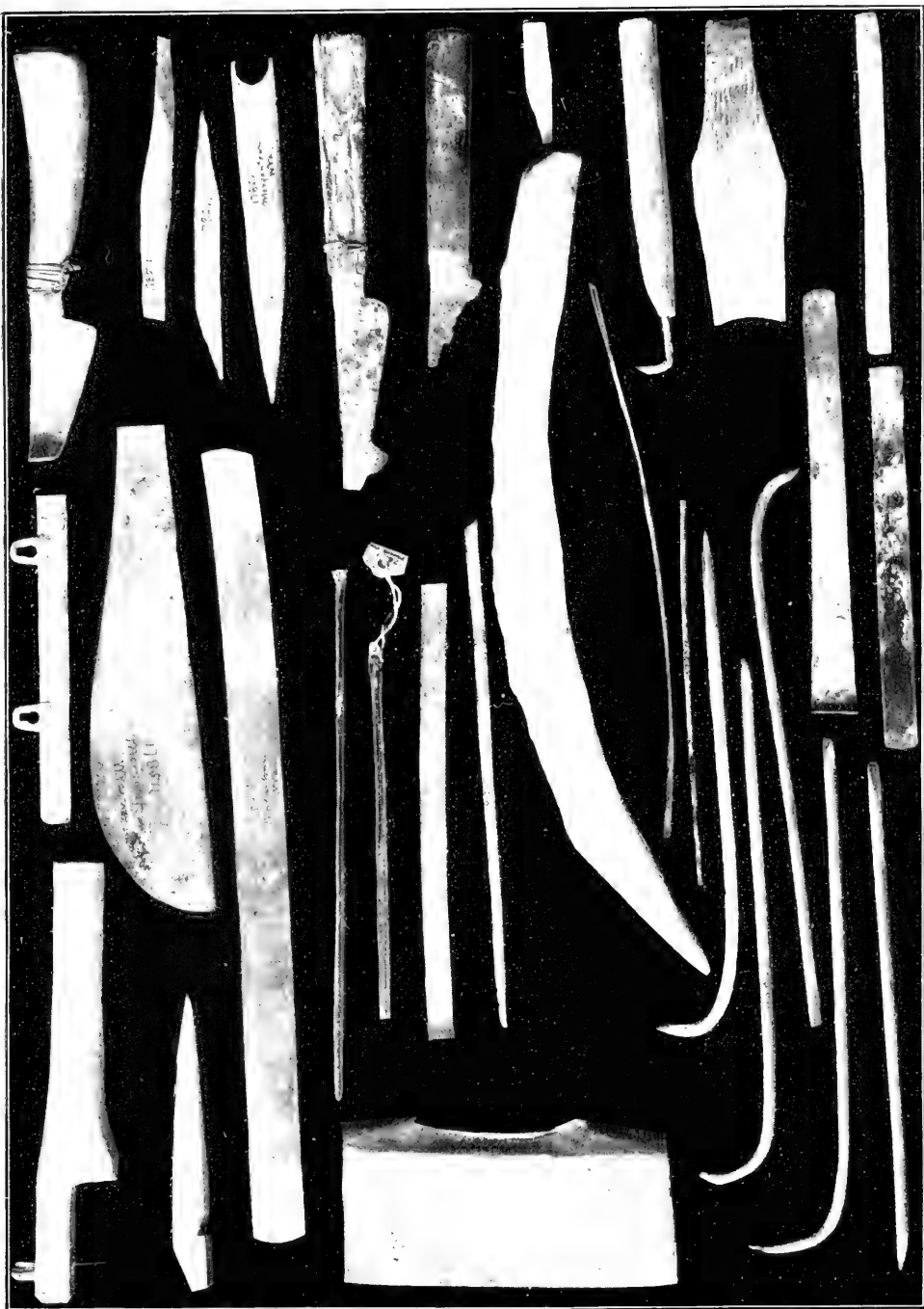
FIGS. 1-5. Small modeling tools made from iron wire. (Cat. No. 178511 belongs to all figures on this plate.)

FIGS. 6-23. Modeling tools, scraper, etc., of various materials and sources put to use by the potter.

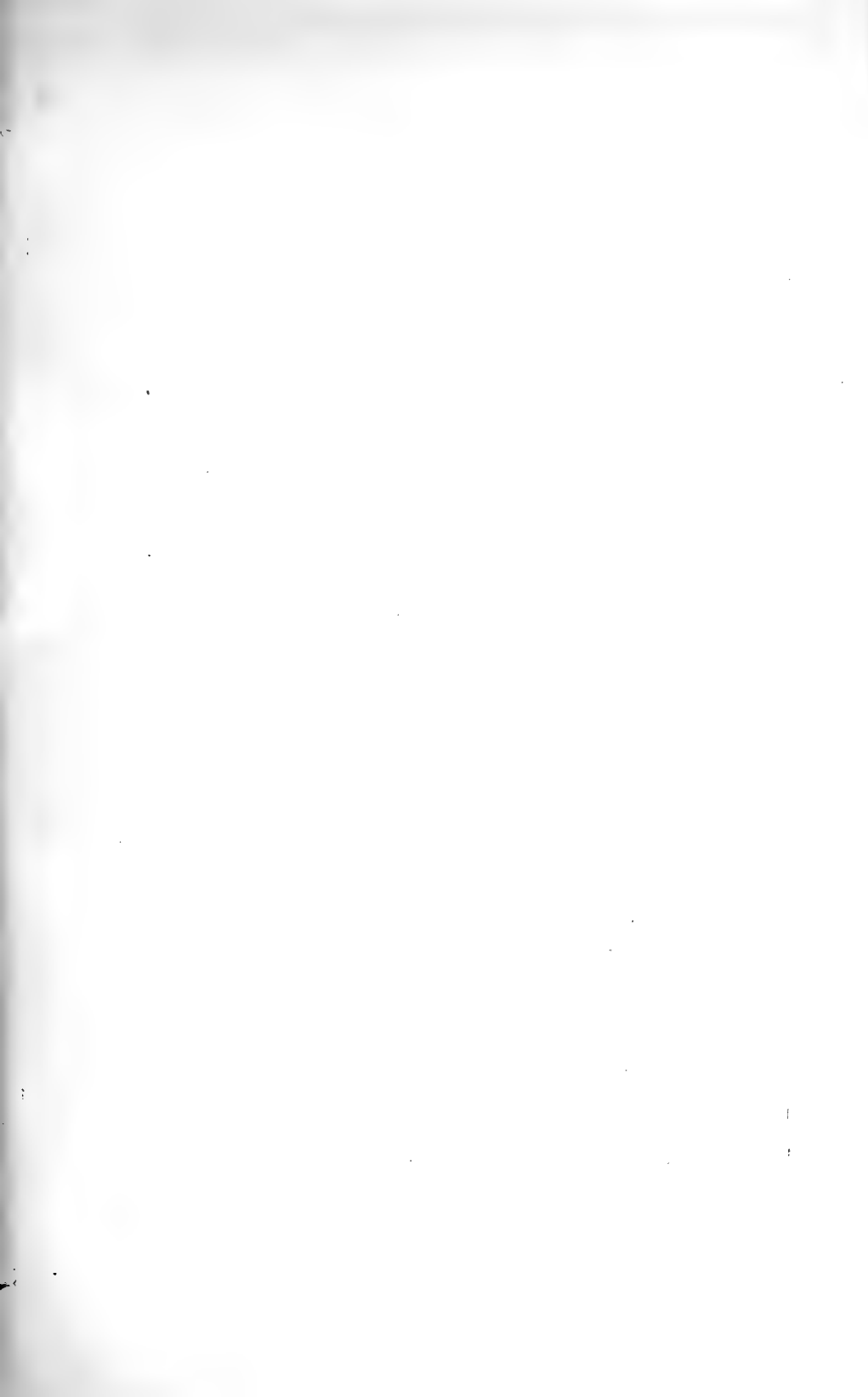
FIG. 24. Old knife used on the wheel for forming ware.

FIG. 25. Bits of wood, etc., adapted for use as modeling tools.

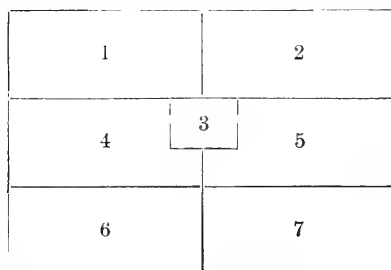
FIG. 30. Gauge.



TOOLS OF THE POTTER.



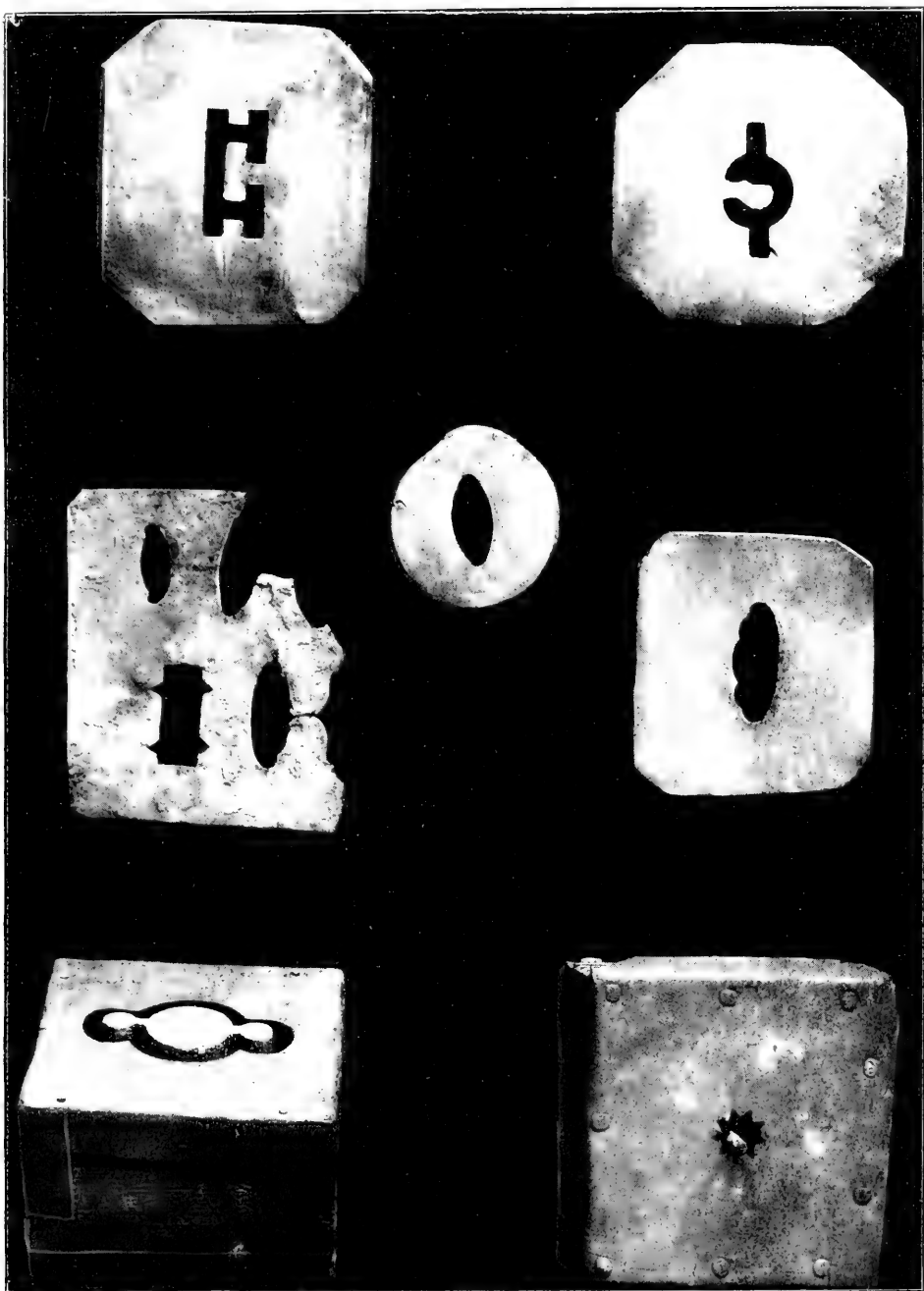
EXPLANATION OF PLATE 11.



FIGS. 1-4. Dies of baked clay. Early form of die placed in bottom of press, fitted with plunger to force clay through forming handles. Cat. No. 178515.

FIG. 5. Pattern for handle dies; sheet iron. Cat. No. 178507.

FIGS. 6-7. Dies. Square frame of oak, over one end of which is tacked sheet iron, pierced with the shape and fitted with a core. Placed in the press for forming hollow handles. Cat. No. 178501.

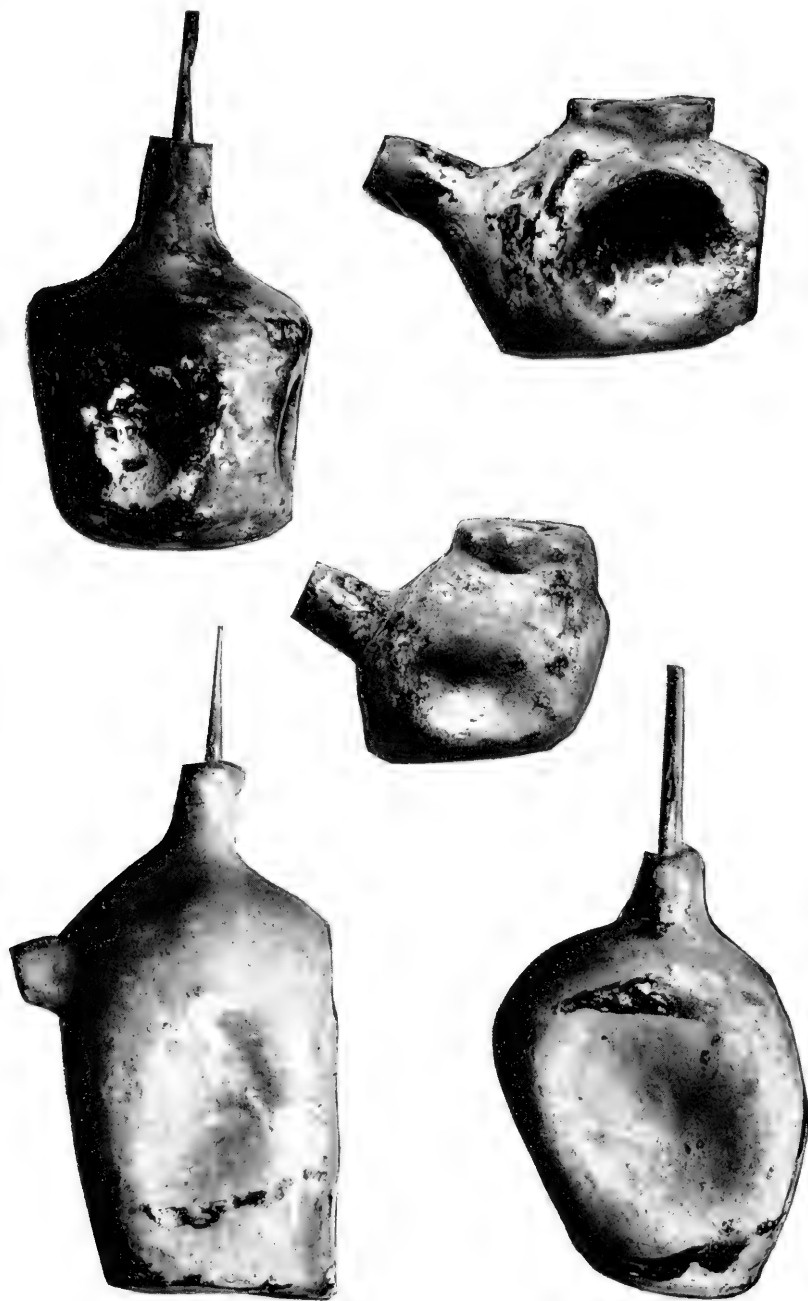


HANDLE DIES OF THE POTTER.

EXPLANATION OF PLATE 12.

1	2
3	
4	5

- FIG. 1. Vessel for slip decoration. Red body covered with brown glaze. The upper side of the vessel has an orifice to which was fitted a plug pierced with a small hole, and the spout is supplied with a quill. The vessel is shaped for grasping in the hand. Being filled with clay slip about the consistence of thick cream, the stopper was inserted and the flow of the slip regulated by the opening and closing of the orifice by the thumb. By this means designs were applied to pottery, often complicated, and producing pleasing effects. A specimen of the work may be seen on Plate 4, fig. 5. Cat. No. 96597.
- FIG. 2. Vessel for slip decoration. Red body, thin brown glaze.
- FIG. 3. Vessel for slip decoration. Red body, brown glaze. Wings at sides of body.
- FIG. 4. Vessel for slip decoration. Cream-colored body; splotches of brown glaze. This vessel has two orifices in the top for convenience of the slip decorator. Cat. No. 96598.
- FIG. 5. Vessel for slip decoration. Cream-colored body; splotches of brown glaze. One orifice; four holes for quills at the spout.



BOTTLES FOR SLIP PAINTING.

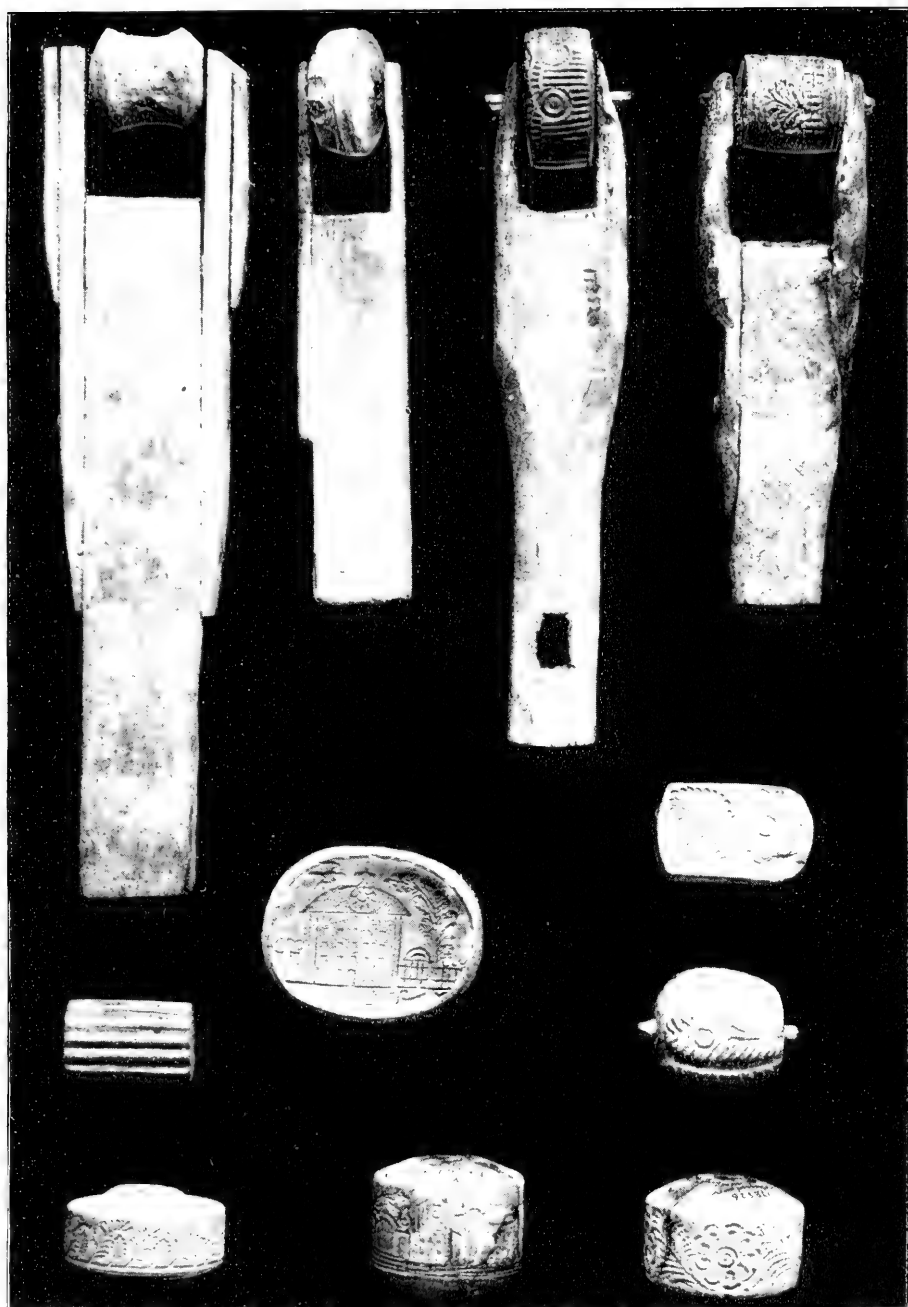
EXPLANATION OF PLATE 13.

1	2	3	4
5	11	10	
6	7	9	
		8	

FIGS. 1-4. Rollers for decorating pottery. Sections of cylinders of baked clay with sunken designs on the periphery, mounted in rude guides. Cat. No. 178526.

FIGS. 5-9. Unmounted rolling stamps of wood and baked clay. Cat. No. 178526.

FIGS. 10-11. Hand stamps of baked clay. Cat. Nos. 178525, 178520.



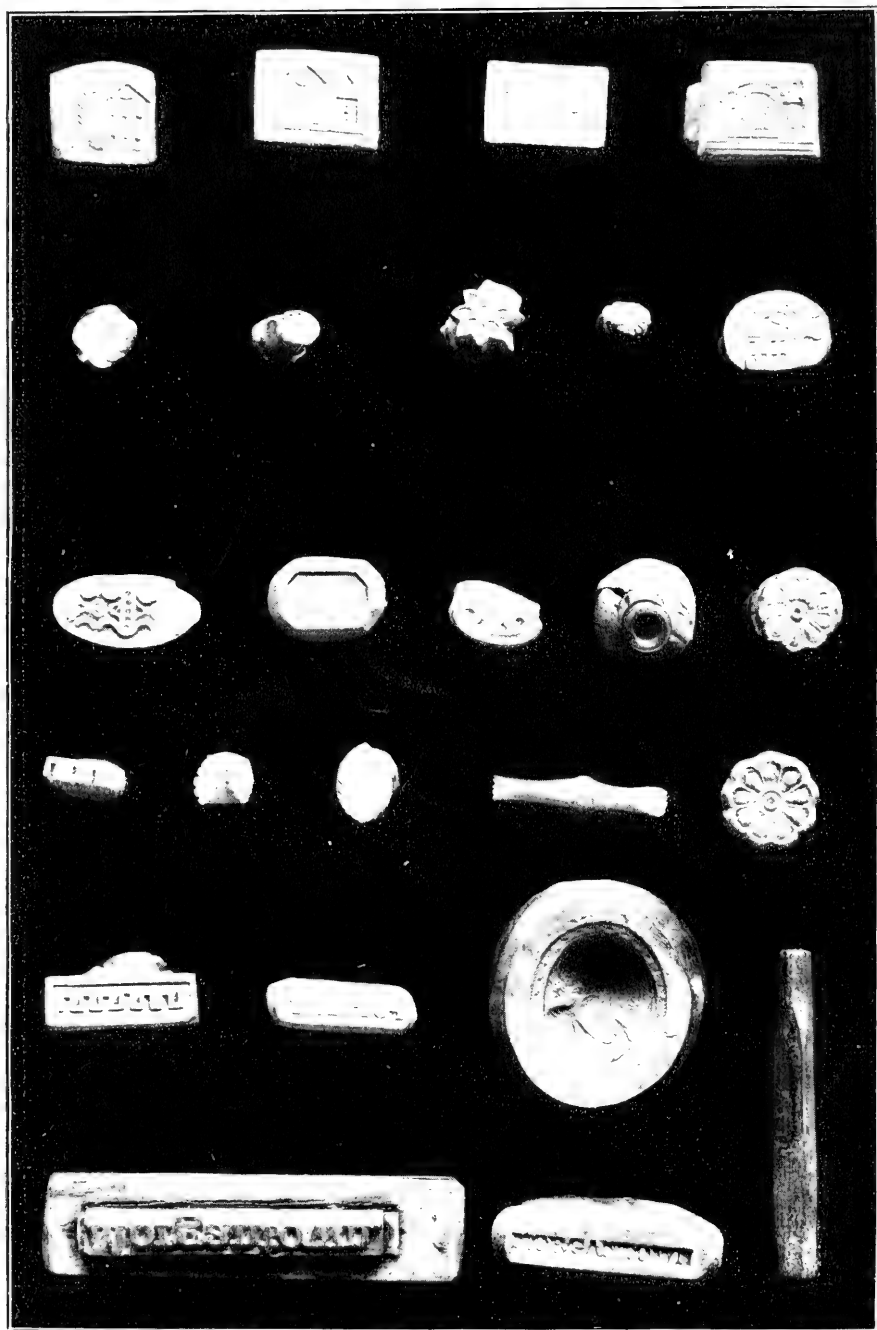
ROULETTE WHEELS FOR ORNAMENTS POTTERY.

EXPLANATION OF PLATE 14.

1-20
21-25

FIGS. 1-20. Hand stamps of baked clay used in the early manufacture of pottery at Morgantown, West Virginia. Cat. No. 178520.

FIGS. 21-25. Stamps of printing type and molds from type used in signing later ware. Cat. No. 178520.



STAMPS FOR WARE.

EXPLANATION OF PLATE 15.

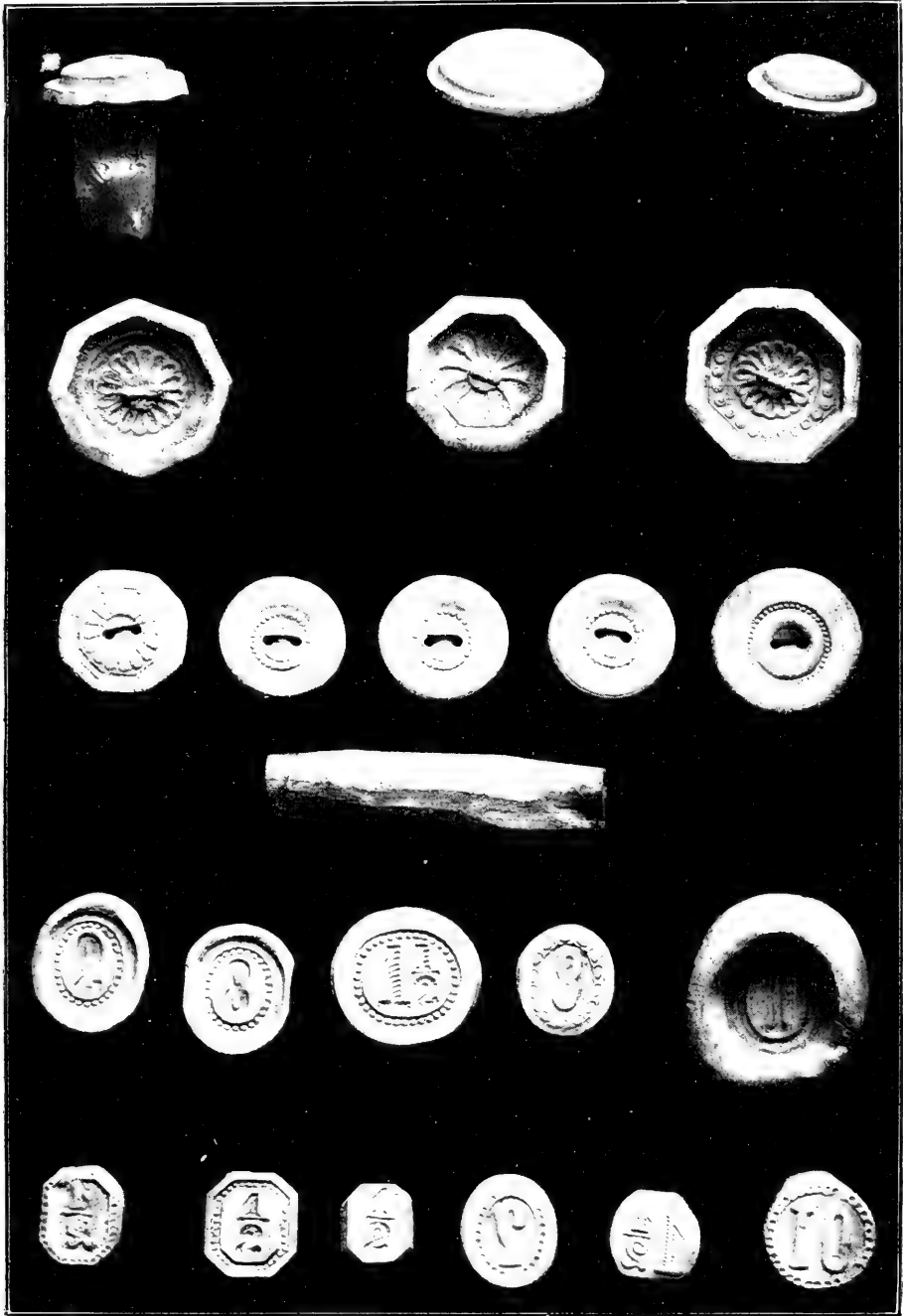
1			2		3
4			5		6
7	8		9	10	11
12					
13	14		15	16	17
18	19	20	21	22	23

FIGS. 1-6. Button molds. Cat. No. 178519.

FIGS. 7-11. Buttons cast from mold, unbaked. Cat. No. 178519.

FIG. 12. Figure stamps of wood. Cat. No. 178518.

FIGS. 13-23. Figure stamps of baked clay and impression of stamps. Used in stamping ware according to cubical capacity. Cat. No. 178518.



BUTTON MOLDS, BUTTONS AND FIGURE STAMPS FOR WARE.

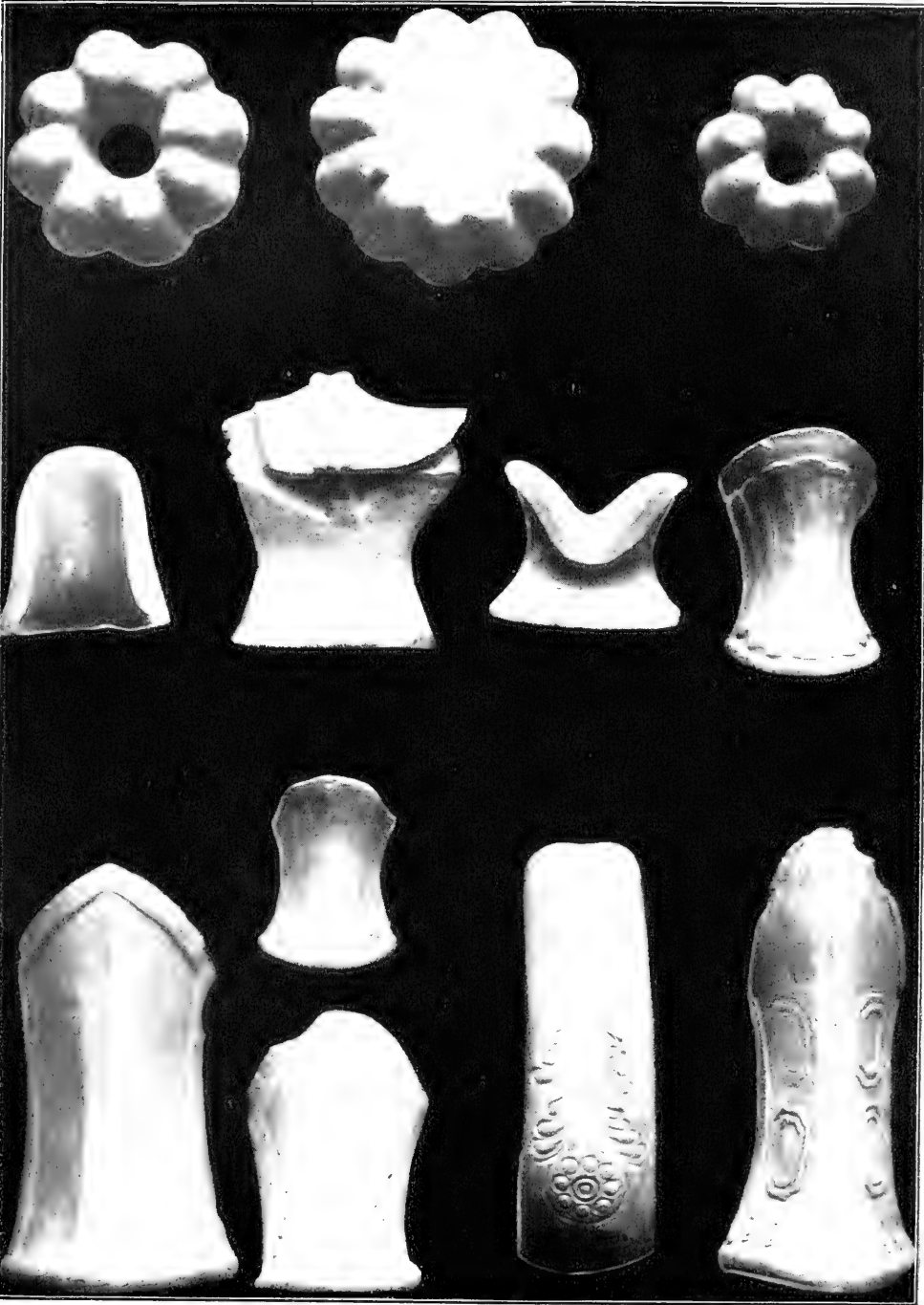


EXPLANATION OF PLATE 16.

1		2		3	
4	5		6		7
8	9		11		12
	10				

FIGS. 1-3. Forms for molding small cake pans. Cat. No. 178514.

FIGS. 4-12. Forms and molds for making mouths of pitchers. (See Plate 1, fig. 3.)
Baked cream-colored clay. Date, 1790. Cat. Nos. 178516-178517.



MOLDS.

EXPLANATION OF PLATE 17.

1	2
3	4
5	6
7	8

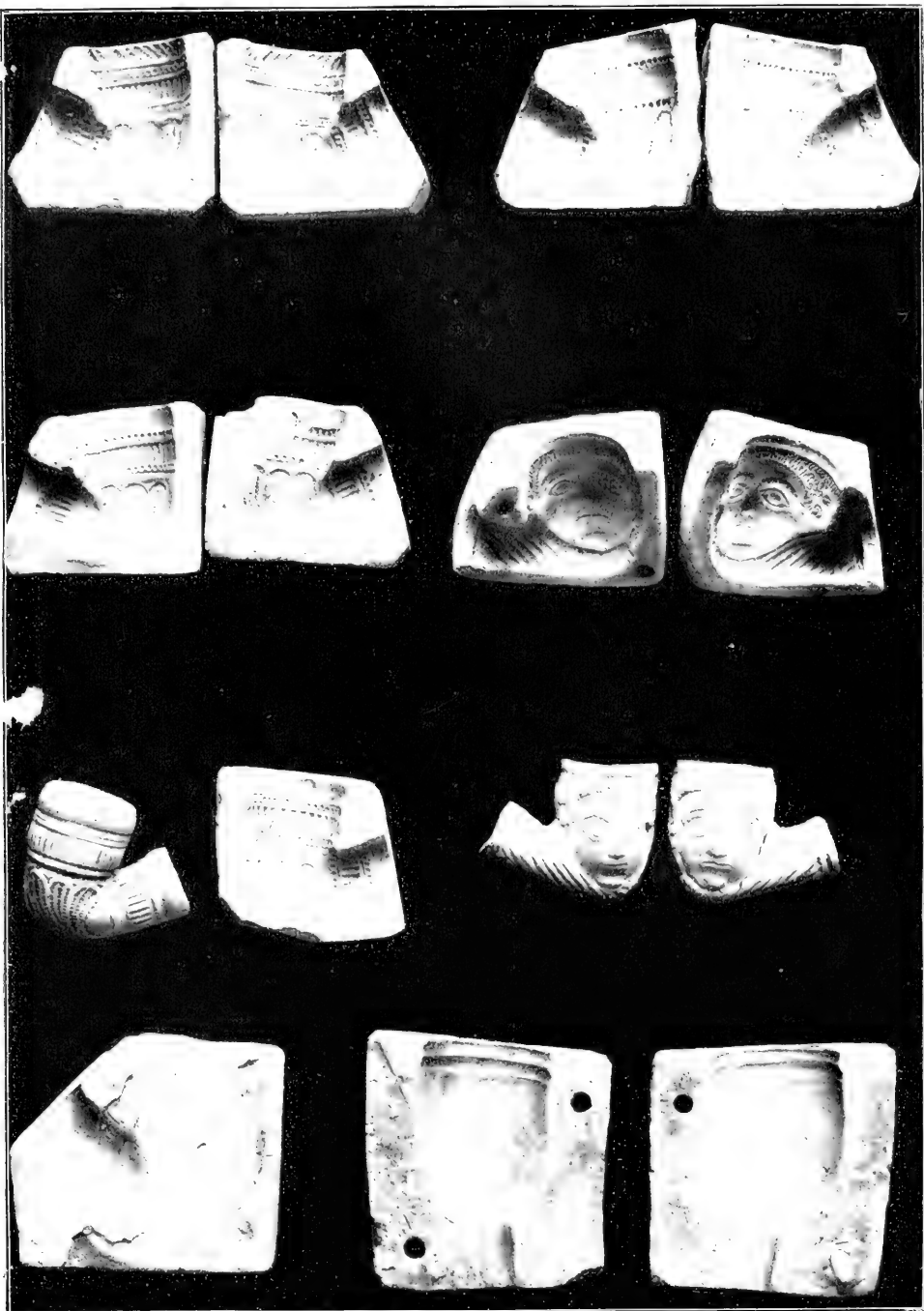
FIGS. 1-3. Pipe molds of unbaked clay, conventional pattern. (Cat. No. 178521 belongs to all the figures in this plate.)

FIGS. 4, 5. Pipe mold, "Indian pattern," and casts from halves of the mold. These halves are afterwards joined by luting to form a pipe.

FIG. 6. Half mold and cast.

FIG. 7. Half mold; plain pipe.

FIG. 8. Pipe mold; baked cream-colored clay. Showing dowels for holding mold together.

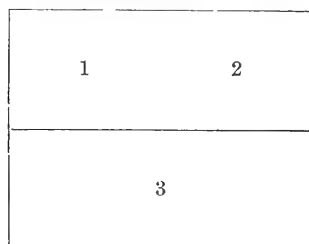


PIPE MOLDS.



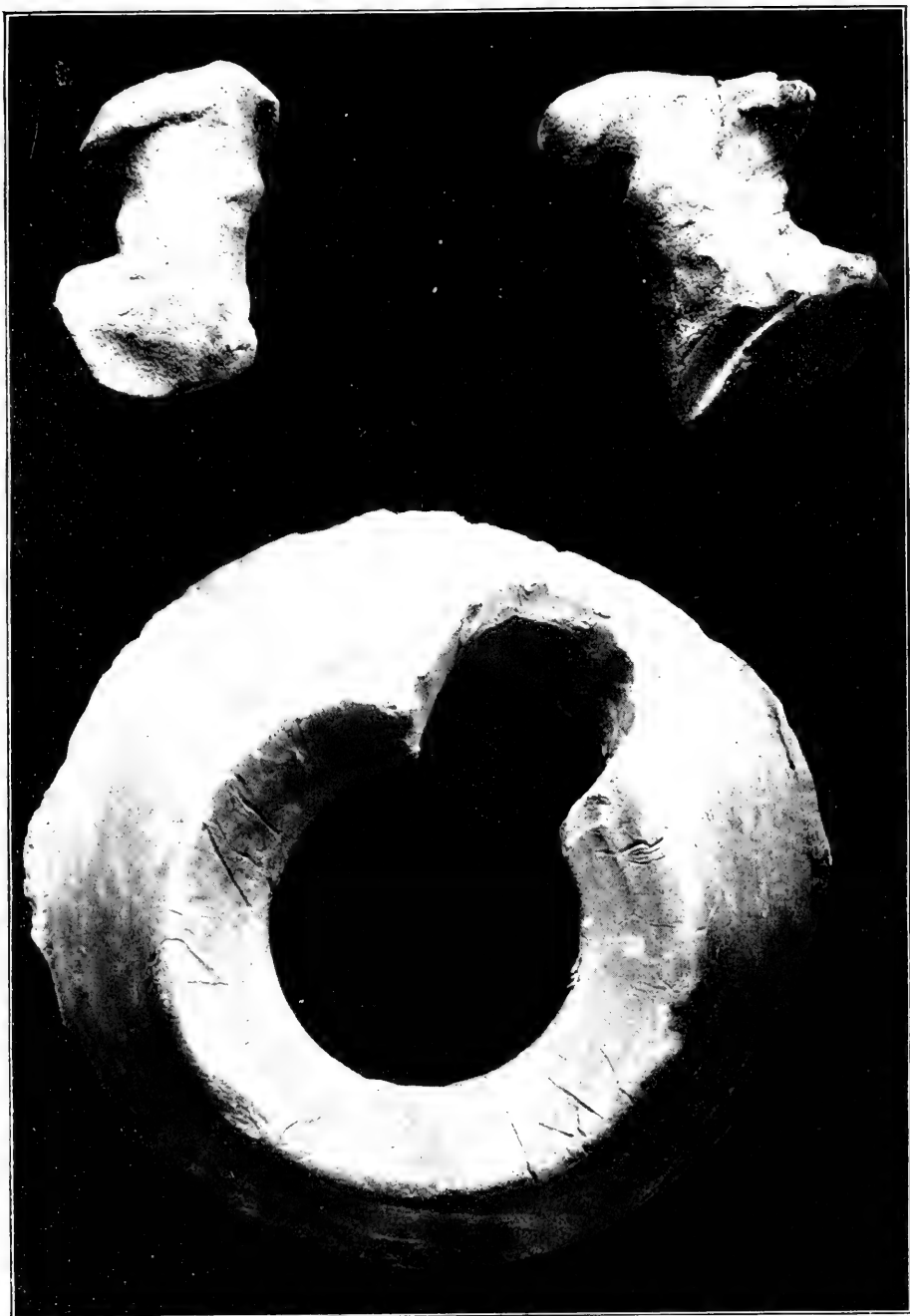


EXPLANATION OF PLATE 18.



FIGS. 1-2. Separators of clay. Formed by hand before setting up the kiln and rolled in coarse sand to prevent adhering to ware. Cat. No. 178523.

FIG. 3. Rest for large vessels at bottom of kiln. Unbaked. Cat. No. 178522.



SEPARATORS FOR WARE AND REST FOR WARE IN THE KILN.

POINTED BARK CANOES OF THE KUTENAI AND AMUR.

BY

OTIS T. MASON,
Curator, Division of Ethnology.

WITH NOTES ON THE KUTENAI CANOE BY MERIDEN S. HILL.

POINTED BARK CANOES OF THE KUTENAI AND AMUR.

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INTRODUCTION.

Among the series of models to illustrate the history of navigation gathered in the U. S. National Museum there is one of a canoe secured a long time ago by Mr. George Gibbs and numbered 641 in the Anthropological Catalogue. Figures of such canoes are given in the Standard Natural History,¹ Lord's British Columbia,² Proceedings of the Royal Society of Canada,³ and by Julian Ralph.⁴

The model in question is not of birch-bark, but of pine-bark (*Pinus monticola*), laid on with the inner or smooth side out. The canoes of this type are all pointed like a monitor, at either end, on or below the water line; that is, they are longest on the line of the keel. When new they seem to be straight along this line, but, from being loaded in the middle, they sag afterwards, and the pointed ends get turned up through striking the shore in landing.

Mackenzie mentions the use of spruce-bark in canoe building, but does not speak of the shape.

A glance at a large collection of American Indian water craft throughout both continents reveals the fact that this pointed type is unique for the Western hemisphere. In the north and east the birch-bark canoes prevail, and farther north the kaiak and the umiak. In the west the dugout is universal and assumes often large size and graceful outline. But every example of skin boat, bark canoe, and dugout on the Western Hemisphere, excepting the Kutenai canoe, is longer on top and narrower at the bottom, or what would be the keel if any were present. In a few local forms of Canadian bark canoes there is a suggestion of a chin at the ends, faintly hinting at kinship with the Kutenai type. Further examination into the water craft of North and South America fails to reveal any such form as that of the Kutenai canoe. The bark boats or "woodskins" of the Amazon and its affluents and

¹ Vol. VI, p. 441.

² Vol. II, p. 178.

³ Vol. IX, p. 15, fig. 4.

⁴ On Canada's Frontier, p. 293.

the Orinoco have no such motives.¹ The reader will have to search in another part of the world for similar models, as will be shown further on.

TYPES OF AMERICAN WATER CRAFT, BY AREAS AND FAMILIES.

ZOOTECNIC AREAS.	PEOPLES.	WATER CRAFT.
1. Arctic.	Eskimaun.	Kaiak and umiak of skin.
2. Canadian.	Athapaskan.	Bark canoes.
3. Atlantic slope.	Algonquian-Iroquoian.	Dugouts and rafts.
4. Plains of the West.	Siouan.	Coracle of buffalo hide.
5. Louisiana or Gulf.	Muskhogan.	Cane floats and pirogues.
6. Southeastern Alaska.	Haida-Skiddagetan.	Dugout, exclusively.
7. Columbian region.	Salish-Chinookan.	Dugout and pointed bark canoes.
8. Interior basin.	Shoshonean.	None.
9. California region.	Very mixed stocks.	Dugouts and reed rafts.
10. Pueblo region.	Tanoan-Tewan and Sonoran.	None.
11. Middle America.	Aztec-Mayan.	Reed floats and dugouts.
12. Antillean region.	Carib-Arawakan	Dugout and woodskins—(1) woodskins, (2) buckshell, (3) corial, (4) canoe.
13. Cordilleran region.	Chibcha-Kechuan.	Balsas, reed floats with sails.
14. Upper Amazonian.	Jivaro, Peba, Puno, etc.	Dugouts.
15. Eastern Brazilian region.	Tupi-Guaranian, Tapuyan.	Jangadas or catamarans.
16. Mato Grosso and southward.	Mixed people of Brazilian and Andean types.	Woodskins and dugouts.
17. Argentina-Patagonian region.	Chaco, Pampean, and Patagonian stocks.	Dugouts or none.
18. Fuegian region.	Aliculuf, Ona, and Yahgan.	Bark canoe in streaks or longitudinal sections.

It would occur to any student of technography that in this particular spot the birch trees fail and nature furnishes an excellent substitute in the pine bark. On this point Mr. Gifford Pinchot, of the Forestry Division of the U. S. Department of Agriculture, calls my attention to the following quotations from Sargent's *Silva of North America*:

The canoe birch is one of the most widely distributed trees of North America. From Labrador it ranges to the southern shores of Hudson Bay and to the Great Bear Lake, and thence to the valley of the Yukon River and the coast of Alaska, forming with the aspen, the larch, the balsam poplar, the banksian pine, the black and white spruces, and the balsam fir, the great subarctic transcontinental forest; and southward it ranges through all the forest region of the Dominion of Canada and the Northern States to Long Island, New York, and northern Pennsylvania, central Michigan, and Minnesota, the bluffs of the Niobrara River in northern Nebraska, the Black Hills of Dakota, northern Montana, and northwestern Washington. An inhabitant of the rich wooded slopes and the borders of streams, lakes, and swamps, the canoe birch, although it never forms a large part of the forest, is very common

¹ Von den Steinen, *Unter den Naturvölkern Zentral Brasiliens*, Berlin, 1894, p. 120, pl. X.

in the maritime provinces of Canada, in the region immediately north of the Great Lakes, and in northern New England and New York, where it ascends to higher elevations than any other deciduous-leaved tree; it is small and comparatively rare in the coast region of southern New England, in southern New York, and central Minnesota; widely distributed at high latitudes from Labrador to the eastern base of the Rocky Mountains; it is never very abundant there nor a conspicuous object in the landscape, and within the Arctic Circle becomes small and crooked. West of the Rocky Mountains, where it attains its largest size, the canoe birch usually grows singly and is found only along the banks of streams. (Vol. IX, p. 57.)

The Western white pine is distributed through mountain forests from the basin of the Columbia River, in southern British Columbia, to Vancouver Island, southward along the western slopes of the Rocky Mountains to northern Montana, and to the Bitter Root Mountains of Idaho, westward along the mountain ranges of northern Idaho and Washington, reaching the sea level near the shores of the Straits of Fuca, and southward along the Cascade Mountains and the Washington and Oregon coast ranges, extending eastward in Oregon to the high mountains east of Goose Lake, and southward along both slopes of the California Sierras to the ridge between Little Kern and Kern rivers, in latitude $36^{\circ} 25'$. In northern Idaho the western white pine grows to its largest size, and is most abundant, often forming an important part of the forest at elevations of from 2,000 to 2,500 feet above the sea on the bottom lands of streams tributary to Lake Pend Oreille; farther east, in Montana, it is less abundant and smaller; in the interior of British Columbia it is not abundant, although it sometimes is large; it is scattered in considerable numbers through the coniferous forests of the coast ranges of British Columbia and through the interior of Vancouver Island; and it is not rare on the Cascade Range, where it ascends to elevations of 5,000 to 6,000 feet, nor on the California Sierras, first appearing singly or in small groups along the upper margin of the fir forest, and attaining its noblest dimensions in California at elevations of about 10,000 feet above the sea, where trees 90 feet high, with trunks 5 or 6 feet in diameter, sometimes occur, and resist for centuries, with their massive trunks, and short, contorted branches, the fiercest Sierra gales. (Vol. XI, p. 23.)

As to the unique shape of the Kutenai canoe on the American Continent, it will not suffice to say that pine bark is more easily bent after this fashion, and that in obedience to the law of economy of effort this was the natural result of employing that material. The writer made experiments with substances having similar toughness and elasticity and found it no more difficult to bend them into the common canoe form than into the monitor form when the material is properly cut out. As to the economy of sewing at the ends, that is difficult to determine. At any rate, the other American Indians invariably slope their birch-bark canoes outward from the bottom at both ends, but the Oltscha and Goldi of the Amur, and even the Tungus and Yakut, imitate the Kutenai tribes and point their birch canoes below the water.

In order to ascertain the distribution and handling of these pine-bark canoes, the assistance of Mr. Meriden S. Hill, secretary of the Tacoma Academy of Sciences, Washington, was invoked, and the results of his investigations will now be given.

THE KUTENAI CANOE.

The pine-bark canoe, pointed at both ends below water, is used in only a circumscribed area on the Kootenai River, and on the Columbia at the mouth of the Kootenai. In order to make sure of this and to know more about the uses of this craft, at the suggestion of the curator of the Division of Ethnology in the U. S. National Museum, an extensive correspondence was conducted with missionaries and others who have spent years on the Kootenai and the Upper Columbia. (Plate 1.)

It is well to say that the birch-bark canoe of regions east of the Rocky Mountains does not exist on the Columbia or the Kootenai, but the dugout, in ruder form, is to be found in many localities, becoming more beautiful and seaworthy as one approaches the ocean. The writer has never heard of any other regularly built canoe of bark or other material in America pointed at or below the water line. All the birch-bark canoes are rounded up the other way, like the prow of an old-fashioned ship or of a lifeboat. It was the writer's purpose to work up the matter with greater detail, but he was prevented by continued illness.

In the second volume of Ross's *Fur Hunters* he says, speaking of the Kutenai upon the Arrow Lakes, in British Columbia:

At the water's edge we saw and examined a birch-rind canoe, of rather singular construction, such as I had never seen in any other part of the country, but used by the natives here; for I saw several of the same make when I passed this place two years ago. Both stem and stern, instead of being raised up in a gentle and regular curve, as is customary elsewhere, lie flat on the surface of the water, and terminate in a point resembling a sturgeon's snout. The upper part is curved, except a space in the middle. Its length is 22 feet from point to point and the whole bottom between these points is a dead level.¹

Such craft must prove exceedingly awkward in rough water, and there is often a heavy swell on these lakes. Dawson has also mentioned these canoes in the following language:

In addition to the ordinary and always rough dugout canoe made from the cottonwood (*Populus trichocarpa*) probably, and employed occasionally on certain lakes or for crossing the rivers, the Shushwaps in the eastern part of their territory in British Columbia made small and shapely canoes from the bark of the western white pine (*Pinus monticola*). These may still be occasionally seen on Shushwap Lake and in the vicinity of the Columbia. The inner side of the bark stripped from the tree in one piece becomes the outer side of the canoe, which is fashioned with two sharp, projecting spur-like ends, strengthened by wooden ribs and thwarts internally; the whole is lashed and sewn with roots, and knot holes and fissures are stopped with resin. The canoes thus made are very swift, and, for their size, when properly ballasted, remarkably seaworthy.²

Mr. G. M. Sproat, author of *Scenes and Studies of Savage Life*, says that the pointed canoe is the common craft on the Columbia River

¹ Alexander Ross, *The Fur Hunters of the Far West*, London, 1855, 2 vols. Vol. II, pp. 169, 170.

² Transactions of the Royal Society of Canada, December 11, 1891, fig. 4.

above Colville and on the lower part of the Kootenai. They are in daily use there, but are not known to have existed in any other part of America.

Mr. A. J. Kent, of Idaho, writes that the Kutenai have no other kind of canoe except the one made of spruce, white pine, or cedar-bark, pointed at both ends beneath. These are about 15 feet long and weigh, say, 50 pounds. The bark is very tough and pliable when it is taken off in the spring. The squaws build the canoes when the sap starts, sewing them with rawhide or anything else strong enough, closing the cracks with pitch from the yellow pine. It takes two squaws four or five days to make a canoe, the chief difficulty being to get the bark off whole and to turn it wrong side out successfully.

Mr. John Sizelove, postmaster at Kalispel, says that the pointed canoes are made of spruce-bark peeled off in a single piece. The frame is made of split cedar. The Indians at Kalispel will use no other kind of boat, as these are very light and can be taken out of the water and kept away from snow and ice in winter. This writer states that the points curve upward and do not sink below the water. It is

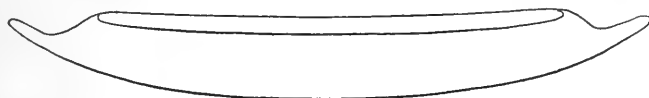


Fig. 1.

OUTLINE OF KALISPEL POINTED CANOE, SHOWING CURVED BOTTOM.

a little difficult to decide at present whether this is a local peculiarity or due to the sinking of the middle when loaded. Mr. Sizelove sends a drawing to confirm his statement (fig. 1).

The Kutenai bark canoes, *ac-so-molth*, are thus described by Mr. D. M. McLaughlin: The pine-bark is cut from the tree in the length required. The gunwales are prepared by splitting three pieces of cedar wood from a stem 3 to 4 inches in diameter, one of them a half cylinder wide, the other two in quarters, placing them about and above the margin of the bark, and lashing all fast with a band of the bark of the vine maple (*Acer circinatum*). After this is finished the ribs, made of the same vine-maple wood split into the required lengths, are forced in between the gunwales. Thin cedar boards are then pushed between these ribs and the bark of the canoe. The ends of the thwarts are forced in between the three pieces of cedar wood, forming the gunwales, closing or opening the canoe as required. These thwarts are then securely bound with the vine-maple so as to keep all stiff and solid, especially the middle one, since it has to bear the greatest strain. Mr. McLaughlin says that the canoes, in spite of their frailty, can stand an extraordinary amount of storm and wave when well managed.

He is sure that when the canoes are first finished they are as straight as an arrow along the bottom. After one has been used awhile the ends turn up more or less, according to the weight put into them. The Indians, after using one, take it out of the water to dry and this has a tendency to draw up the points.

The Rev. Joseph M. Caruana, S. J., gives the following general measurements of the pointed canoe (in Salishan languages, *thie* or *thlie*), in use among the Lakes or Snaichisti Indians, in Stevens County,



Fig. 2.

POINTED CANOE OF THE LAKE INDIANS, WASHINGTON.

Washington: length, 24 feet; width, 4 feet; depth, $2\frac{1}{2}$ feet; paddle, 6 feet; poles, used perpendicularly in strong currents, 6 feet; mat in bottom to kneel on while paddling, 3 by 4 feet. The same writer says that in 1862 pointed canoes were in great use among the Spokane and Cœur d'Alène tribes, as well as the Colville, or Sgoyelpy, and Kalispel. He crossed many a river on such bark canoes while living among the Cœur d'Alène or Szechizue Indians. These canoes held two persons with luggage. The bottoms were flat and the ends somewhat turned

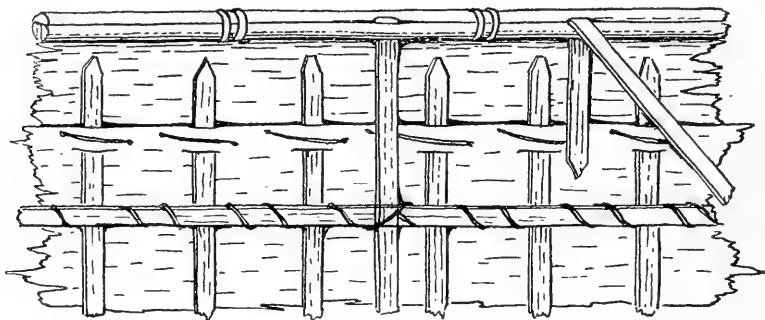


Fig. 3.

DETAIL OF THE LAKE INDIAN CANOE, WASHINGTON.

up. They were fragile and swift. The Indians had no tradition and could give no account of their origin. The canoes examined by Father Caruana had ribs of white cedar, very light and pliable, and bound to the horizontal framework with split cedar roots or willow twigs. The ribs are pointed at the top and do not reach the gunwale, but are forced through the bark and covered in. The chinks are well pitched, especially at the two ends. Mr. Kent, of Bonners Ferry, Idaho, describes one of the canoes as 14 feet long, weighing 50 pounds.

Fig. 2 is of a model of the pointed canoe of the Lake Indians, made

under the supervision of Father Caruana. It is 3 feet long from point to point; open space, 2 feet; width, 6 inches; depth, 4 inches. This represents a larger one, 24 feet in length. Fig. 3 represents the detail of construction in the framework. In putting in the ribs incisions are made into and halfway through the bark of the hull at its upper border. The ribs are inserted into these openings and pushed upward and out at the edge, which has been split for this purpose. The ends of the ribs do not reach quite up to the gunwale. The ribs are fewer in number, but larger, and pass at their ends between the bark and the inside one of the three strips or staves which together form the gunwale. These also pass outside the longitudinal slats toward the hold of the boat, while the ribs pass between the longitudinal slats and the bark sheathing. Slender roots and thin bark ribbons, apparently of spruce, are used in stitching and wrapping the various sections of the canoe together. The seams and joints are well covered with pitch. As in the full-sized craft, the inside surface of the bark becomes the outside of the hull, which is formed of three pieces, as indicated in the drawing. The part marked shows the method of bending on of one of the thwarts. In some cases the ends are pierced and seized or sewed to the gunwale. With this model were two pointed sticks representing the poles used in managing the canoe over swift currents, a paddle, and a mat on which the man kneels.

CANOE OF THE KUTENAI AND OF THE AMUR COMPARED.

Through the researches of Mr. Meriden S. Hill, given in the foregoing lines, and the courtesy of Dr. Demetri N. Anutchine, president of the Society of Friends of Natural Science, Ethnology, and Anthropology in Moscow, and of Dr. N. Doubrovine, perpetual secretary of the Imperial Academy of Sciences in St. Petersburg, it is made possible to bring into a comparative study two inventions that are like to each other and unlike to any other craft in either hemisphere. It is not necessary to do more than to refer to Mr. Hill's remarks, since he has ransacked the upper drainage of the Columbia in northern Idaho, northeast Washington, and southeast British Columbia. Additional information comes from Mr. A. J. Kent, Bonners Ferry, Idaho, to the effect that the Kutenai tribes are not ingenious; that they follow closely their model; that the squaws make the canoes in the spring, after the sap starts, sewing the parts with rawhide as well as with bark splints, and that it takes from three to five days to finish a canoe. Maj. C. A. Bendire, U. S. A., had traveled often in one of these, and found no trouble in placing therein, besides himself and the boatman, his saddle and outfit.

The Gibbs specimen, No. 641 in the U. S. National Museum, is made of pine-bark (*Pinus monticola*), in three pieces, drawn over a wooden frame, the inside of the bark forming the outside of the canoe.

The framework consists of four longitudinal rods, to which are lashed a series of ribs by means of bark strips. Outside of this frame and next to the bark are a series of false ribs or slats to hold the bark in place. The canoe is straight along the bottom and pointed at bow and stern. The gunwale consists of three long pieces, one, the inwale, laid along the inner margin of the bark; one, the outwale, laid parallel to this along the outer margin of the bark; and the third, the gunwale, which is broader and semicircular in section, is laid on top of all, so as to cover in the upper edge of the bark and the other two strips of the gunwale. The whole are lashed together with bark. This triple arrangement is also found on the upper margin of the bow and stern where the two edges of the bark are joined. The gunwale is held in shape and place by thwarts lashed at their ends. (Plate 2.)

From the descriptions elicited by Mr. Hill concerning full-sized boats, it appears that the model is correctly made, and it is safe to conclude that—

1. The Salishan and Kitunahan tribes that occupy the area included in the Kutenai drainage, make a canoe differing from any other craft known to American tribes.

2. These canoes are made chiefly of the tough leathery pine-bark, on cedar frames and sewed with tough roots, such as the Indians employ for basketry all over this northwestern region.

3. The bark is stripped off in lengths equal to those of the desired canoes, about 15 feet, and in order to increase its gliding quality is turned inside out.

4. At a convenient distance from the ends the margins of the bark are firmly tied together. Between these two points of union the edges are forced apart and held in place by thwarts varying in length. Outside the two points of union the ends of the bark are pinched together and triangular pieces cut from the corners, so that when the sloping edges are joined a sloping or incurved line extends from the points of union on top to the extremities of the bottom, in fact causing the canoe to look at each end something like a modern "ram" or monitor.

5. The bark is strengthened by ribs and by horizontal slats, and the parts are sewed together by means of vinemaple, pine, cedar, or spruce root, or with strips of bark.

6. A gunwale is built up by splitting a cedar pole into three parts, one of them the segment of a circle in section for topwale; the other two, inwale and outwale, are quarters of circles in section, so that they will fit neatly on top and along the outer and inner margin of the upper border of the bark. In this part of the construction the Kutenai craft is in contrast with other northern bark canoes.

By reference to Major Powell's map¹ of the linguistic stocks of

¹ J. W. Powell, Seventh Annual Report of the Bureau of Ethnology, Washington, 1891.

North America, it will be seen that the tribes in Washington using the pointed canoe are:

1. Shushwap, of the Salishan family.
2. Colville or Tgoyelpi, Salishan family.
3. Kalispel, Salishan family.
4. Spokane, Salishan family.
5. Lakes or Snaichisti, Salishan family.
6. Kutenai, Kituanahan family.

In the light of these Kutenai specimens it may be interesting to examine similar craft of Asia. There being no trees yielding bark fit for canoe making along the Arctic coast, it is necessary to trace the fiftieth parallel of latitude, that of the Kutenai canoe, across the Pacific, and this brings one to the Amur basin. Upon this stream dwell Giliaks, Goldi, Manyargs, etc., unclassified ethnic groups—that is, ethnologists have not been able to relegate them to any of the well-known Asiatic families.

An excellent account of these tribes is given by Leopold von Schrenk in a work entitled *Reisen und Forschungen in Amurlände*. He shows a Giliak man seated in a pointed bark canoe.¹ Layard also figures a Phœnician war galley pointed beneath the water.²

Von Schrenk describes three types of boat on the Amur River and about its mouth, the built-up boat, or bateau, the dugout, and the birch-bark canoe.³ The first named is a sort of flat boat or scow made of three planks hewed out of the larch or *Picea ajanensis*, worked out with adze and knife and fitted together with pegs. Bow and stern boards are set in and the bottom board projects at the bow into a sort of platform, slightly turned up. In many examples considerable style and ornamentation are added, so that Schrenk believes this built-up form to have been introduced under Manchu-Chinese influence from Soongaria. For centuries Chinese merchants, and among them Manchu officials, have come from Soongaria into the Lower Amur country, the former to trade with the people, the latter in order to collect from them the tribute owed to the Chinese Government. The boats in which these journeys are made are indeed much larger and more complicated than the Goldi Giliak examples, but they are on the whole of like construction. It is to be remarked in this connection that the plank boat in use by the Giliaks at the Amur mouth; on Saghalin, by the Oltscha, their neighbors up the river; by the Golde, occupying the stream as far as the Usuri mouth; and by the Oltscha on the seacoast south of the Giliak, is entirely absent from upper Amur areas. Schrenk saw none,

¹Leopold von Schrenk, *Reisen und Forschungen in Amurlände*. St. Petersburg, 1881, III, p. 510.

²Perrot et Chipiez, *Phœnecia*, London, 1885, I, p. 34.

³*Reisen und Forschungen in Amurlände*, III. St. Petersburg, 1881, pp. 500-515.

and Maack, following the Amur from the Schilka, encountered the first craft of this kind at the Usuri mouth. Maack also missed the kind of dugout (called *unjamagda* or *awarpe*) resembling in form the plank boat.

The dugout canoe is found in the interior of Saghalin. Schrenk saw a Giliak example (called *mlomu*) in winter in the village of Yokyrn, carefully protected from snow, resting on a frame near the yurt. It was 20 feet long, broadest in the middle and tapering toward the ends. The bow terminated in a point, but the stern was square and perpendicular with a broad let-in, as in the plank boats.

Much simpler and more primitive are the little canoes also excavated out of the Hammagda tree and pointed fore and aft, which, with small differences in proportions, are called by the Oltscha and the Golde *otongo* and *gulba*. Both are of the same form, pointed fore and aft, but the *gulba* in relation to its length is narrower and deeper and with thicker walls than the *otongo*, and for that reason better fitted to be used in rough water and in places abounding in stones and rocks, etc. The dugouts of Hammagda wood made by the Orochi on the seacoast and the mountain streams flowing to the sea and on the tributaries of the Lower Amur or Usuri are the same as those made by the Golde and Oltscha on the main stream. So was the *awarpe* of the Orochis, on the Upper Munamu stream, made and used outward on the Amur. On the contrary, only now and then, throughout the long course of the Amur does one of the Golde, Oltscha, or Giliak plank boats find its way to the Orochi, on the seacoast.

Schrenk saw among the Birari of Ossika on the Amur a dugout canoe called by them *mango*, 28 feet long, 3 feet broad, and 1 foot deep, and another time one still larger, in which Biraris from the Aar River were returning from their summer fishing grounds on the Amur to their winter settlements. It was deeply laden and carried mast, and sail made of canvas, and held at the corner with the hand instead of with shrouds. On the testimony of the Birari these boats were made from the stem of the abundant *dshagda* tree (*Pinus sylvestris*, L.).

Canoes made of a wooden interior structure covered with birch-bark are more commonly in use than dugouts among the Oltscha and Golde on the Lower Amur, and they are employed also by the Tungus on the Amur tributaries and throughout the streams of the Stanavoi Mountains. In general, of like type everywhere, having the two ends similarly pointed, these bark canoes called *dsai* by the Oltscha and Golde, in their outlines and proportions, as in individual traits, present many peculiarities. However, corresponding nearly to the *gulba* and *otongo* dugouts of the Oltscha and Golde, there are two forms of bark canoes, one deeper and narrower in proportion to the length, generally decked a little with bark at bow and stern; and a broad, flat, and open form, with ends strongly upcurved. Of the former Von

Schrenk furnishes a lithograph¹ and of the latter a woodcut, showing a Goldi man at the mouth of the Usuri River sitting in his *dsai*. The former, through its light form and the deck over the bow to keep off the spray of the turbid waters, is better adapted to use on the upper streams. The latter, on the contrary, furnishes more room for the fishing and hunting outfit and for the game. The handling of the canoes is precisely the same as that of the dugouts, the *otongo* and the *gulba*.

The measurements of the Oltscha canoe were $18\frac{1}{2}$ feet long, $2\frac{1}{2}$ feet broad in the middle, depth 11 inches. In managing these frail and light canoes the Amur-Tungus, Oltscha, Goldi, and other tribes, like their Siberian congeners, develop a skill and dexterity which, at times, in the mad rush of the swollen streams, not seldom recalls the hardihood and readiness of the Aleuts in their baidarkas, and is in strong contrast with the clumsiness and prudent foresight of the Giliak at the Amur mouth and on Saghalin Islands. What the snowshoes are in winter the birch-bark canoes are to the Tungus as soon as the waters have thrown off their icy coverings. Their light weight allows also the carrying of them with ease over long portages and in visiting other waters, either in hunts or migrations. Thus the birch-bark canoe furnishes the unique, typical, characteristic conveyance to the hunting, fishing, wandering, hungry Tungus. Also the Birari and the Managér have bark canoes of the form and structure of the *dsai*, but twice as long, while the width is the same. Schrenk saw among the latter an example $35\frac{1}{2}$ feet long and only 2 feet 2 inches wide. Such a boat is like the Aleut baidarka with several holes, and more like the great *mango*. These are propelled with poles or with two or three double paddles, and are worked by men paddling first on one side and then on the other, shooting forward with great velocity.

The pointed dugouts, as well as the birch-bark canoes, are found also among all the aboriginal tribes of the Upper Amur. Since these are chiefly nomads living by the chase, who only occasionally go down from their hunting grounds and the Amur tributaries to the main stream in order here to prosecute their fishing, these simple, easily repaired, and, on occasion, readily transported craft, which are also available in rapid as in still water, suffice for all their needs. Not merely the narrow patterns, like the *otongo* or the *dsai*, are thus diffused, but also those of large dimensions. In such boats they migrate from winter to summer quarters and back, transporting not only women and children, but a multitude of tools and utensils.

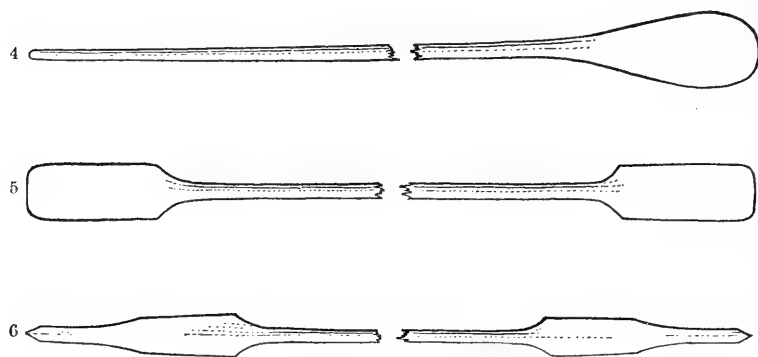
In the museum of the Imperial Academy of Sciences of St. Petersburg are three models of pointed canoes, all made of birch bark. Through the kindness of Dr. N. Doubrovine, secretary, I am able to

¹ Reisen und Forschungen in Amurlände, III, pl. xxxviii, fig. 5, p. 510.

reproduce them here. The rudest paddle, a Tungus example, has a simple handle with oblong elliptical blade, without decoration (fig. 4). The Yakut paddle is double, with cylindrical grip and oblong pentagonal blades, square on the outer ends (fig. 5). The Goldi paddle has a similar grip and hexagonal blades with long tapering points, a gracefully shaped implement (fig. 6).

The double paddle is seen in the Giliak's hand in Schrenk's figure. The Goldi and Yakut employ also the double paddle in their pointed canoes, but in the Tungus pointed canoe the simple paddle is used. The single paddle is found elsewhere around the great circle of the earth that includes the two areas of the pointed canoe. The double paddle exists sparingly in the Eskimo area of Alaska and among the same people in Greenland. On all the waters of the southern United States the negroes propel their dugouts and skiffs with the double paddle.

The Tungus model (Plate 3), though clumsy looking, is built up in five sections. Five strips of bark are bent in the middle and united at their edges to form the hull. The four seams extend quite around



Figs. 4, 5, and 6.

TUNGUS PADDLE; YAKUT PADDLE; GOLDI PADDLE.

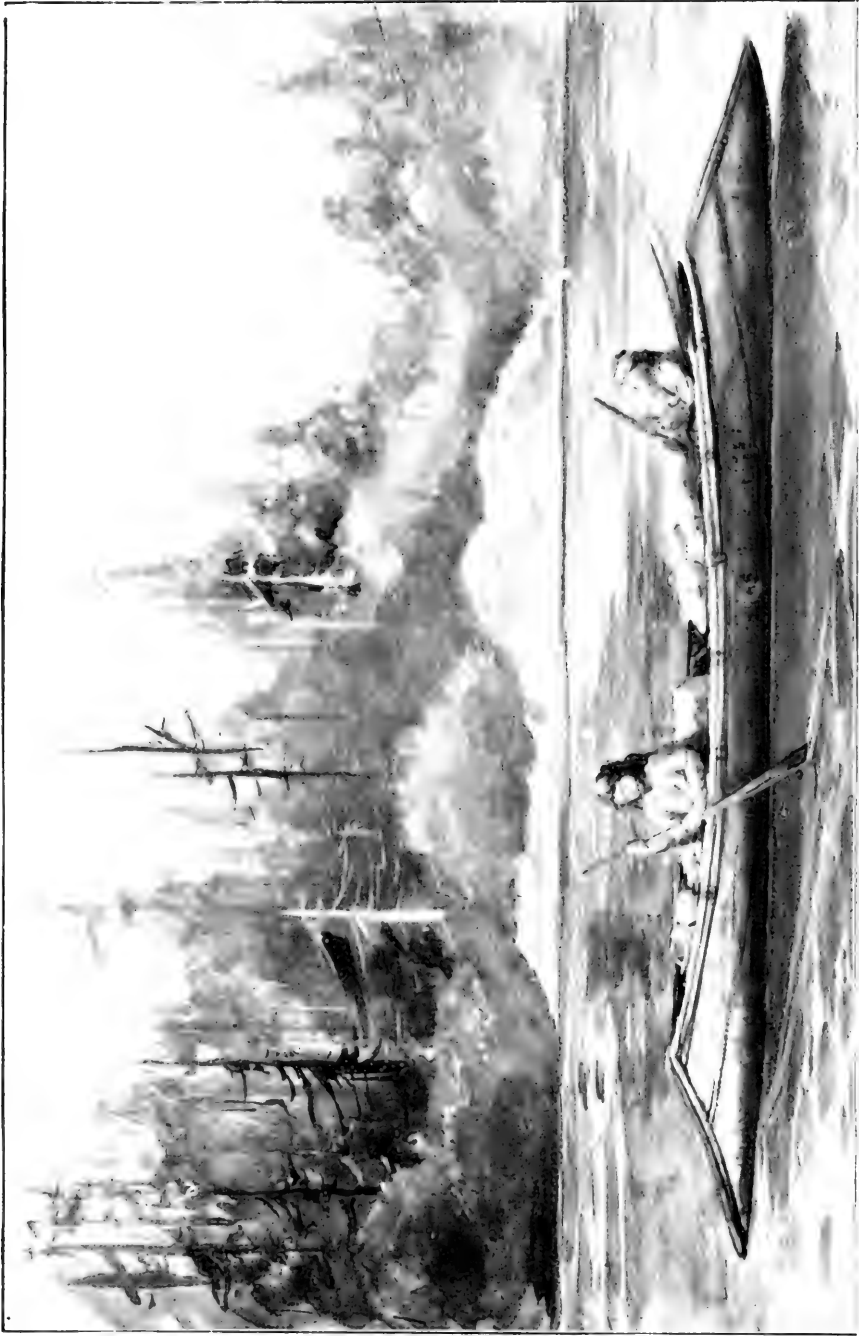
the craft and are rendered tight with pitch. The canoe is kept in form by a series of flat ribs, almost touching one another, and extending along the inside from end to end of the structure, as in a canoe. On the outside of the canoe, along the bottom, a wide strip of bark is sewed neatly, the stitches long on the inside of the boat and short on the outside, passing quite through two thicknesses of bark, including the flat ribs on the inside, holding all together. At the ends the canoe front is straight, the lines sloping inward only a little, so that it is but slightly pointed below. The bark is simply doubled over at the ends and sewed down. On the upper margin strips of wood are sewed on both sides of the bark to form inwale and outwale. There is no top piece except along a short space between the thwarts. Here the side strips for wales leave the margin and pass downward a little to make

way for the cap piece along the middle. The top piece is neatly chamfered and grooved to fit in place. There are four thwarts, two near the ends of the hold, which are merely lashings, the material passing backward and forward two or three times and then closely woolded, two solid pieces near the middle of the canoe serving as spreaders. The ends of the thwarts are pierced and lashed to the gunwale at the ends of the cap pieces so as to hold all parts firmly together. The Tungus canoe is wide and shallow and is an excellent freight boat.

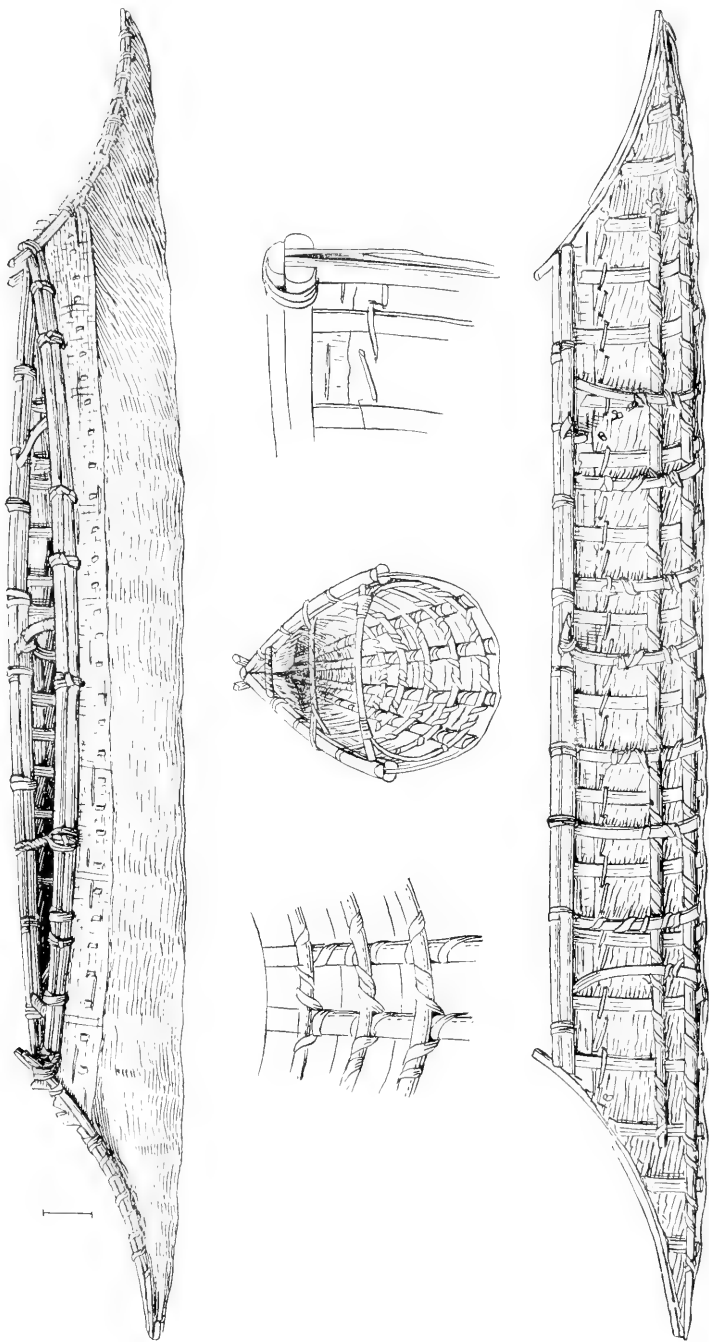
The Yakut pointed canoe (Plate 4) is also made in sections of birch bark, of which, in the model here studied, there are four in number, passing around from gunwale to gunwale, overlapping and stitched together. The bottom is strengthened by adding broad strips of bark from end to end and sewing them down at their edges. At the ends the Yakut canoe is shaped like a snout, the line from bottom upward being incurved. The joint at the ends is a very simple one, the edges of the bark cut to shape and sewed together. The gunwale is formed by a binding of bark turning over and hemmed down, the edges showing on the outside and inside. Two thwarts are held in place by a lashing which passes across parallel and on both sides of the thwart and fastened through the bark sides. The canoe is held in shape by means of flat, wide ribs, whose ends are concealed under the bark binding of the gunwale. The Yakut canoe is a wide craft, better suited to freight than speed. As the model here described is rougher than the others shown, it is possible that the larger ones have better elements of construction.

The Goldi pointed canoe (Plate 5) more closely resembles that of the Giliak and of the Kutenai. The hull of the model consists of a single piece of bark (but in full-sized boats it may be in sections) and there is no additional layer of bark on the bottom. The gunwale is formed by clasping the edge of the bark between two strips of wood, forming inwale and outwale, and there are no top strips as in the Kutenai craft. The unique feature in the Goldi canoe is the insertion of a wooden point at either end. This is curved upward gracefully. Another noteworthy feature is the covering of a portion of the hold at either end with a sheet of bark, forming a partial deck. One thwart is shown in the model, though others must exist in the full-sized canoes. Slats are laid along the inside lengthwise and over these are neatly forced in flat-rib pieces at intervals. This is a dainty looking craft, long and slender, and doubtless used for speed and fishing and not for freight. In the middle of the inside a piece of hide affords a kneeling place for the boatman.

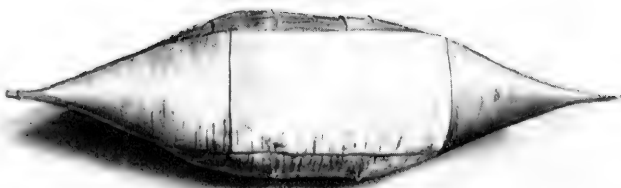
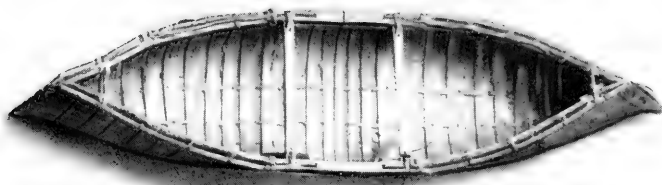
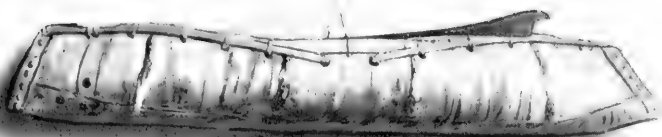




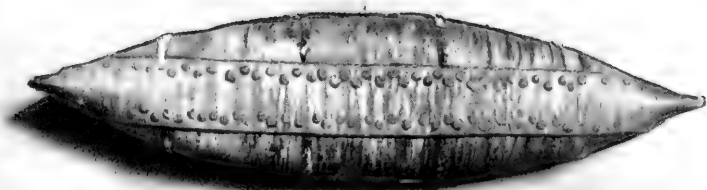
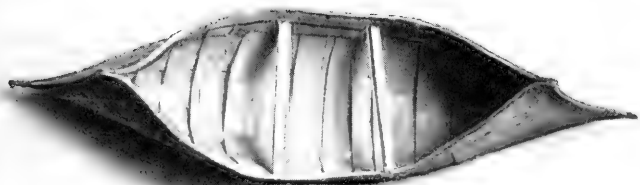
KUTENAI CANOE IN MOTION.



DETAIL OF KUTENAI CANOE.
Cat. No 641, U.S.N.M.



TUNGUS POINTED CANOE.



YAKUT POINTED CANOE.



GOLDI POINTED CANOE.

DESCRIPTIVE CATALOGUE OF A COLLECTION OF OBJECTS
OF JEWISH CEREMONIAL DEPOSITED IN THE
U. S. NATIONAL MUSEUM BY HADJI
EPHRAIM BENGUIAT.

BY

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Aid, Division of Historic Archaeology.

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33. Tapestry representing the Judgment of Solomon	560
34. Embroidery representing the Prophet Elijah fed by ravens	560
35. Tapestry representing the story of Susanna	560
36. Tapestry representing the story of Judith and Holofernes	560

DESCRIPTIVE CATALOGUE OF A COLLECTION OF OBJECTS OF JEWISH CEREMONIAL.

DEPOSITED IN THE U. S. NATIONAL MUSEUM BY HADJI EPHRAIM
BENGUIAT.

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INTRODUCTION.

Hadji Ephraim Benguiat, the owner of the collection here described, is the descendant of an illustrious Spanish Jewish family which traces its origin as far back as the beginning of the eleventh century. Many members of the family have distinguished themselves in Biblical and rabbinical learning, in philosophy and letters. The love for religious art has been a tradition in the family, and many of the objects of the collection are family heirlooms.

The collection comprises all the important objects which come into use in Jewish religious life, and is unique for its artistic and historical value.

I. OBJECTS USED IN THE SERVICE OF THE SYNAGOGUE.

1. TORAH SCROLL.—Parchment scroll of the Pentateuch in Hebrew mounted on wooden rollers, wrapped in a cloth of green velvet embroidered in silk, which is held by a silver-worked belt and covered with a mantle of black velvet embroidered in gold. The upper handles of the rollers are of carved wood, the lower of ivory, with silver bells on the rollers. The scroll was made in Smyrna, Asia Minor, in the eighteenth century. The bells were manufactured in Damascus and bear the inscription: "Joseph, son of Ephraim Benguiat." Height

of scroll, 7 inches; of rollers, 14 inches. (Plate 1, fig. 1, and Plate 7. U.S.N.M., No. 154606.)

The Pentateuch, called by the Jews *Torah*, i. e., the Law (properly instruction), is considered by them the most important and sacred portion of the Scriptures. In order to keep it alive in the minds of the people, it is divided into pericopes¹ according to the number of Sabbaths, the whole to be read through during service in the synagogue within a year.² For this purpose a manuscript copy of the Pentateuch is used. The copy is written by a professional scribe (*sofer*) on parchment made of the skin of a clean animal (one whose flesh may be eaten), in Hebrew, without vowel points, accents, or verse divisions, in certain stated columns. The sheets are fastened together with sinews of a clean animal so as to form a scroll, and mounted on wooden rollers. When not in use the scroll is covered with a robe of costly stuff and, when the congregation can afford it, adorned with silver or gold bells and breastplate.³

2. WRAPPER FOR THE TORAH SCROLL.—Made of yellow silk, embroidered with flowers and Hebrew inscription in silver, gold, and silk, with silver lace fringes. The inscription reads: "And it brought forth buds, and bloomed blossoms, and yielded almonds."⁴ Embroidered as a holy work by the hands of Magdalene Bassan in the year 5496" (1736). Measurements, 11 feet 1 inch long, 6½ inches wide. (Plate 2, fig. 1. U.S.N.M. No. 154603.)

3. WRAPPER FOR THE TORAH SCROLL.—Made of green silk, embroidered with flowers and Hebrew inscription in silk. The inscription reads: "This holy cover was made by Simha, wife of Levy Hai, of Buttrio [Italy], in the year 5457 [1697], and was purchased by Phineas Veneziani and brothers." Measurements, 8 feet 1½ inches long, 7¼ inches wide. (Plate 2, fig. 2. U.S.N.M. No. 154604.)

4. SILVER BAND (fragment).—Inscribed in Hebrew: "David, King of Israel, lives and is established forever." Perhaps part of an ornament of the Torah scroll. Measurements, 7½ inches long, ⅜ inch wide. (U.S.N.M. No. 1291.)

5. VEIL OF THE HOLY ARK (*Parocheth*).—Made in Padua, in 1736, of yellow silk and richly embroidered in silver, gold, and silk, with flowers, and the first words of the Decalogue (Ten Commandments) borne upon clouds—the symbol of the Deity. Measurements, 6 feet 3 inches long, 5 feet 2 inches wide. (Plate 3, U.S.N.M. No. 154602.)

¹Such a weekly pericope is called by the German Jews (Ashkenazim) *sidra*, or "order;" by the Portuguese Jews (Sefardim) *parasha*, division, section. This latter term is applied by the Ashkenazim to the shorter divisions into which the *sidra* is divided.

²Many modern Jewish congregations have adopted a triennial cycle, which was also known in ancient times.

³Compare Report of the U. S. National Museum for 1896, p. 993, and Plate 15.

⁴Numbers xvii, 23.

EXPLANATION OF PLATE 1.

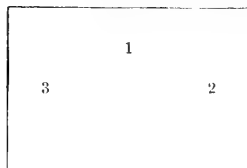
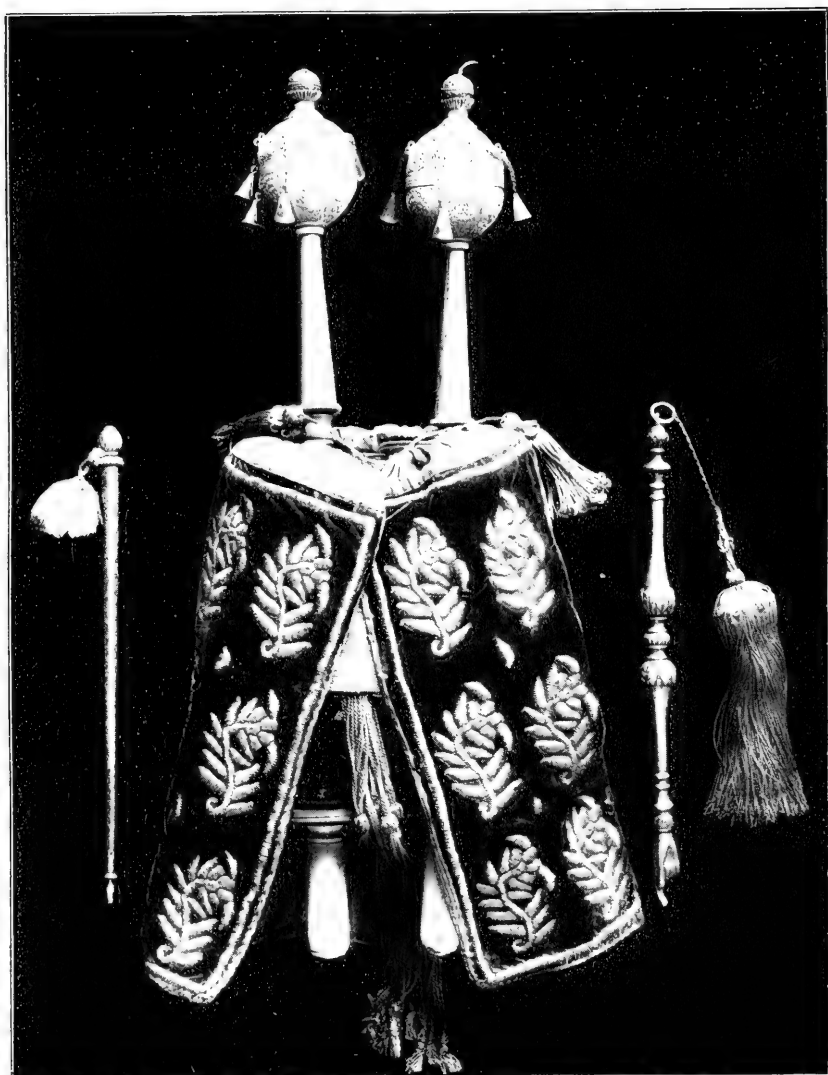


Fig. 1. TORAH SCROLL WITH MANTLE AND SILVER BELLS.
(Cat. No. 154606, U.S.N.M. Smyrna, Asia Minor.)

Fig. 2. SILVER POINTER (*yad*).
(Cat. No. 158347, U.S.N.M. Morocco.)

Fig. 3. SILVER POINTER (*yad*).
(Cat. No. 154808, U.S.N.M.)



TORAH WITH POINTERS.



EXPLANATION OF PLATE 2.



Fig. 1. WRAPPER FOR THE TORAH SCROLL.

(Cat. No. 154603, U.S.N.M.)

Fig. 2. WRAPPER FOR THE TORAH SCROLL.

(Cat. No. 154604, U.S.N.M. Butterio, Italy.)



WRAPPERS FOR THE TORAH SCROLL.



VEIL OF THE HOLY ARK (PAROCHETH).

Padua, Italy.

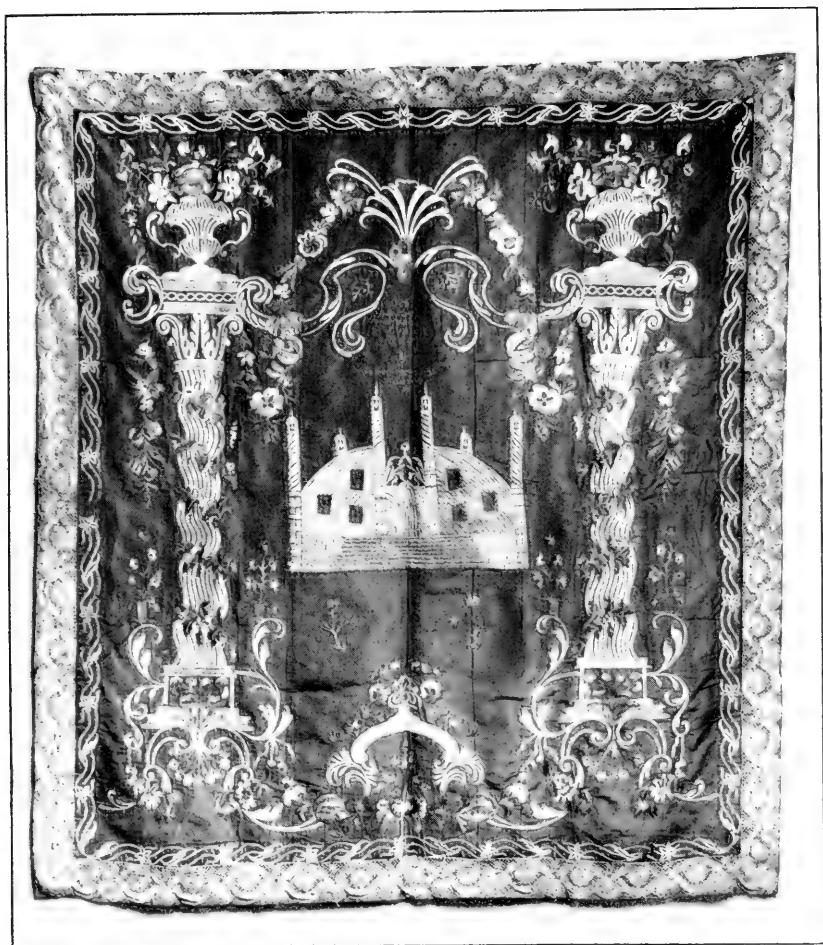
Cut. No. 151602, U.S.N.M.



VEIL OF THE HOLY ARK (PAROCHETH).

Smyrna, Asia Minor,

Cat. No. 154588, U.S.N.M.

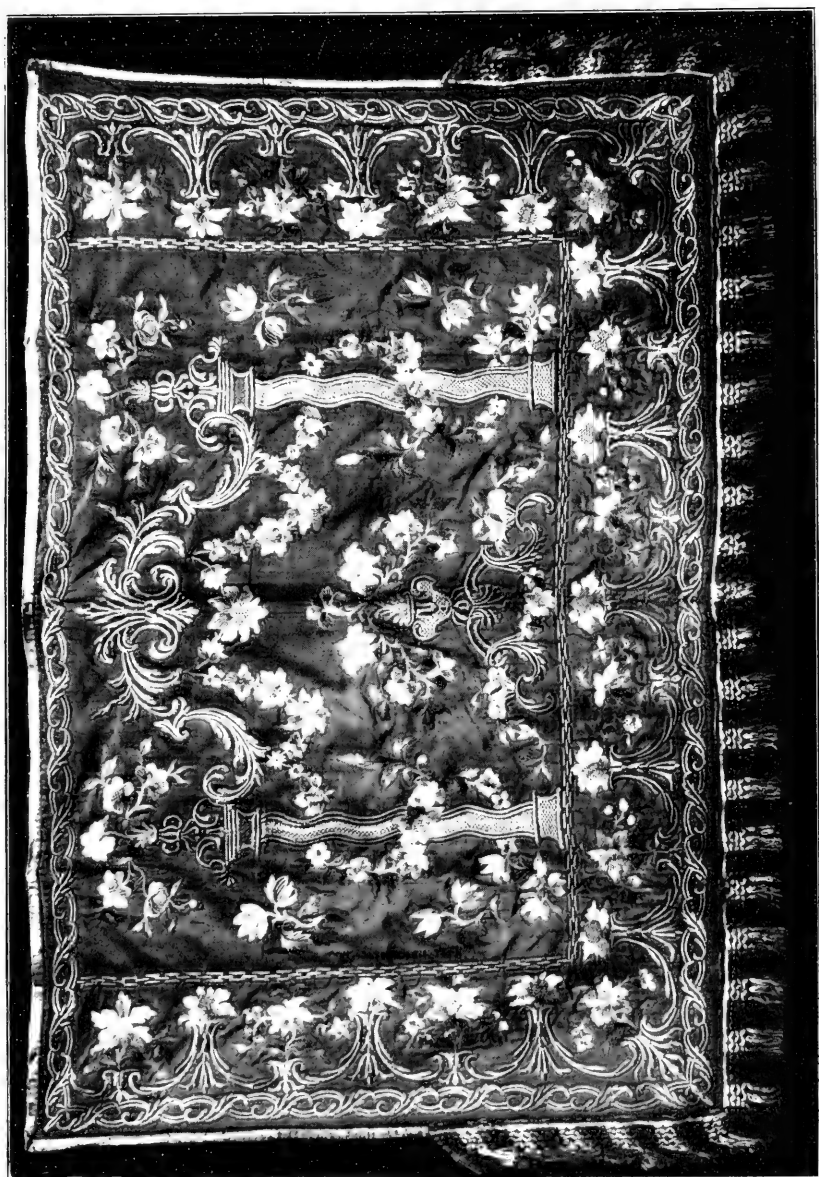


VEIL OF THE HOLY ARK (PAROCHETH).

Probably Asia Minor.

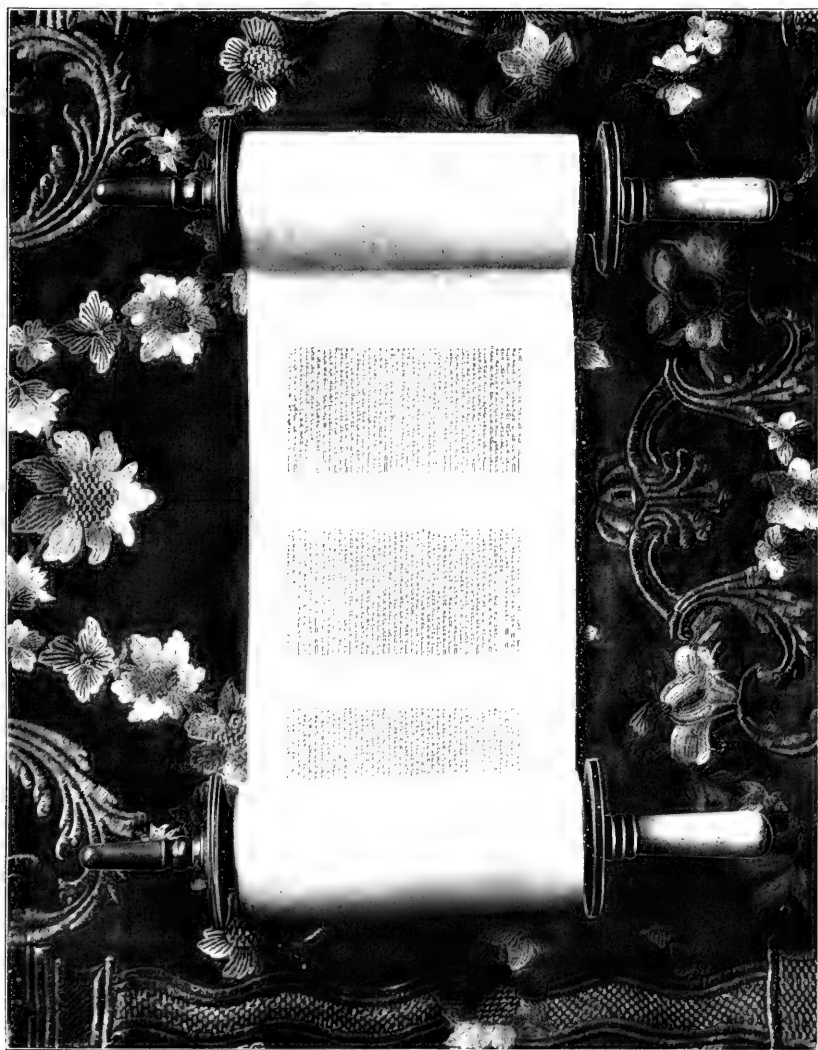
Cat. No. 1286, U.S.N.M.





COVER FOR THE READING DESK.
Cat. No. 15186, U.S.N.M.





TORAH SCROLL UNROLLED ON THE READING DESK.
Cat. No. 15400, U. S. N. M.

The Torah scroll when not in use is kept standing upright in a press or wall closet placed slightly above the floor of the nave and reached by steps. As the Torah is in the eyes of the Jew the most sacred and precious object, so is the closet which holds it the most important part of the synagogue. It is called "Holy Ark" (*aron ha kodesh*), after the Ark of the Covenant in the Tabernacle and Temple, whose place it has taken. The Holy Ark is set in or against that wall of the synagogue toward which the worshipers turn in the more solemn parts of the liturgy, the wall which is in the direction of Jerusalem. Whenever the Holy Ark is opened, the congregation rises in reverence for the Law of God it holds. Before the Ark is a curtain of costly material, which is named *parocheth*¹ after the curtain which in the Tabernacle and the Temple screened the Holy of Holies.

6. VEIL OF THE HOLY ARK.—Made in Smyrna, Asia Minor, of blue silk and richly embroidered in gold, with the inscription in Hebrew, "Portuguese congregation." Measurements, 6 feet 3 inches long, 4 feet wide. (Plate 4, U.S.N.M. No. 154588.)

7. VEIL OF THE HOLY ARK.—Made, probably in Asia Minor, of yellow silk with silver-lace borders embroidered with flowers in silk, with silver appliqué work representing vases of flowers supported by columns on either side and a synagogue in the center. A Hebrew inscription in gold appliqué indicates that the veil was dedicated by Benjamin, Modico, and Solomon Nabaro to the congregation "Talmud Torah" (Study of the Law). Measurements, 5 feet 10 inches long, 5 feet 3½ inches wide. (Plate 5, U.S.N.M. No. 1286.)

8. COVER FOR THE READING DESK.—Made of yellow silk and embroidered with flowers in silver and silk. Measurements, 4 by 3 feet. (Plates 6 and 7, U.S.N.M. No. 154806.) When the time arrives for the reading of the Torah, which is about the middle of the service, the scroll is taken out of the Holy Ark and carried in procession, the congregation standing, to the *bima* (from the Greek *βῆμα*) or *almemer* (corrupted from the Arabic *al-minbar*, pulpit). This is a table or desk standing upon a raised platform, upon which the scroll is unrolled (Plate 6). This table or desk is covered with a costly cloth similar to the curtain of the Holy Ark.

9. SILVER POINTER (*yad*).—Made in Morocco in the seventeenth century. Length, 11½ inches. (Plate 1, fig. 2, U.S.N.M. No. 158347.) The pointer, usually terminating in the shape of a hand, hence called *yad* (hand), is used at the public reading of the Torah to guide the reader (*ba'al qoré*) of the lesson and prevent him from losing the place in the scroll.

10. SILVER POINTER.—Length, 11½ inches. (Plate 1, fig. 3, U.S.N.M. No. 154808.)

¹ Compare Report of the U. S. National Museum for 1896, p. 994 and Plate 16.

11. ROLL OF THE BOOK OF ESTHER.—Parchment scroll inserted in a revolving silver case, with marginal illuminations illustrating the events narrated in the book. Written in Venice, Italy, in the seventeenth century. The silver case was once in possession of the Jews of Granada, Spain. Height of scroll, 8 inches. (Plate 8, fig. 1, U.S.N.M. No. 154592.)

Five of the shorter books of the Bible—Canticles, Ruth, Ecclesiastes, Lamentations, and Esther—are called the “Five Rolls” (*hamesh megilloth*), and are read on special occasions during the service in the synagogue, viz, Canticles on Passover, Ruth on Pentecost or Feast of Weeks, Ecclesiastes on Tabernacles, Lamentations on the 9th of Ab, and Esther on the Feast of Purim. The first three are read privately by each member from his own copy during a pause in the public service (between the first part of the liturgy and the reading of the Torah). The Lamentations are chanted by the leader and members of the congregation, each reading a chapter, during the services of the 9th of Ab (August) in commemoration of the destruction of the Temple of Jerusalem. Still more ceremony is attached to the reading of the Book of Esther, which takes place during the services of the Feast of Purim, which is celebrated on the 15th of Adar (March–April) to commemorate the deliverance of the Jews of Persia from the machinations of Haman. For this purpose a parchment scroll, written in the same manner as the Pentateuch (see under 1) is used. The reading takes place from the same desk as that of the Torah, and is preceded and followed by a benediction. At certain passages the congregation joins in, reciting them before the public reader. The Book of Esther is therefore known as *the roll* (*Megillah*).

12. ROLL OF THE BOOK OF ESTHER.—Parchment scroll inserted in a revolving silver case. Written in Smyrna, Asia Minor, in the eighteenth century. The case was once in possession of the Jews of Granada, Spain. Height of scroll, 8 inches. (Plate 8, fig. 2. U.S.N.M. No. 154592^b.)

13. ROLL OF THE BOOK OF ESTHER.—Written in columns of eight lines and about 1 inch wide, on a scroll of vellum seven-eighths of an inch wide, and inserted in a hexagonal revolving silver case, surmounted by a cupola, from which rises a crescent and star, the emblem of the Mohammedan peoples. Height of case, 1½ inches; diameter, 1 inch. Made in Fez, Morocco. (Plate 8, fig. 3. U.S.N.M. No. 158347.)

14. RAM'S HORN (*shofar*).—(Plate 9, fig. 1. U.S.N.M. No. 154589.) In ancient times the horn or shofar was used, according to the Pentateuch, for the announcement of the New Moon and solemn festivals,¹ for the proclamation of the year of release (Sabbatical year),² and

¹ Numbers x, 10; compare Psalms lxxxi, 4.

² Leviticus xxv, 9.

EXPLANATION OF PLATE 8.

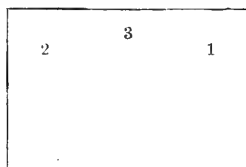


Fig. 1. ROLL OF THE BOOK OF ESTHER.

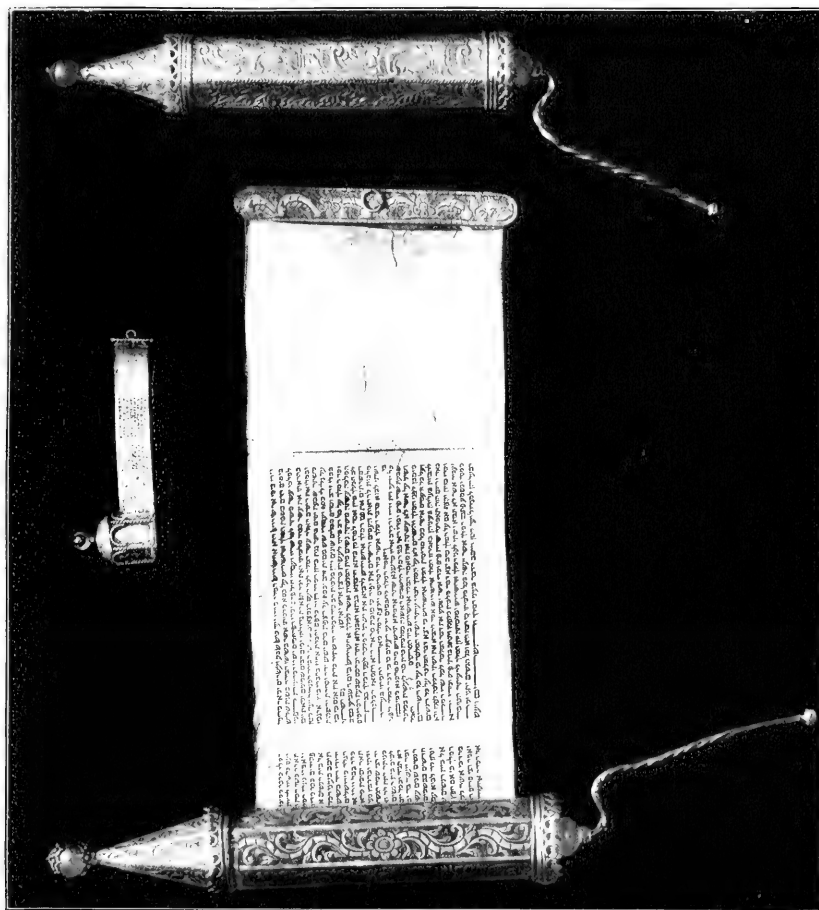
(Cat. No. 154592, U. S. N. M. Venice, Italy.)

Fig. 2. ROLL OF THE BOOK OF ESTHER.

(Cat. No. 154592^b, U. S. N. M. Smyrna, Asia Minor.)

Fig. 3. MINIATURE ROLL OF THE BOOK OF ESTHER.

(Cat. No. 158347, U. S. N. M. Fez, Morocco.)



ROLLS OF THE BOOK OF ESTHER.



EXPLANATION OF PLATE 9.

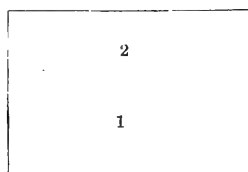


Fig. 1. RAM'S HORN (*Shofar*).
(Cat. No. 154589, U. S. N. M.)

Fig. 2. HANUKAH LAMP.
(Cat. No. 154591, U. S. N. M.)



RAM'S HORN AND HANUKAH LAMP.

above all for military purposes, like the modern bugle, to give the signal for going out to battle, for the announcement of a victory, and for a recall of the troops.¹ It was also used as a musical instrument in religious processions.²

At present the shofar is especially used during the penitential season, which begins with the 1st of the month Ellul (August-September) and culminates on the Day of Atonement (*yom kippur*) on the 10th of Tishri (September-October). During the month of Ellul the shofar is sounded three times at the close of the morning service each day, with the exception of the Sabbaths, in some congregations and in others at the evening service. On the 1st of Tishri, the beginning of the civil year (*rosh ha-shana*), one of the most solemn of the Jewish feasts, and the "memorial of blowing of trumpets,"³ thirty blasts, among the Sefardim seventy-two, are sounded on the shofar in the middle of the morning service, after the reading of the day's lesson from the Torah, and before the "additional service" (*musaf*). On Atonement Day the shofar is sounded once, among the Sefardim four times, at the close of the concluding service (*ne'ilah*), and on the seventh day of Tabernacles (*Hosha'na Rabba*) it is sounded at each of the seven circuits. The shofar is usually made of a ram's horn, but the goat's horn is also employed.⁴

15. HANUKAH LAMP.—Made of brass. Height, 7½ inches; width at base, 6¼ inches. (Plate 9, fig. 2, U.S.N.M. No. 154591.)

The feast of dedication or Hanukah (the latest addition to the cycle of Jewish festivals) is celebrated for eight days, beginning with the 25th of Kislew (December-January), in commemoration of the purification of the temple and the restoration of the service after the deliverance of Jerusalem from the oppressions of Antiochus Epiphanes, King of Syria, by the Maccabees in 164 B. C. The institution of this festival is related in I Maccabees iv, 47-59. In the New Testament⁵ it is mentioned under the name of *ἐγκαίνια* (*enkainia*), "dedication." The principal feature in the observance of this festival is the lighting of lights in the synagogue, as well as in private houses, whence it is also called the "feast of lights."⁶

On the first night one light is lit, on the second two, and so on to the eighth. The lights are set in a place where people on the street may see them, in the window or by the door. They are considered sacred, and must not be employed for any ordinary purpose. For this reason

¹ Numbers x, 1-9.

² II Samuel vi, 15; I Chronicles xv, 28; compare Psalms xcvi, 6; cl, 3.

³ Leviticus xxxii, 24.

⁴ Compare Cyrus Adler, *The Shofar, its Use and Origin*. (Proceedings, U. S. National Museum, XVI, pp. 287-301; Report U. S. National Museum, 1892, pp. 437-450.)

⁵ John x, 22.

⁶ Compare Josephus, *Antiquities*, xii, 7, 7.

a "servant light" (*shammash*) is placed next to them, which is used in lighting them. Rabbinical tradition accounts for this feature of the feast by the story that when the priests entered the sanctuary, after the Syrians had been driven out, to light the perpetual lamp they found a vial of sacred oil unpolluted, which under ordinary circumstances was only sufficient for one night, but by a miracle lasted for eight nights.

When possible, lamps burning olive oil are to be used, though frequently candles made of pure beeswax are employed. In the synagogues there is usually for this purpose a lamp made after the form of the candlestick (*menorah*) of the tabernacle and temple, as described in Exodus xxv, 31-140.¹

16. PAIR OF CANDLESTICKS.—Silver repoussé work. Measurements, 12½ inches high, 6¼ inches wide at the base. (U.S.N.M. No. 1287.) The candlesticks come from a church in the Philippine Islands. Mr. Benguiat is of the opinion that they originally belonged to a Jewish synagogue in Spain, which was converted into a Christian church after the expulsion of the Jews from that country and found their way to the Philippines.

II. OBJECTS USED AT PRAYER.

17. MINIATURE PRAYER BOOK.—Containing all the prayers and devotions used on week days and on special festal occasions, in the synagogue and at home. Printed at Amsterdam, Holland, in the year 5499 (1739). Bound in leather, with silver clasps, with the name of "Ephraim Benguiat" in Hebrew characters impressed on the left cover. (Plate 10, fig. 1, U.S.N.M. No. 154581.)

18. MANUSCRIPT CONTAINING THE FORMULAS USED FOR THE ABSOLUTION FROM VOWS HASTILY OR UNCONSCIOUSLY MADE, AND PRAYERS RECITED AT THE CEMETERY, AND ON THE EVE OF NEW YEAR'S AND ATONEMENT DAY.—Written in Hebrew square characters in black ink with the rubrics in red. Bound in leather with pressed covers and red edge. Measurements, 7 by 5 inches. (U.S.N.M. No. 1294.)

19. MANUSCRIPT CONTAINING THE PSALMS AND VARIOUS PROPITIATORY PRAYERS.—Written in a quaint, Arabizing cursive script by Abraham Zarfati at Asmir in the year 5522 A. M. (1762 A. D.). The Psalter, besides contributing extensively to the synagogal liturgy, constitutes in itself a prayer book of the Jews. It is recited in part or in its entirety by pious Jews as a means of prayer and devotion. Measurements, 6 inches long, 4 inches wide, ¾ inch thick. (Plate 12, U.S.N.M. No. 1293.)

20. THE OLD TESTAMENT IN THE HEBREW LANGUAGE AND THE NEW TESTAMENT IN GREEK.—Printed by Christopher Plantin at Ant-

¹ Compare Report of the U. S. National Museum for 1896, p. 996 and Plate 17, fig. 2.

EXPLANATION OF PLATE 10.

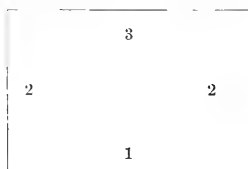


Fig. 1. MINIATURE PRAYER BOOK.

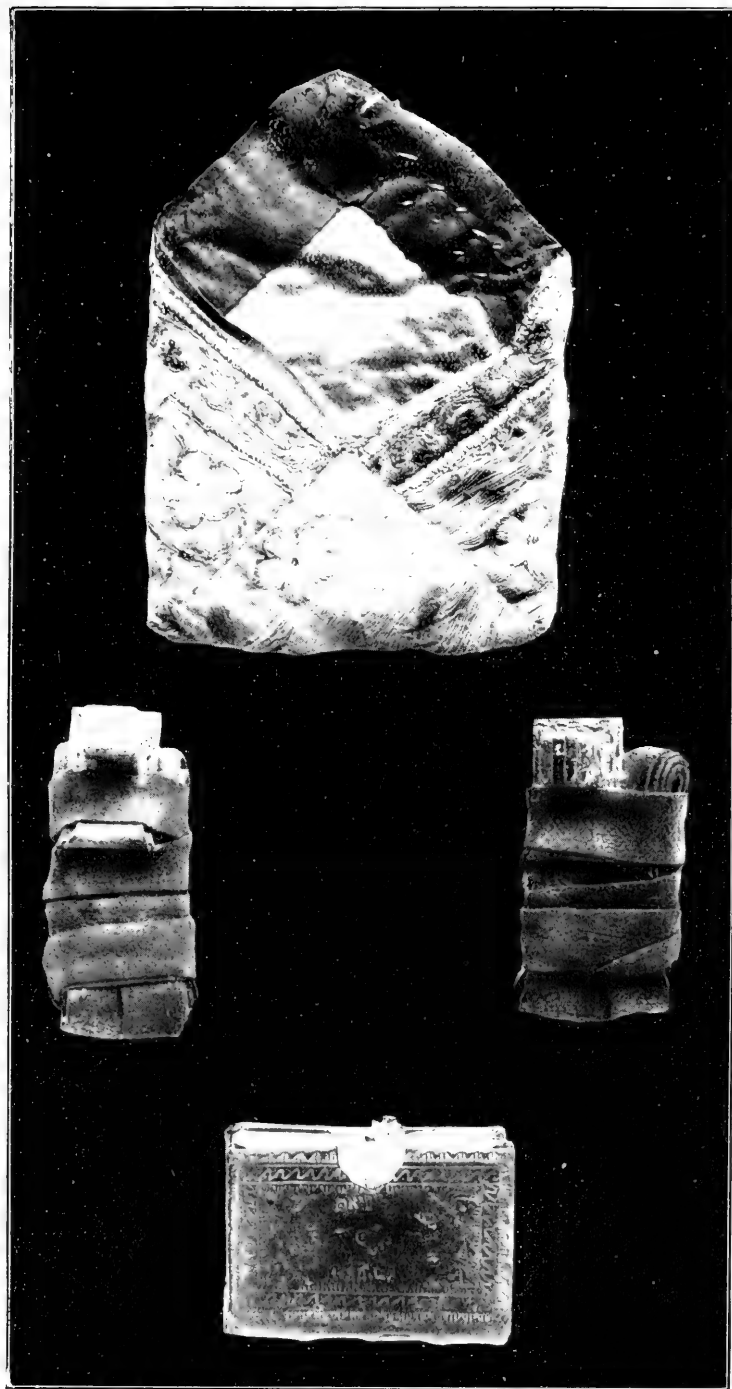
(Cat. No. 154581, U. S. N. M. Amsterdam, Holland.)

Figs. 2. PHYLACTERIES (*Tefillin*).

(Cat. No. 154583, U. S. N. M.)

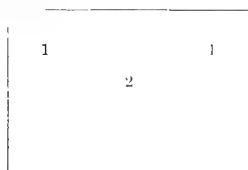
Fig. 3. BAG FOR PHYLACTERIES.

(Cat. No. 154582, U. S. N. M. Chalcis Greece.)



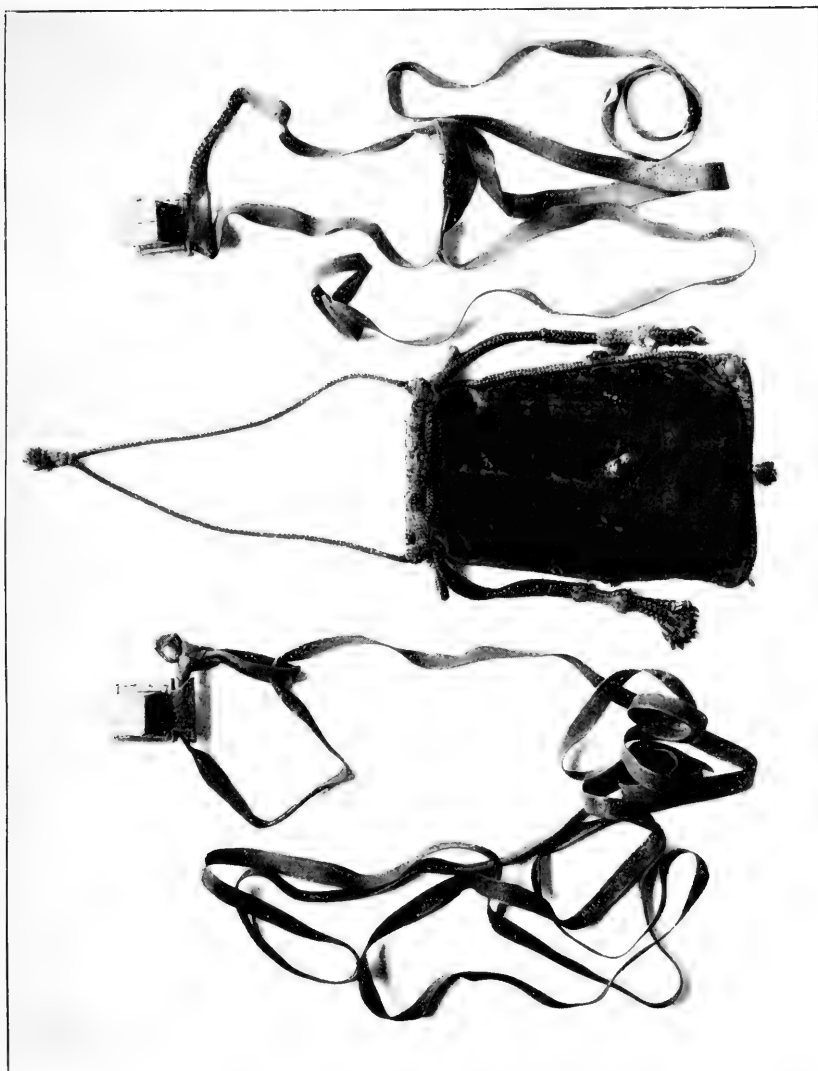
PHYLACTERIES AND PRAYER BOOK.

EXPLANATION OF PLATE 11.

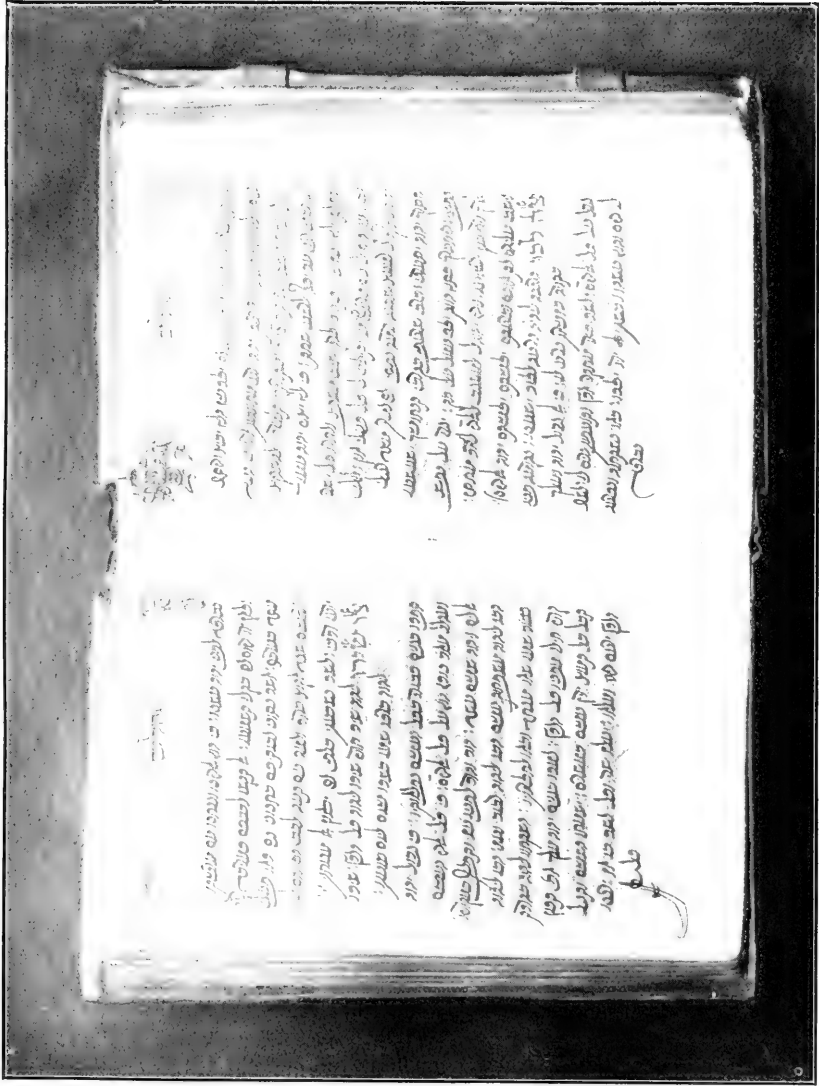


Figs. 1. PHYLACTERIES UNFOLDED.
(Cat. Nos. 154, 154, 583, U. S. N. M.)

Fig. 2. VELVET BAG OF PHYLACTERIES.
(Cat. No. 154580 U. S. N. M. Morocco.)



PHYLACTERIES AND BAG.



MANUSCRIPT CONTAINING PSALMS AND VARIOUS PRAYERS.

Asmir.

Cat. No. 1293, U. S. N. M.

werp in 5338 A. M. (1573 A. D.). The Hebrew text is unpointed. Bound in leather, with gilt edge. Measurements, 7 inches long, $4\frac{1}{2}$ inches wide, and 1 inch thick. (U.S.N.M. No. 1292.)

21. PHYLACTERIES (*tefillin*).—(Plate 10, fig. 2, and Plate 11, fig. 1, U.S.N.M. No. 154583.) The phylacteries, or *tefillin*, are two square boxes of parchment. The boxes are fastened to a kind of a base made of thick parchment with a loop on one side, so as to let a narrow leather strap pass through (Plate 10, fig. 1). Into these boxes are inserted the following passages from the Pentateuch, written on strips of parchment: Exodus xiii, 1–10; Exodus xiii, 11–16; Deuteronomy vi, 4–9, and Deuteronomy xi, 13–21. By means of the straps the boxes are bound around the arm and head and worn by all male Jews who have attained religious majority—i. e., passed the thirteenth year of age—during morning prayers of week days; hence their Hebrew name *tefillin*, from *tefillah*, prayer. The name phylacteries is derived from the Greek *φυλακτήρια* (phylacteria), which is used in the New Testament,¹ meaning, properly, things that guard—i. e., amulets, talismans, which the Jewish *tefillin* are not. The New Testament name may be based upon an external resemblance between the *tefillin* and the Greek *phylacteria*. The obligation to wear *tefillin* is derived from the command included in the extracts mentioned above: “And you shall bind them as a sign upon your hand and for frontlets between your eyes.”²

The *tefilla* for the head is embossed on two sides of the exterior with the Hebrew letter *Shin* (sh), and inside is divided into four compartments, in each of which one of the four extracts from the Pentateuch is put, and the strap is tied at such a distance as to fit the head of the wearer, forming a knot shaped in the form of the Hebrew *Daleth* (d). The *tefilla* for the hand or arm has no letter impressed on the outside and no divisions inside, and the four passages it contains are written continuously on one strip of parchment. One end of the strap is made into a small noose, with a knot resembling the Hebrew *Yod* (y or i). The three letters thus exhibited on the outside of the *tefillin* constitute the Hebrew name of God *Shaddai*, rendered by the English versions: “Almighty.”³ The materials used in making the *tefillin* must come from a clean animal, and the extracts from the Pentateuch are written in the same manner as the Torah scroll. (See under I, 1.)

In “laying the *tefillin*” (*hanohath tefillin*) that of the arm is put on first. The box is fastened on the naked left arm above the elbow, and the strap is wound seven times around the arm below the elbow. Then that of the head is put on so that the box comes to rest on the

¹ Matthew xxiii, 5.

² Deuteronomy vi, 8; xi, 18. Compare Exodus xiii, 9 and 16.

³ Genesis xvii, 1.

forehead below the hair and between the eyes, the knot being at the root of the neck, while the ends of the strap pass over the shoulders and hang down on either side. Next, the end of the strap of the *tefilla* of the arm is wound thrice around the middle finger and around the hand. Each of these performances is accompanied by appropriate benedictions and the recitation of passages from the Scriptures. In taking off the *tefillin* that of the head is removed first, then that of the arm. The straps are folded around the bases (Plate 10, fig. 2), and the *tefillin* are reverently put into a bag, which is sometimes included in another, so that the sacred objects may be more carefully protected.¹

22. INNER BAG OF TEFILLIN.—Made of silk and embroidered. Made at Chalcis (island of Euboea, Greece), in the seventeenth century, and found there after the Jews had departed for the battle of Athens in 1822. (Plate 10, fig. 3. U.S.N.M. No. 154582.)

23. BAG OF TEFILLIN.—Made of velvet in Morocco. (Plate 11, fig. 2. U.S.N.M. No. 154580.)

24. PRAYER SHAWL (*tallith*).—Made of white brocade silk, with gold-embroidered edges. Length, 6 feet; width, 1 foot 5 inches. (Plate 13. U.S.N.M. No. 154588^b.)

The *tallith* is a rectangular piece of cloth, made of wool or silk, worn by male adults (among the Sefardim, or the observers of the Portuguese rite, also by small boys) at the morning services and when performing certain religious functions. To each of the four corners of the *tallith* are attached the *çiqith* or fringes, consisting of four threads (usually woolen) run through an eyelet near the corner and then doubled and knotted in a certain manner, so that eight threads are allowed to hang down as a fringe. It is, besides, usually bordered with bluish-black stripes and adorned with a silk ribbon or silver-corded lace called "crown" (*atarah*) on the top. The *tallith* is loosely thrown over all the other garments, sometimes passing across the top of the head and flowing down over the upper part of each arm and over the back, sometimes wrapped around the neck. The obligation to wear a garment with fringes is derived from Numbers xv, 38: "That they make their fringes in the borders of their garments throughout their generations, and that they put upon the fringe of each border a cord of blue, and it shall be unto you for a fringe, that you may look upon it and remember all the commandments of the Lord, and do them. And that you go not about after your own heart and your own eyes;" and Deuteronomy xxii, 12: "Thou shalt make thee fringes upon the four borders of thy vesture, wherewith thou coverest thyself." Besides the *tallith*, which is worn at stated seasons, the Jews wear at present under the upper garments during the entire day a garment with fringes, called the "small *tallith*" (*tallith katan*), or the "four corners"

¹ Compare Report of the U. S. National Museum for 1896, p. 997, and plate 21.



PRAYER SHAWL (TALLITH).

Cat. No. 15458*b*, U.S.N.M.

(*arba kanfoth*). It consists of a piece of rectangular cloth of any material, but usually of wool, about 3 feet long and 1 foot wide, with fringes fastened to the four corners in the same manner as to the *tallith*, with an aperture in the center sufficient to let it pass over the head, so that part falls in front and part behind. This small *tallith* is assumed to have originated in the times of persecution, when the Jews had to refrain from exhibiting the garment with fringes and could only in this manner comply with the commandment to wear fringes.

III. OBJECTS USED ON FESTAL OCCASIONS AT THE JEWISH HOME.

(a) SABBATH.

25. CUP AND SAUCER USED FOR KIDDUSH.—Made of cut glass, gilded. Measurements: Cup, height $1\frac{1}{4}$ inches, diameters 2 and $1\frac{1}{2}$ inches; saucer, height 1 inch, diameter $4\frac{1}{2}$ inches. (Plate 14, figs. 1 and 2. U.S.N.M. No. 154585.)

The Jews, like other Oriental peoples, compute the day from sunset to sunset. The Sabbath, therefore, begins at sunset on Friday and terminates at sunset on Saturday.

It is inaugurated in the home by blessing and lighting of the candles by the mistress of the house,¹ and in the synagogue by a special service. On returning from the service, and before the evening meal, the head of the house fills a cup with wine, raises it in his right hand, and recites Genesis ii, 1 and 2, which relate the origin of the Sabbath, and pronounces a benediction over the wine to God, who "has sanctified the Sabbath." For this reason the ceremony is called *kiddush*, i. e., sanctification. He then drinks from the cup and hands it to the other persons at the table to partake of. Where no wine or other liquor is available, the *kiddush* is pronounced over two loaves of bread, which are laid on the table in memory, it is assumed, of the two portions of manna that were gathered in the wilderness on Fridays. The loaves are then cut up by the head of the house, the pieces dipped in salt and distributed among the members of the family.

26. SPICE BOTTLE, USED FOR HABDALAH.—Made of china, with neck of oxidized silver. Measurements: $4\frac{1}{4}$ inches high, $1\frac{3}{8}$ inches in diameter. (Plate 14, fig. 3. U.S.N.M. No. 154587.)

27. SILVER CANDLESTICK, USED FOR HABDALAH.—The base is in the form of a leaf, $2\frac{3}{4}$ inches long and $2\frac{1}{2}$ inches wide; height of the candlestick, 1 inch, with an extinguisher. (Plate 14, fig. 4. U.S.N.M. No. 154586.)

The Sabbath is inaugurated at the home by a benediction over a cup of wine (see under 25) and is terminated in a like manner. In addition to the cup a wax candle and a box containing some spices are used.

¹ Compare U. S. National Museum Report for 1896, p. 994.

The head of the house takes the cup in his right hand and the spice box in his left, while the candle is usually held by a child, and, after reciting several passages of the Scriptures, pronounces a blessing over the wine, then over the spices, smelling them and passing them to the others present, then over the light, closing with thanksgiving to God for the distinction He made between Sabbath and workdays, between things sacred and profane, etc. The cup is then passed around among the members of the family and the candle extinguished with drops of wine from the cup. This ceremony is called the *habdalah*, i. e., separation or division, because it divides or separates the Sabbath from the other days of the week.

(b) PASSOVER.

The feast of Passover is celebrated in commemoration of the deliverance of Israel from the bondage of Egypt, as related in the first chapters of the book of Exodus. It begins on the evening of the 14th of Nisan (March-April) and continues, with the Jews who live in Palestine, for seven days, with those in other places for eight days. It is the first of the three pilgrimage festivals (the two others being the feast of the weeks, or *Shabuoth*, and the feast of the Tabernacles, or *Sukkoth*)¹ and begins the ecclesiastical year.²

In ancient times the celebration of Passover centered around the Paschal lamb. As it could not be slaughtered outside of the sanctuary³ its use ceased with the destruction of the Temple, and the eating of unleavened bread, or *maçgoth*, is now the principal feature of the Passover feast. The eating or even the keeping of anything leavened or fermented (*hameç*) is strictly prohibited,⁴ hence the Passover is also called the "feast of unleavened bread."⁵ On the evening preceding Passover the ceremony of "searching for leaven" (*bediqath hameç*) takes place. The head of the house, furnished with a candle, a wooden spoon, and a feather brush, goes over the whole house and gathers all suspicious crumbs into the spoon. This is burned on the morning of the 14th of Nisan in the courtyard (*bi'ur hameç*). In the evening the feast begins with a service in the synagogue. In the home the evening meal is of the nature of a commemoration service, called *Seder*—order, arrangement, or program. At the head of the table are cushioned chairs or lounges for the master and mistress of the house to recline on, as was done and is still customary in the Orient among the high and freeborn. On the table are the articles emblematic of the events commemorated. These are: Three *maçgoth*, or cakes of unleavened bread, baked in the

¹ Compare Exodus xxiii, 14-17; xxxiv, 23; Deuteronomy xvi, 16.

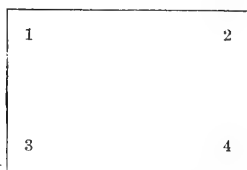
² Compare Exodus xii, 2; Leviticus xxiii, 5; Numbers xxviii, 16.

³ Compare Deuteronomy xvi, 2.

⁴ Compare Exodus xxii, 19; xxiii, 7; Deuteronomy xvi, 3 and 4.

⁵ Exodus xxiii, 15.

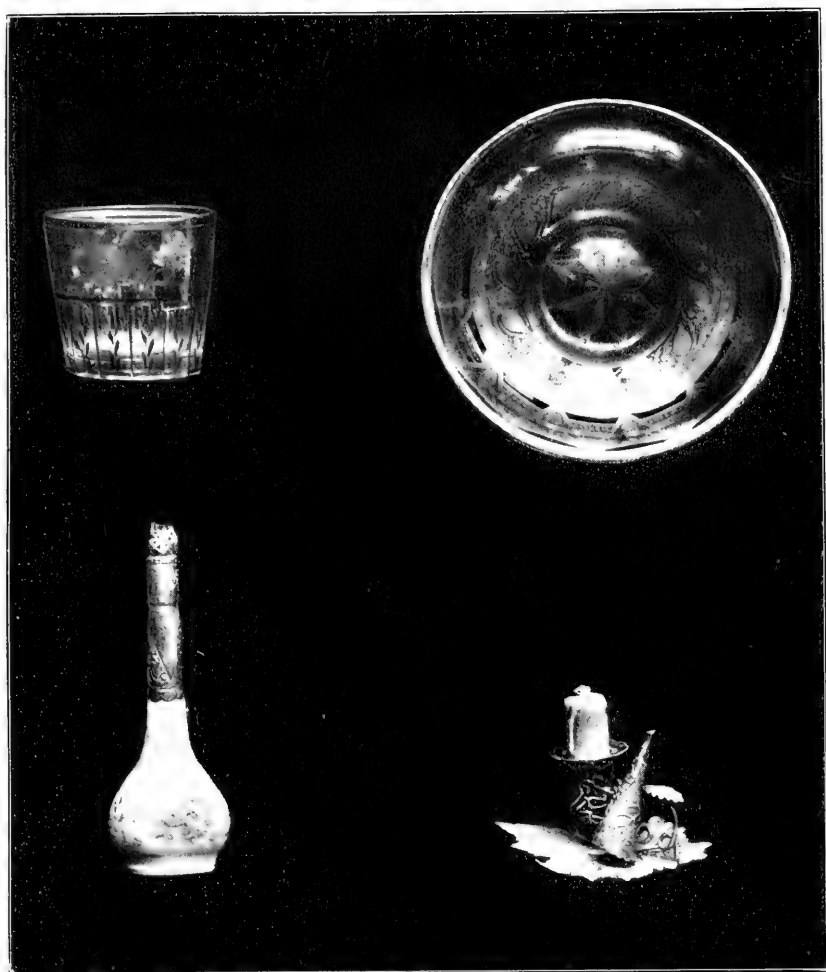
EXPLANATION OF PLATE 14.



Figs. 1 and 2. CUP AND SAUCER, USED FOR KIDDUSH.
(Cat. No. 154585, U. S. N. M.)

Fig. 3. SPICE BOTTLE, USED FOR HABDALAH.
(Cat. No. 154587, U. S. N. M.)

Fig. 4. SILVER CANDLESTICK, USED FOR HABDALAH.
(Cat. No. 154586, U. S. N. M.)



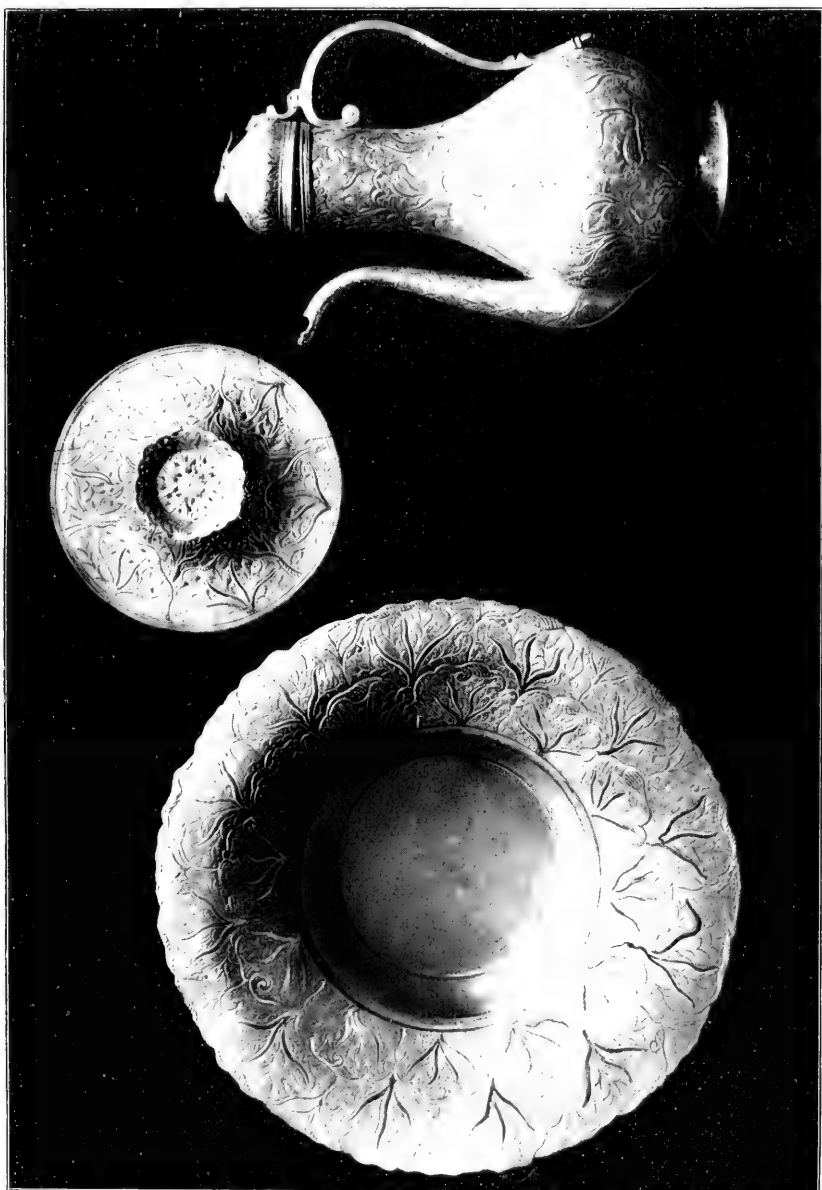
UTENSILS FOR KIDDUSH AND HABDALAH.



TWO EMBROIDERED CUSHIONS, USED AT THE PASSOVER MEAL.

Samacov, Bulgaria.

Cat. No. 15600, U.S.N.M.



EWER AND BASIN USED AT THE PASSOVER MEAL.
Cat. No. 65178, U.S.N.M.





DISH, USED AT THE PASSOVER MEAL.
Spain and Italy.
Cat. No. 154594, U.S.N.M.

shape of large, thin, round crackers, the "bread of affliction",¹ a piece of roasted meat, usually the bone of a lamb, representing the Passover lamb; bitter herbs, usually horse-radish (*maror*), in commemoration of the "embittering of life" which Israel suffered in Egyptian servitude;² a roasted egg, in memory of the festal sacrifice (*hagigah*) offered in the Temple; a compound of almond, apples, and sirup, which has the color of brickelay (*haroseth*), in commemoration of the labor of brickmaking the Israelites performed in Egypt³ and into which the bitter herbs are dipped before they are partaken of; green herbs—parsley or lettuce (*karpas*)—as the "food of poverty;" a cup with salt water, in which the green herbs are dipped to represent the hyssop dipped in the blood of the Paschal lamb.⁴ There are, besides, wine and cups or glasses for each at the table, as everyone assisting at the celebration is supposed to partake of four cups of wine.

The service begins with *kiddush*, as on Sabbath and other festivals.⁵ The family then sits down and the *hagadah*, i. e., narration, consisting of an account of the sufferings of Israel at the hands of the Egyptians and their miraculous deliverance by God, accompanied by psalms and hymns, is recited. At appropriate passages of the *hagadah* the articles mentioned above are partaken of, symbolical ceremonies performed, and the evening meal is eaten.

28. TWO CUSHIONS, USED TO LEAN UPON AT THE PASSOVER MEAL, OR SEDER.—Made of green silk and richly embroidered in gold and silk, in Samacov, Bulgaria, in the sixteenth century. Length, 19 inches; width, 16 $\frac{3}{4}$ inches. (Plate 15. U.S.N.M. No. 154600.)

29. EWER AND BASIN, USED FOR THE ABLUTION AT THE PASSOVER MEAL, OR SEDER.—Brass repoussé and chased work. Height of ewer, 13 inches; diameter of base, 7 inches; height of basin, 4 $\frac{3}{4}$ inches; diameter, 14 $\frac{1}{2}$ inches. (Plate 16. U.S.N.M. No. 155178.) Washing of the hands (*netilath yadayim*) by pouring water over them is observed by the Jews before prayer and before meals, sometimes also before saying grace after meals. The custom is also referred to in the New Testament.⁶

30. PASSOVER DISH.—Used at the Passover meal, or Seder, to hold the *maçgoth* and the other symbolical articles of the service. Made by the Jews of Spain in the thirteenth century, glazed in Italy in the sixteenth century. On its surface are painted the benediction of *kiddush* and the sixteen words containing the program of the ceremonies performed during the Seder, and four vignettes representing the family in the various stages of the service. Height, 3 $\frac{1}{4}$ inches; diameter, 18 $\frac{3}{4}$ inches. (Plate 17. U.S.N.M. No. 154594.)

¹Deuteronomy xvi, 3.

⁴Ibid, xii, 22.

²Exodus i, 14.

⁵See under 25, p. 553.

³Ibid, 14; v. 7 ff.

⁶Compare Matthew xv, 2; Mark vii, 2; Luke xi, 38.

31. COVER FOR THE UNLEAVENED BREAD, OR *maçgoth*, USED AT THE PASSOVER MEAL, OR SEDER.—Linen, embroidered in silk. Made in Chalcis (Eubœa), Greece, in the seventeenth century. Measurements, $16\frac{1}{2}$ by 15 inches. (Plate 18. U.S.N.M. No. 154599.)

32. BRASS DISH, USED FOR HOLDING THE GREEN HERBS AT THE PASSOVER MEAL, OR SEDER.—Chased work. Made in Venice, Italy, in the fifteenth century. Height, $3\frac{1}{4}$ inches; diameter, $17\frac{1}{2}$ inches. (Plate 19. U.S.N.M. No. 154595.)

33. COVER FOR THE GREEN HERBS, USED AT THE PASSOVER MEAL, OR SEDER.—Purple-colored silk, embroidered in silver and gold. Made in Chios (an island off the coast of Asia Minor) in the eighteenth century. Measurements, 21 by 19 inches. (Plate 20. U.S.N.M. No. 154597.)

34. TWELVE WINE GLASSES.—Used for the drinking of the "four cups" (*arba' kosoth*) at the Passover meal, or Seder. Cut glass with gilded rims, and engraved with scenes from human life (the two glasses on the plate, for instance, represent a woman at the loom and a sailing vessel, the others being a woman spinning; a rural idyl; a harvesting scene; a country homestead; a landscape; a chariot race; a house with its inhabitants; a hunting scene). Made in the seventeenth century. Height of each glass, $4\frac{1}{4}$ inches; diameter, $1\frac{7}{8}$ inches. (Plate 21, fig. 1. U.S.N.M. No. 154593.)

35. ANTIQUE CHINA CUP.—Used for the salt water at the Passover meal, or Seder. Height, $1\frac{1}{8}$ inches; diameter, $2\frac{1}{2}$ inches. (Plate 21, fig. 2. U.S.N.M. No. 154618.)

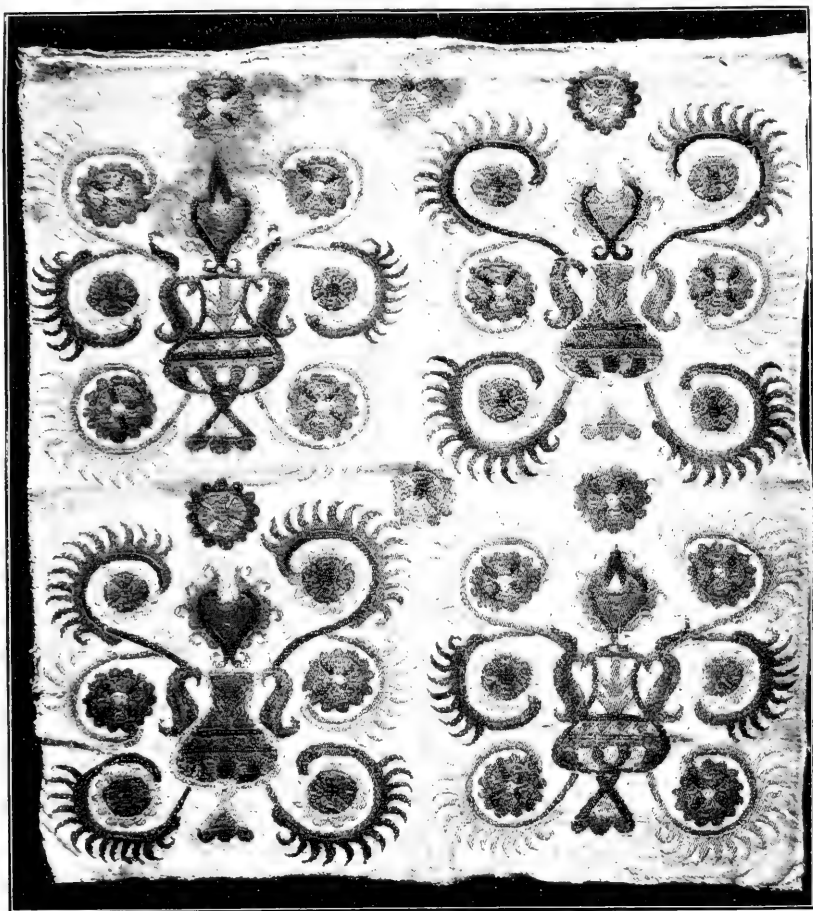
36. ENAMELED SAUCER AND SILVER SPOON.—Used for the compound of almonds, apples, and other fruit, or *haroseth*, at the Passover meal, or Seder. Height of saucer, seven-eighths inch; diameter, $4\frac{1}{2}$ inches; length of spoon, $5\frac{1}{2}$ inches. (Plate 21, figs. 3. U.S.N.M. No. 154596.)

37. GLASS AND PLATE.—Used for the counting of the ten plagues inflicted on the Egyptians, at the Passover meal, or Seder. Height of glass, $6\frac{1}{2}$ inches; diameters, $5\frac{1}{8}$ and $3\frac{5}{8}$ inches; height of plate, 1 inch; diameter, $8\frac{1}{2}$ inches. (Plate 22. U.S.N.M. No. 1290.) During the reciting of the account of the deliverance from Egyptian servitude in the liturgy of the Seder, or *hagadah*, at the mention of the ten plagues sent against the Egyptians¹ a drop of wine is poured out from a glass into a plate at the mention of each plague, or sometimes is dipped out with the finger.

38. PIECE OF BROCADE.—Used as a tablecloth at the Passover meal, or Seder. Measurements, 3 feet $10\frac{1}{2}$ inches by 1 foot $6\frac{1}{2}$ inches. (Plate 23. U.S.N.M. No. 154596^b.)

39. TABLE CENTER.—Used at the Passover meal or Seder. Linen, with edge and corners richly embroidered in silk and gold. Made in

¹Compare Exodus vii-xii.

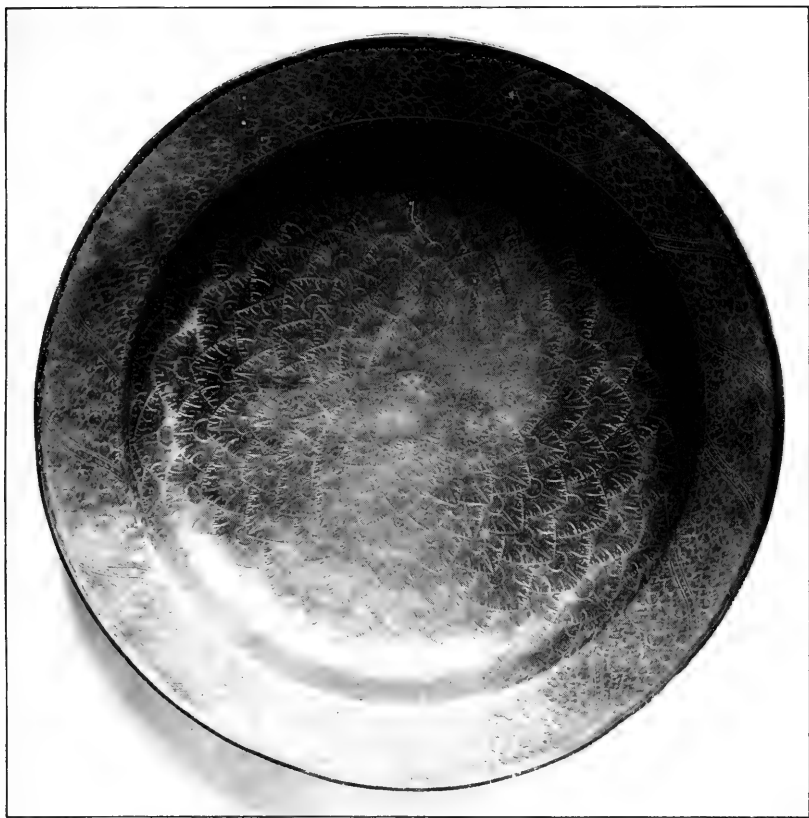


COVER FOR THE UNLEAVENED BREAD AT THE PASSOVER MEAL.

Chaleis, Greece.

Cat. No. 154599, U.S.N.M.



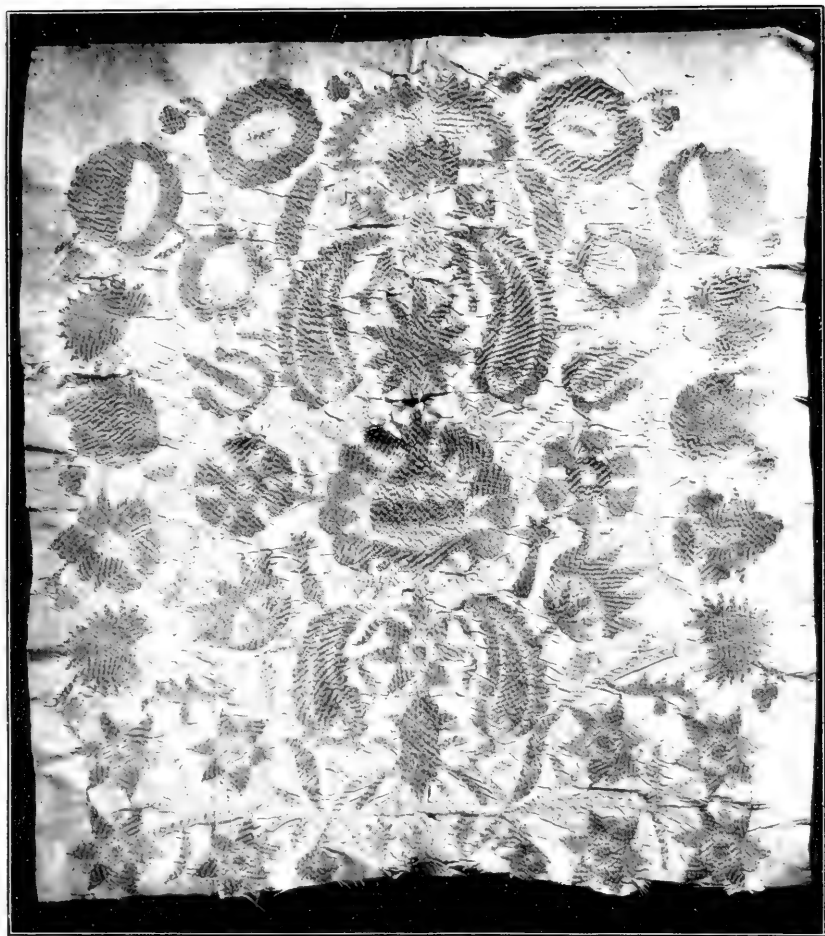


BRASS DISH, USED AT THE PASSOVER MEAL.

Venice, Italy.

Cat. No. 154595, U.S.N.M.





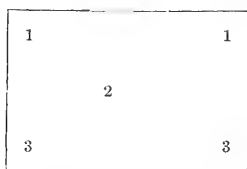
COVER FOR GREEN HERBS AT THE PASSOVER MEAL.

Chios.

Cat. No. 154597, U.S.N.M.



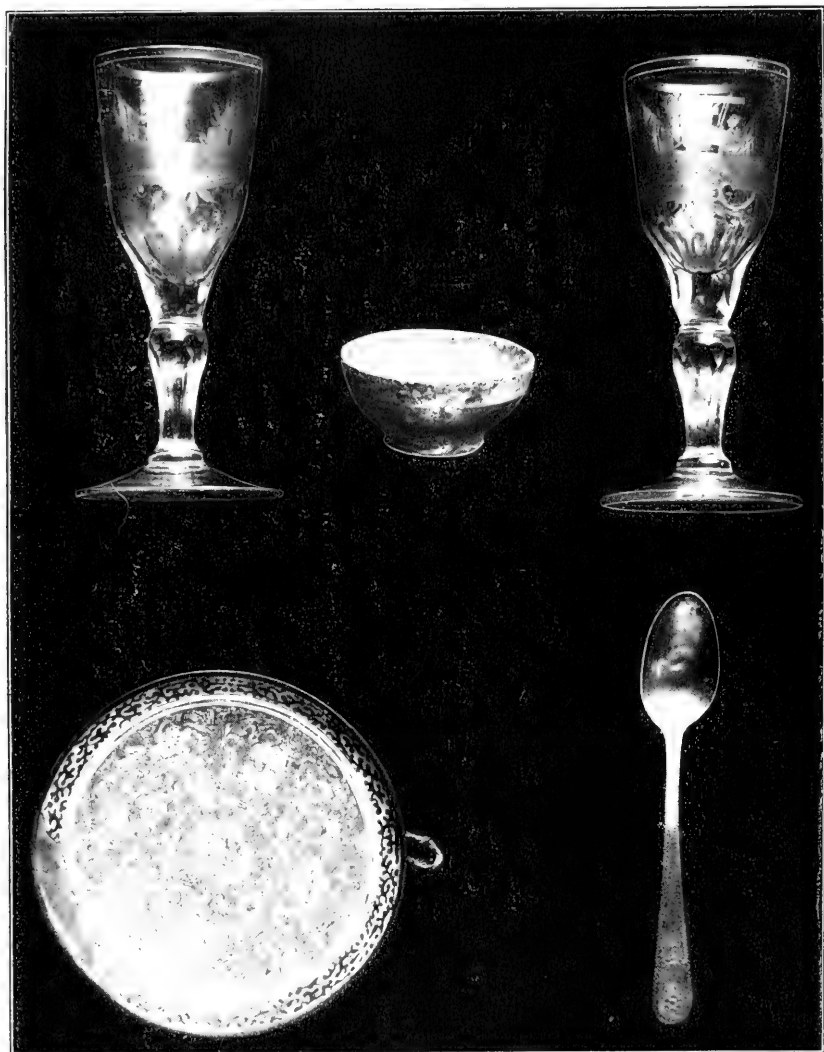
EXPLANATION OF PLATE 21.



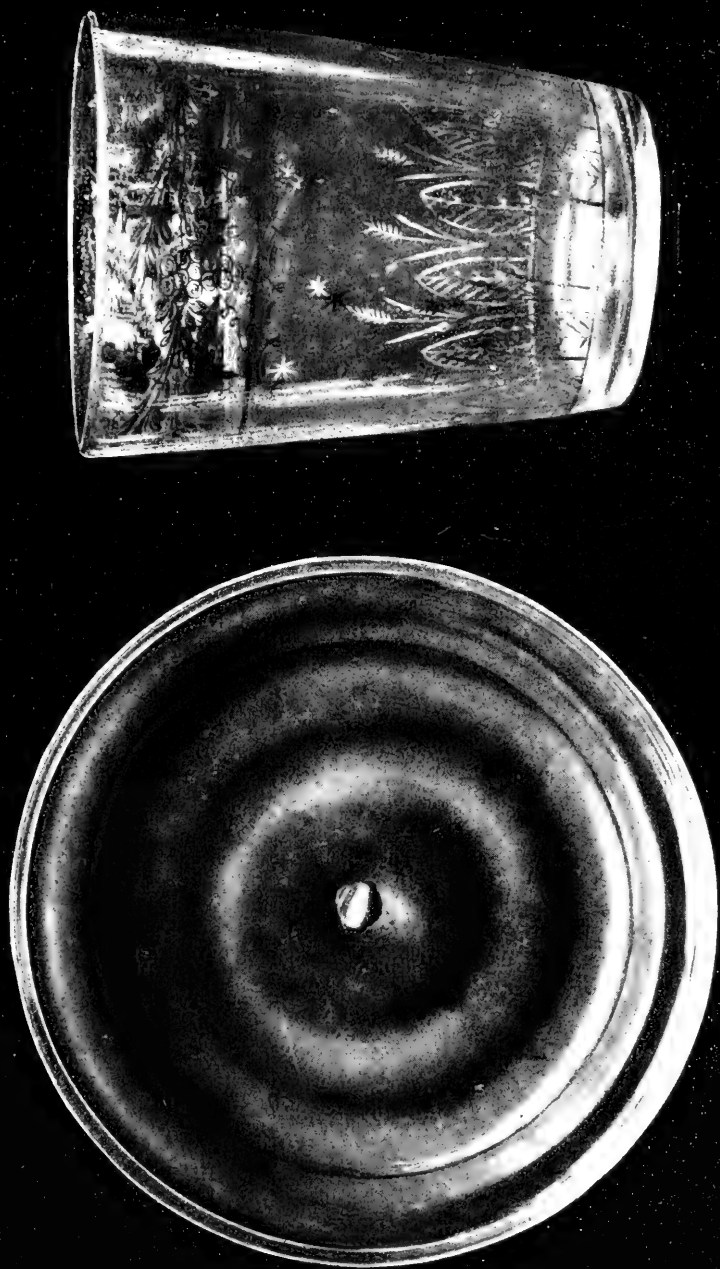
Figs. 1. WINE GLASSES USED AT THE PASSOVER MEAL.
(Cat. No. 154593, U. S. N. M.)

Fig. 2. ANTIQUE CUP USED AT THE PASSOVER MEAL.
(Cat. No. 154618, U. S. N. M.)

Figs. 3. ENAMELED SAUCER AND SILVER SPOON USED AT THE PASSOVER MEAL.
(Cat. No. 154596, U. S. N. M.)

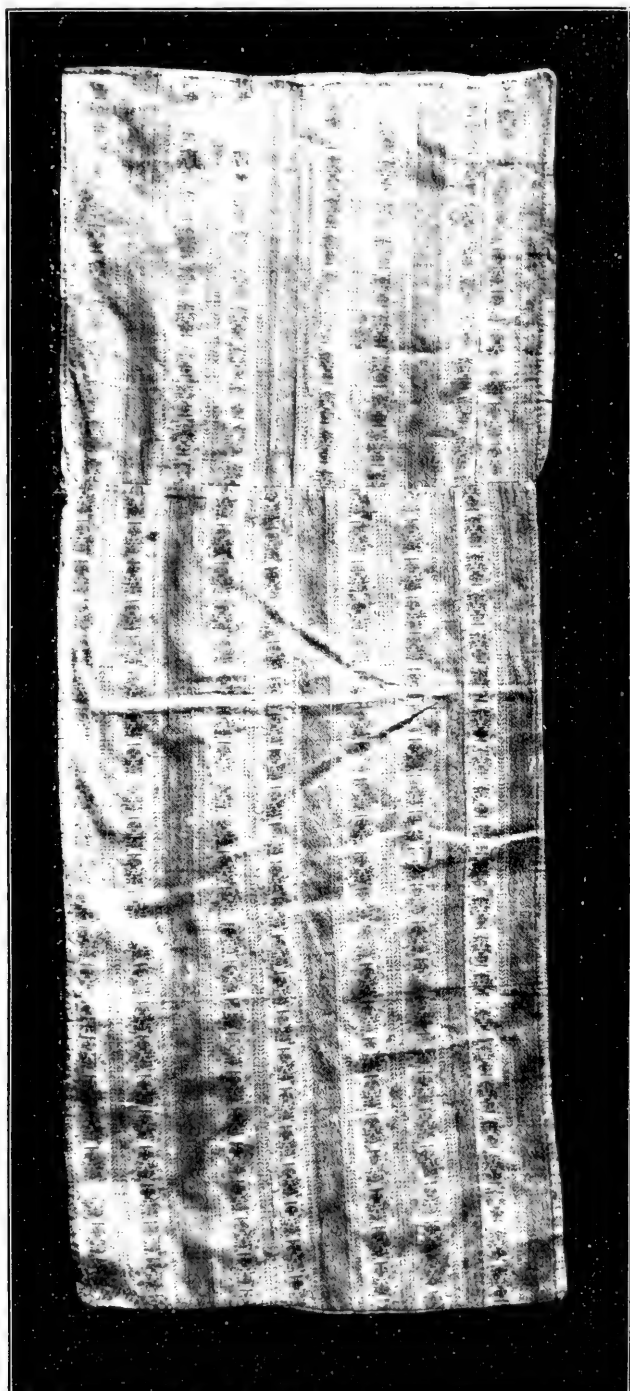


VESSELS USED AT THE PASSOVER MEAL.



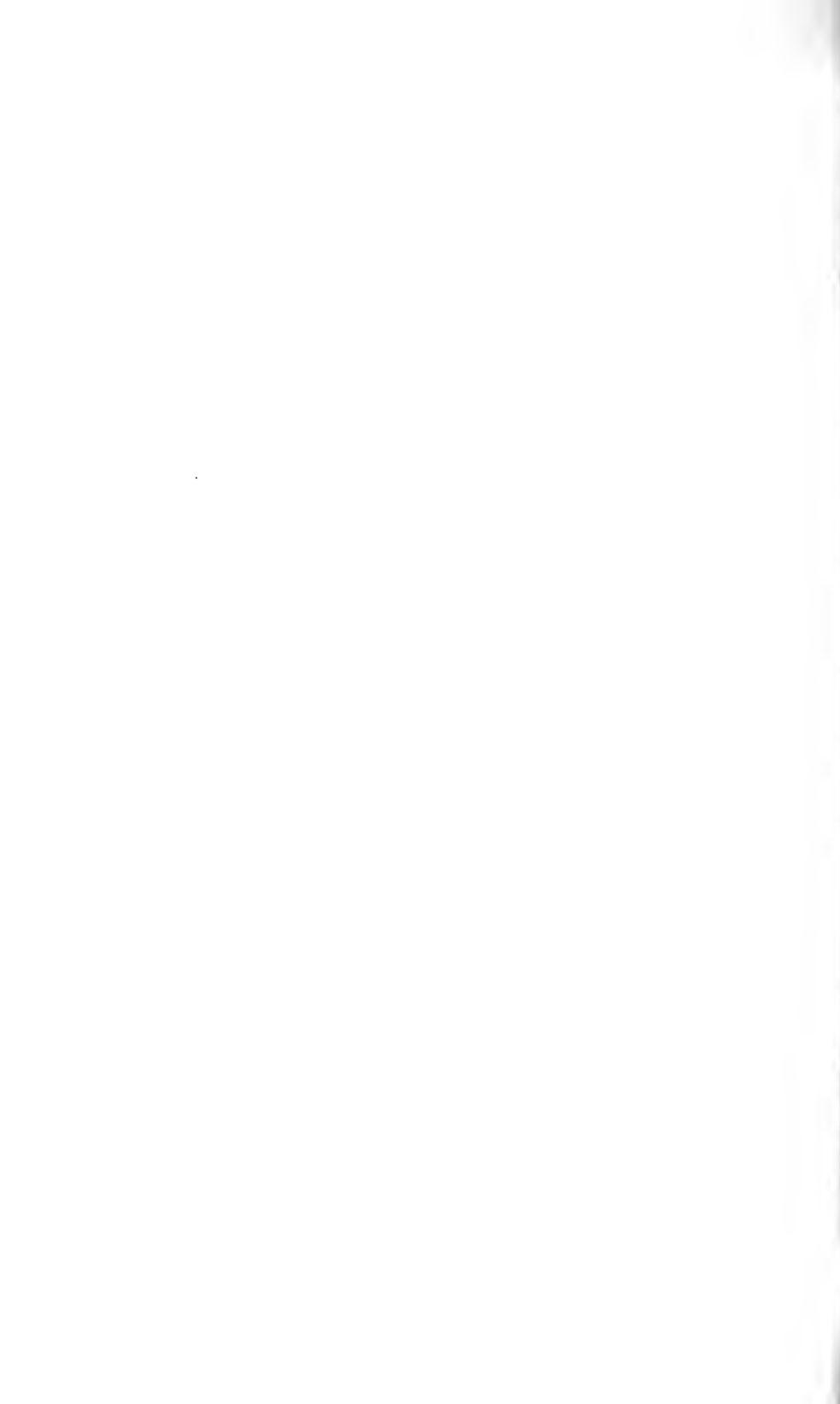
GLASS AND PLATE, USED AT THE PASSOVER MEAL.

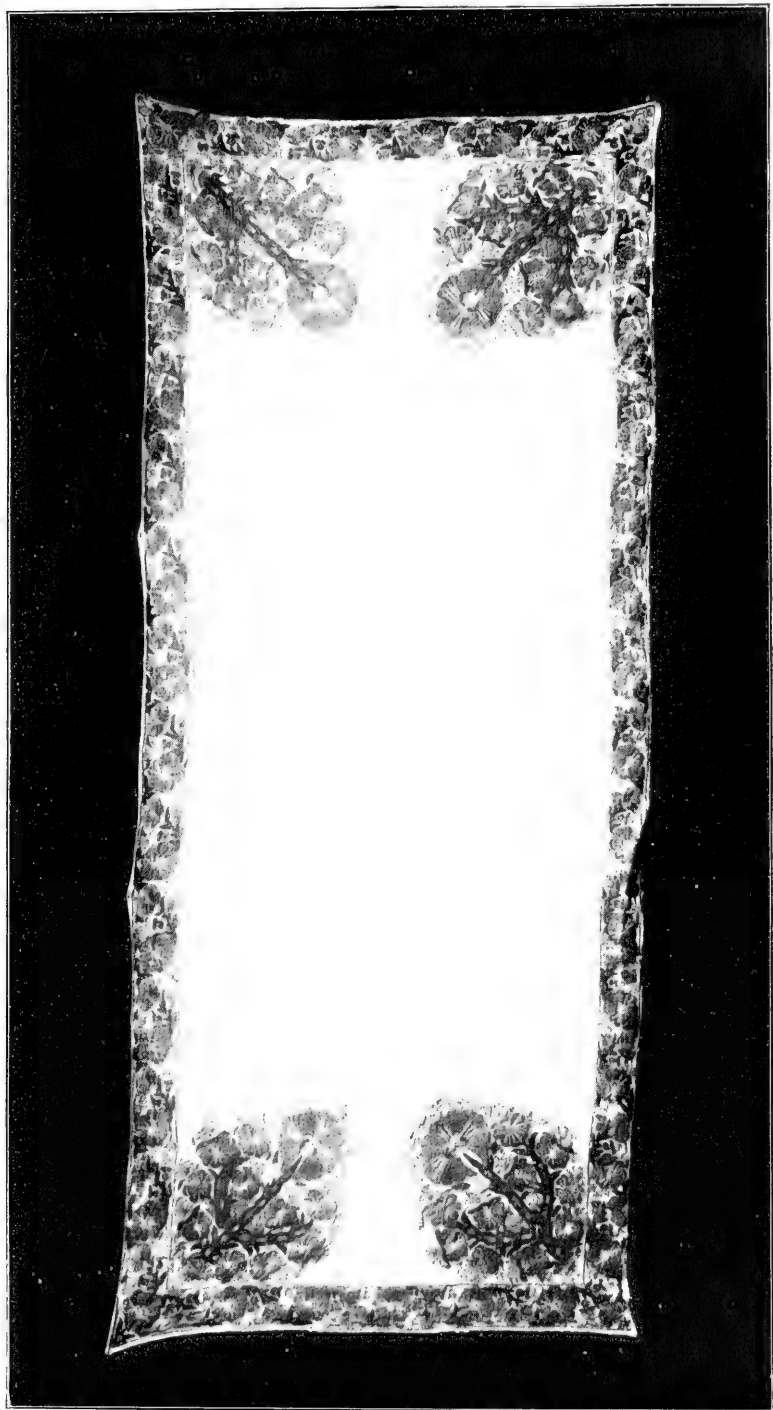
U. S. NAT. MUSEUM, WASHINGTON



PIECE OF BROCADE, USED AT THE PASSOVER MEAL.

Cat. No. 154596, U.S.N.M.



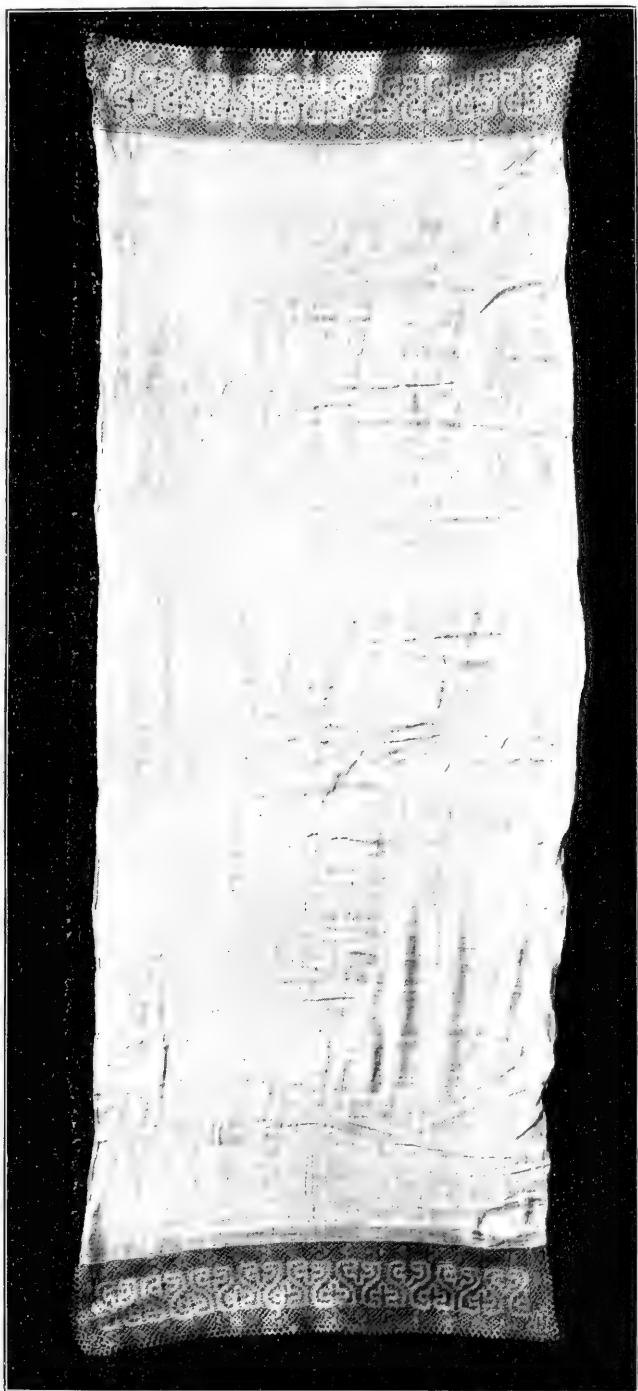


LINEN TABLE CENTER, USED AT THE PASSOVER MEAL.

Janina, Turkey.

Cat. No. 154601, U.S.N.M.

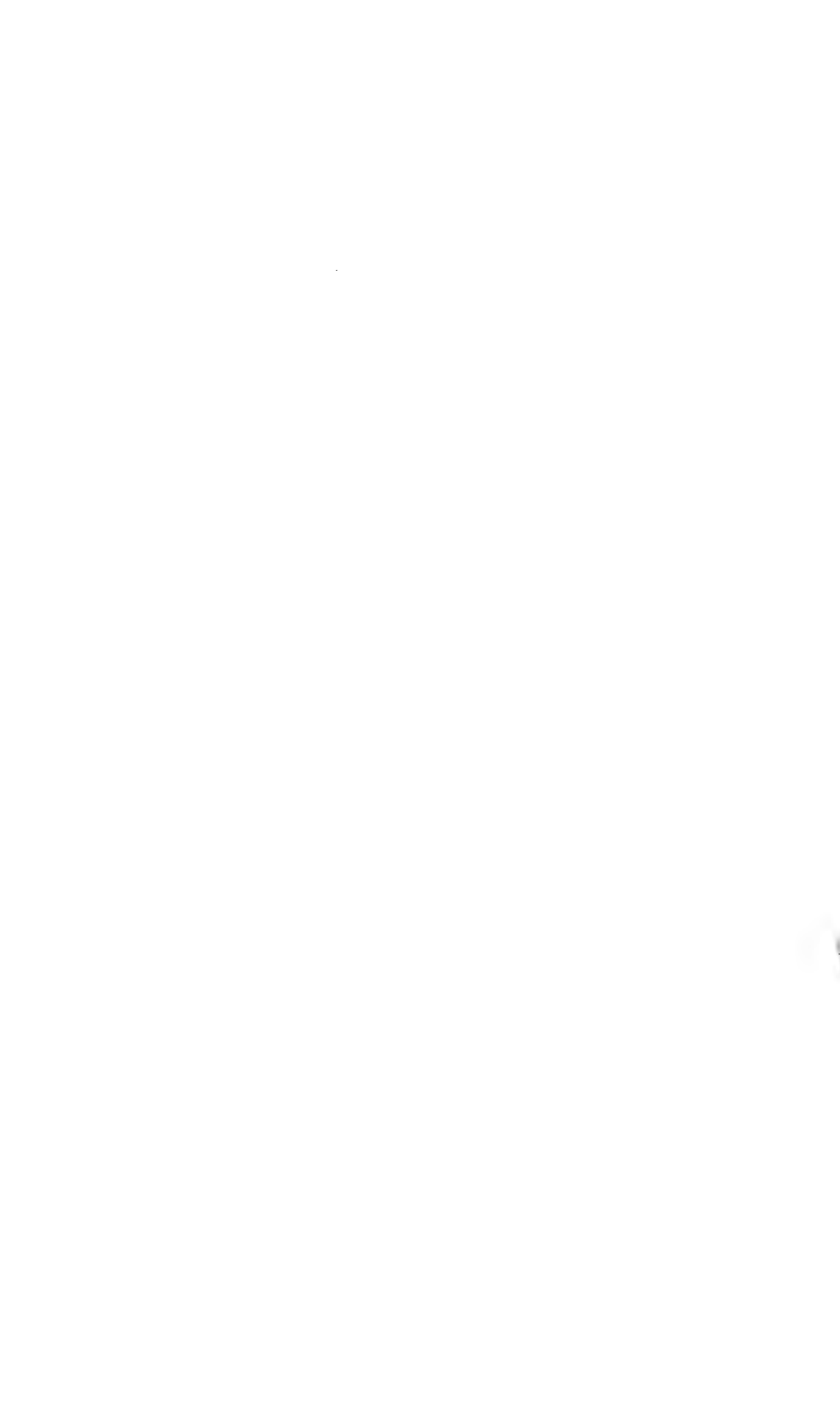




SERVLETTE USED AT THE PASSEOVER MEAL.

Chios.

Cat. No. 15498, U.S.N.M.



Janina, Turkey, in the seventeenth century. Length, 3 feet 10 inches; width, 1 foot 7 inches. (Plate 24. U.S.N.M. No. 154601.)

40. **SERVLETTE.**—Used at the Passover meal or Seder. Woolen, with lace edge worked in silver and silk. Made in Chios in the sixteenth century. Length, 4 feet 3 inches; width, 1 foot 7½ inches. (Plate 25. U.S.N.M. No. 154598.)

(C) TABERNACLES.

41. **CURTAIN FOR THE BOOTH OR TENT (SUKKAH) OF THE FEAST OF TABERNACLES.**—Made of linen and silk, with gold threads in the edge, by the Beduins of Jerusalem in the eighteenth century. Length, 10 feet 2 inches; width, 6 feet 4 inches. (Plate 26. U.S.N.M. No. 154590.)

42. **CURTAIN TIE.**—Linen with edges embroidered in gold and silk. Made by the Jews of Smyrna, Asia Minor, in the seventeenth century. Length, 8 feet; width, 8½ inches. (Plate 27. U.S.N.M. No. 154617.)

The Feast of Tabernacles takes place on the 15th of Tishri (September-October), and continues, according to Leviticus xxiii, 39–43, seven days, with an eighth day for the conclusion of the feast, to which is added the feast of the “Rejoicing of the Law,” thus extending it to nine days. It is celebrated in remembrance of the wandering of the Israelites through the desert where they dwelt in booths or tents¹. In ancient times the feast was coincident with the harvest season and was a feast of thanksgiving.² It was one of the most important and joyous of the three pilgrimage festivals. The most characteristic feature of the celebration of this feast is the dwelling in booths or tents, whence is derived its Hebrew name, *Sukkoth*, or more fully *hag ha-sukkoth*, the feast of booths. The booth has three sides of wood, usually boards or planks, while the fourth side, on which is the entrance, is hung with a curtain. It must be erected in the open air and covered with green branches and leaves, affording protection against the sun by day, but permitting a small portion of the sky to be seen and the stars to show at night. Inside it is usually adorned with draperies and garlands. Being the “dwelling place”³ during the festival, the meals are taken in the booth and especially pious people even sleep in it. Sick and feeble people, however, are exempt from the obligation of “dwelling in tents,” and the precept is generally suspended in inclement weather. Another of the important ceremonies connected with the observance of the Feast of Tabernacles is the use of palm branches (*lulab*), bound up with myrtle and willow branches, and a kind of citron (*ethrog*), for which see the Report of the U. S. National Museum for 1896, page 996.

¹ Compare Leviticus xxiii, 43.

² Leviticus xxiii, 39; Exodus xxiii, 16; xxxiv, 22.

³ Leviticus xxiii, 42.

IV. OBJECTS USED ON SPECIAL OCCASIONS.

43. WRAPPER USED ON THE OCCASION OF CARRYING A CHILD TO SYNAGOGUE.—Linen with embroidered inscription in Hebrew reading: "Jacob, surnamed Kapel, son of Naphthali Shalita, surnamed Hirsh Heller, born Wednesday, the 15th of Shebat (January–February) 5604 (1844). May the Lord let him grow up to the study of the Torah, to marriage and good works. Amen. Selah." Made in France. Length, 9 feet 4 inches; width, 6 inches. (Plate 28. U.S.N.M. No. 154605.)

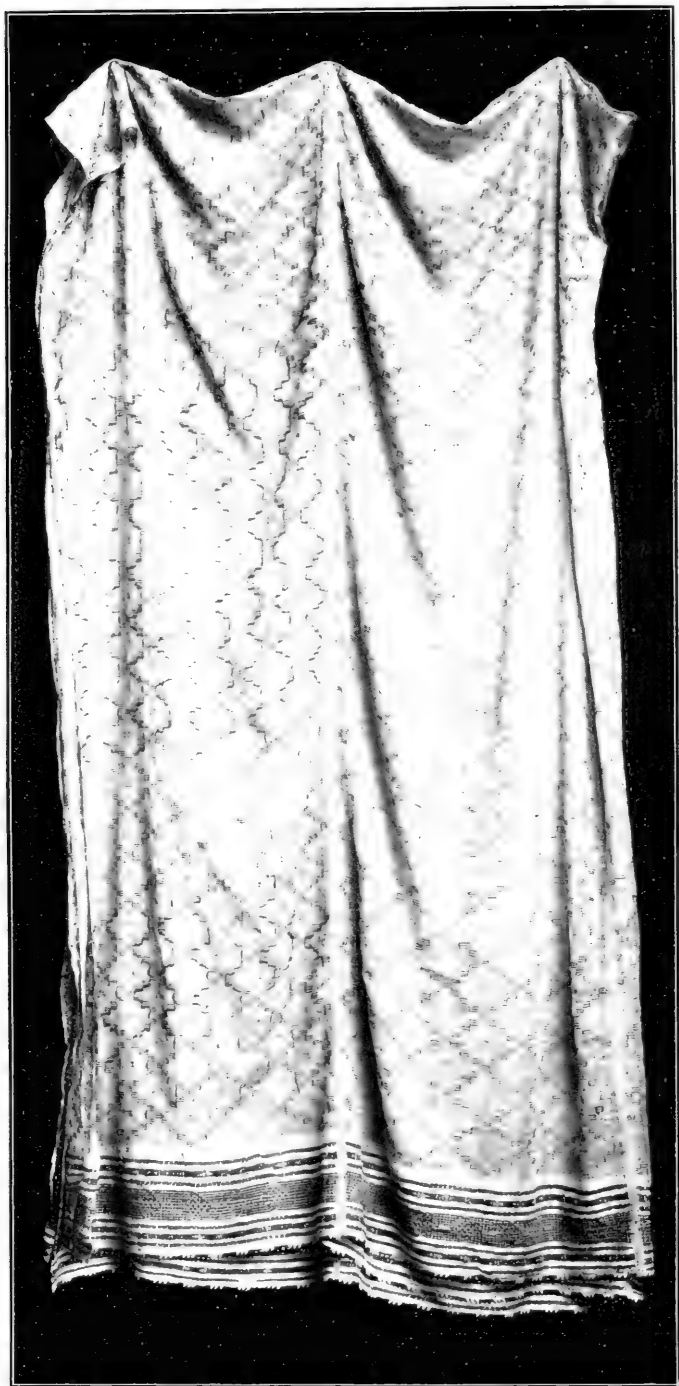
Among some Jews it is the custom when a child is brought for the first time to the synagogue that the father takes it to the desk, where the lesson from the Law is read during service, and presents a wrapper for the Torah scroll.

44. MARRIAGE CONTRACT (*kethubah*).—Written on parchment in the so-called Rashi or Rabbinical script with gilded initials and decorated borders. Height, 12 inches; width, 18½ inches. Dated Haskeuy, Constantinople, the 7th of Tishri (September–October) 5361 A. M. (1601 A. D.). The contracting parties are Solomon Medinah and Mercada, daughter of Moses Firmon. Marriage is usually preceded by an engagement or betrothal, on which occasion it is customary among some Jews to draw up a formal writ of agreement between the bride and groom, whence the ceremony is called *tenaim*, "articles of agreement." The marriage ceremony takes place under a canopy (*huppah*) of silk, or velvet about two yards square, supported by four poles. The bride and bridegroom are led under it by their parents and friends. The rabbi, or anyone competent to perform the ceremony, takes a cup of wine, and after pronouncing an appropriate blessing, gives it to the bride and bridegroom to taste. The bridegroom then places a ring on the finger of the bride with the words: "Behold thou art wedded to me by this ring, according to the law of Moses and Israel." This act, which is called sanctification (*kiddushin*) in itself makes the marriage valid. Then the marriage contract is read. This is written in Aramaic after an established form. It states that the bridegroom agrees to take the bride as his lawful wife, and that he will keep, maintain, honor, and cherish her, etc., and also specifies the sum he settles upon her in case of his death. After that the bridegroom crushes an empty glass with his foot in remembrance of the destruction of Jerusalem.¹ The rabbi, or whosoever performs the ceremony, takes another cup of wine, pronounces over it seven benedictions, and hands it again to the bride and bridegroom, who taste it, and the ceremony is then concluded.

45. MARRIAGE CONTRACT.—Written on parchment. The margins are richly decorated; of the writing only a few traces are left, which, however, exhibit fine workmanship. Height, 20¼ inches; width, 18¼ inches.²

¹Compare Psalms cxxxvii, 5.

²For an illustration of an old marriage contract, see Report of the U. S. National Museum for 1896, p. 998.



CURTAIN FOR BOOTH (SUKKAH) OF THE FEAST OF TABERNACLES.

Jerusalem, Palestine.

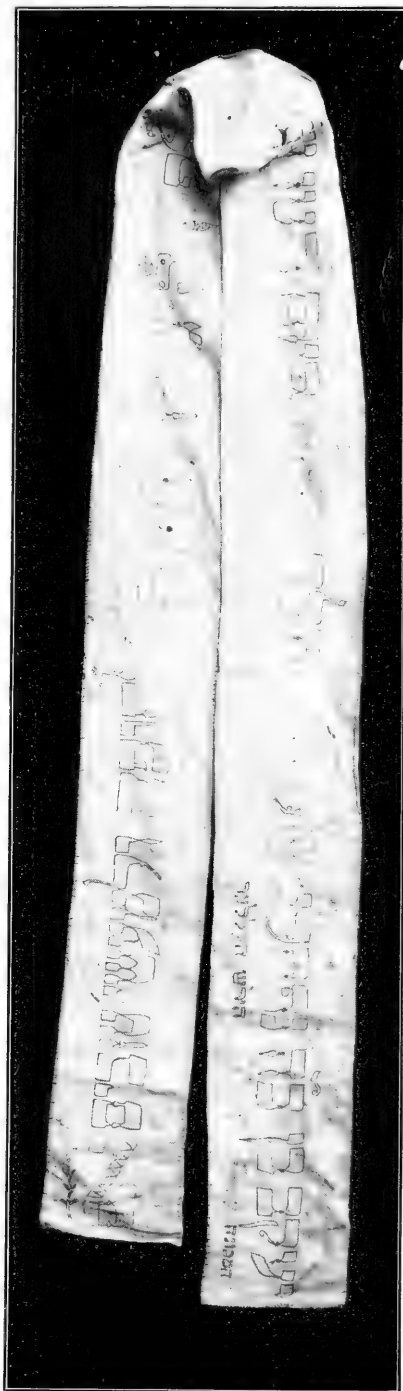
Cat. No. 154590, U.S.N.M.



CURTAIN TIE.

Smyrna, Asia Minor.

Cat. No. 154617, U.S.N.M.



WRAPPER FOR CARRYING CHILD TO SYNAGOGUE.

France.

Cat. No. 154605, U.S.N.M.



EXPLANATION OF PLATE 29.

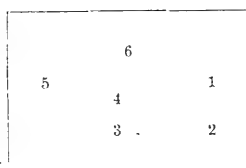


Fig. 1. MEZUZAH INCASED IN A QUILL.

Fig. 2. MEZUZAH IN A TIN CASE.

Fig. 3. MEZUZAH IN A GLASS TUBE.

Fig. 4. MEZUZAH UNFOLDED.

(Cat. No. 154584, U. S. N. M.)

Fig. 5. AMULET OF PARCHMENT.

(Cat. No. 154611, U. S. N. M.)

Fig. 6. SILVER MEDALLION, USED AS AMULET.

(Cat. No. 154613, U. S. N. M.)

V. MISCELLANEOUS.

46. **MEZUZAH.**—The *mezuzah* consists of the passages Deuteronomy vi, 4-9, and xi, 13-21, written on parchment in the same manner as the Torah scroll and the phylacteries¹ and inserted in a wooden or metal case or glass tube. On the outer side is written the Hebrew name of God, *Shaddai*, "Almighty," and a small opening is left in the case opposite this word. The case is fastened in a slanting position to the right-hand side of the doorpost, in compliance with the words: "And thou shalt write them (the words of the Lord) on the doorposts of thy house and within thy gates."² Pious Jews touch and kiss the *mezuzah* as they pass through the door. Some Jews in the Orient nail to the doorway the entire Decalogue inclosed in a tin case. The custom has been widely adopted by other peoples of the East, particularly by Mohammedans, who write passages from the Koran over the doors and windows of their homes. (Plate 29, fig. 1, mezuzah incased in a quill; fig. 2, mezuzah in a tin case; fig. 3, mezuzah in a glass tube; fig. 4, mezuzah unfolded. U.S.N.M. No. 154584.)

47. **AMULET OF PARCHMENT.**—Written for Hadji Ephraim Benguiat when he was sick in childhood. Length, 9 $\frac{1}{4}$ inches; width, 1 $\frac{3}{4}$ inches. (Plate 29, fig. 5, U.S.N.M. No. 154611.)

Amulets are charms, or preservatives against evil spirits, witchcraft, the evil eye, or disease. They are made of stone, metals, animal products, etc., in fact of any substance. The most common consists of words, characters, or sentences ranged in a particular order and written on parchment, or engraved upon wood, stone, or metal, and worn about the neck or some other part of the body. Amulets are found in use among nearly all peoples and religions of ancient and modern times.

48. **SILVER MEDALLION, USED PROBABLY AS AN AMULET.**—Filigree work. On one side is, in gilt relief, the Hebrew name of God, *Shaddai*, ("Almighty"), on the other the figure called "Shield of David" (*magen David*) with a fleur-de-lis inside. Height, 2 $\frac{3}{8}$ inches; width 1 $\frac{1}{2}$ inches. (Plate 28, fig. 6. U.S.N.M. No. 154613.)

49. **TWO SILVER RINGS, USED AS AMULETS.**—Engraved with the name of the owner: "Ephraim Benguiat," and kabbalistic words. Diameter, three-fourths inch.

50. **SILVER MEDAL.**—Struck in commemoration of the edict of Emperor Francis Joseph I of February 18, 1860, granting the Israelites of his Empire the right to own real estate. On the obverse are in relief, to the right, a crowned female figure holding a scroll inscribed in Hebrew, "One people and one nation;" to the left, the figure of a boy holding in his right hand a wreath, in his left a palm branch. Between the figures are, above, two tablets inscribed in Hebrew, "One law for us all;" beneath, the bust of the Emperor and the double eagle

¹See above under 1 and 21, p. 546 and 551.

²Deuteronomy vi, 9; xi, 20.

of the imperial standard. The margin and bottom of the medal have appropriate German legends, expressive of the gratitude of the Israelites. The reverse is inscribed with the paragraphs of the edict bearing on the subject. Diameter, $2\frac{1}{8}$ inches; thickness, one-fourth inch.

51. SILVER COIN.—On the obverse is, in relief, a seated female figure laying her right hand in blessing upon the head of a boy standing in front of her. The margin is inscribed with part of the Aaronitic blessing in German, "The Lord bless thee and keep thee,"¹ while the chair on which the female figure is seated is adorned with the monogram of Christ (X). At the bottom is the name "Abramson." On the reverse is, on the top, the name of God, "Jehovah," in Hebrew characters, with rays of the sun going out from it, surrounded by the inscription in German, "Light and truth." It may have originated with some Kabbalistic sect and have been used as a talisman. Diameter, $1\frac{3}{4}$ inches.

52. SCRIPTURAL MOTTO.—Made of red silk and embroidered in gold, with the Hebrew passages, "Let thy garments be always white, and let not thy head lack ointment,"² and, "I will dwell in thy tabernacle forever; I will take refuge in the covert of thy wings. Selah."³ Made in Smyrna, Asia Minor, at the beginning of the nineteenth century. Length, $27\frac{1}{2}$ inches; width, $7\frac{1}{2}$ inches.

VI. ILLUSTRATIONS OF BIBLE NARRATIVES, MOSTLY TEXTILES.

53. THE SACRIFICE OF ISAAC.—As related in Genesis, chapter xxii. Piece of red tapestry, made in Spain. Length, 22 inches; width, $7\frac{1}{2}$ inches. (Plate 30, fig. 1. U.S.N.M. No. 154607.)

54. THE DEFEAT OF GOLIATH BY DAVID.—As described in I Samuel, chapter xvii. Piece of green tapestry, made in Greece. Length, 5 feet 5 inches; width, 11 inches. (Plate 30, fig. 2. U.S.N.M. No. 154608.)

55. THE STORY OF DAVID AND BATHSHEBA.—As related in II Samuel, chapter xi. Piece of green tapestry, supposed to have been made in England in the thirteenth century. Length, 29 inches; width, $10\frac{1}{2}$ inches. (Plate 30, fig. 3. U.S.N.M. No. 154609.)

56. JOSEPH AND THE WIFE OF POTIPHAR.—As related in Genesis xxxix, 7. Oil painting on copper. Height, $21\frac{1}{2}$ inches; width, 18 inches.

57. THE PASSING OF THE ISRAELITES THROUGH THE RED SEA.—As described in Exodus xiv, 15. Lithograph. Height, $20\frac{1}{2}$ inches; width, 30 inches. (Plate 31. U.S.N.M. No. 1289.)

58. THE STORY OF THE GOLDEN CALF.—As related in Exodus, chapter xxvii. On the top to the right is seen Moses on Mount Sinai holding the two tablets of the law; to the left is the calf mounted on a column; below are the people dancing around it, and Aaron with his

¹ Numbers vi, 24.

² Ecclesiastes ix, 8.

³ Psalms lxi, 4.

EXPLANATION OF PLATE 30.

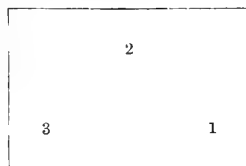


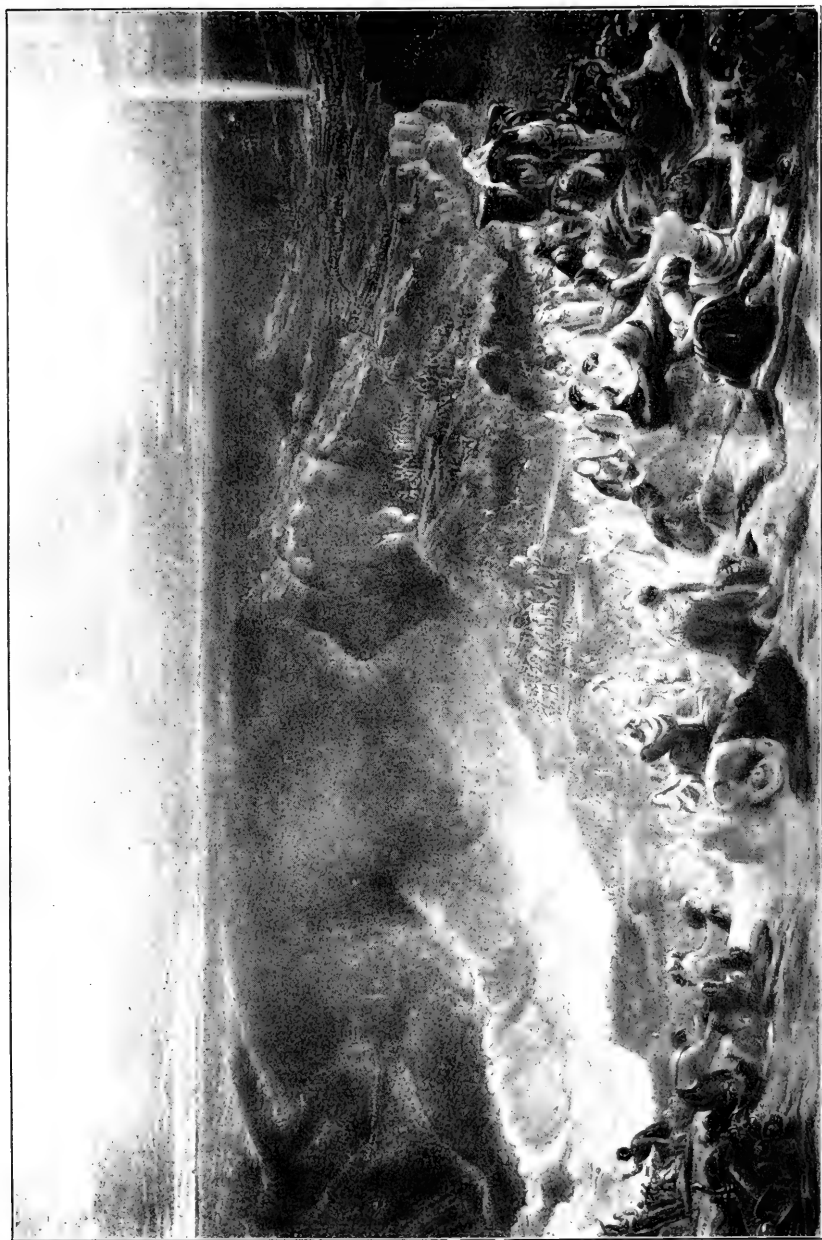
Fig. 1. TAPESTRY REPRESENTING THE SACRIFICE OF ISAAC.
(Cat. No. 154607, U. S. N. M.)

Fig. 2. TAPESTRY REPRESENTING THE DEFEAT OF GOLIATH BY DAVID.
(Cat. No. 154608, U. S. N. M. Greece.)

Fig. 3. TAPESTRY REPRESENTING THE STORY OF DAVID AND BATHSHEBA.
(Cat. No. 154609, U. S. N. M. England.)



TAPESTRIES ILLUSTRATING BIBLICAL NARRATIVES.



LITHOGRAPH REPRESENTING THE PASSING OF THE ISRAELITES THROUGH THE RED SEA.

Col. No. 1280, U. S. N. M.



EMBROIDERY REPRESENTING THE STORY OF THE GOLDEN CALF.

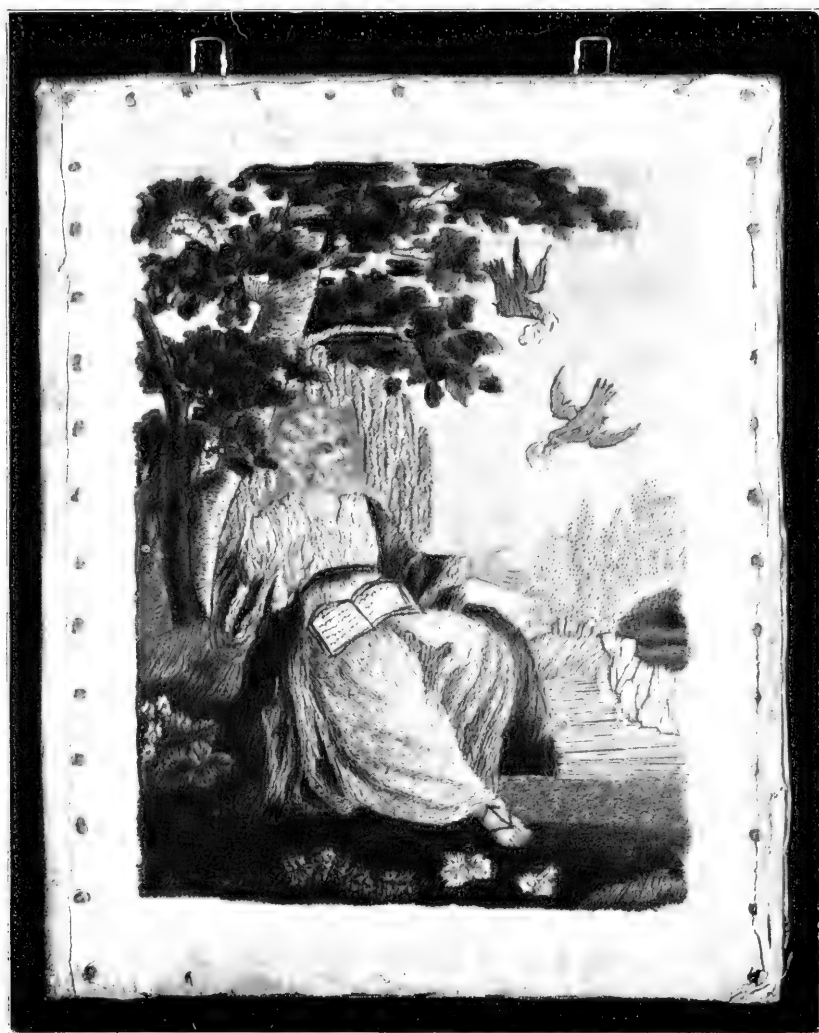
Spain.

Cut. No. 158319, U. S. N. M.



TAPESTRY REPRESENTING THE JUDGMENT OF SOLOMON.

Cat. No. 15850, U.S.N.M.



EMBROIDERY REPRESENTING THE PROPHET ELIJAH FED BY RAVENS.

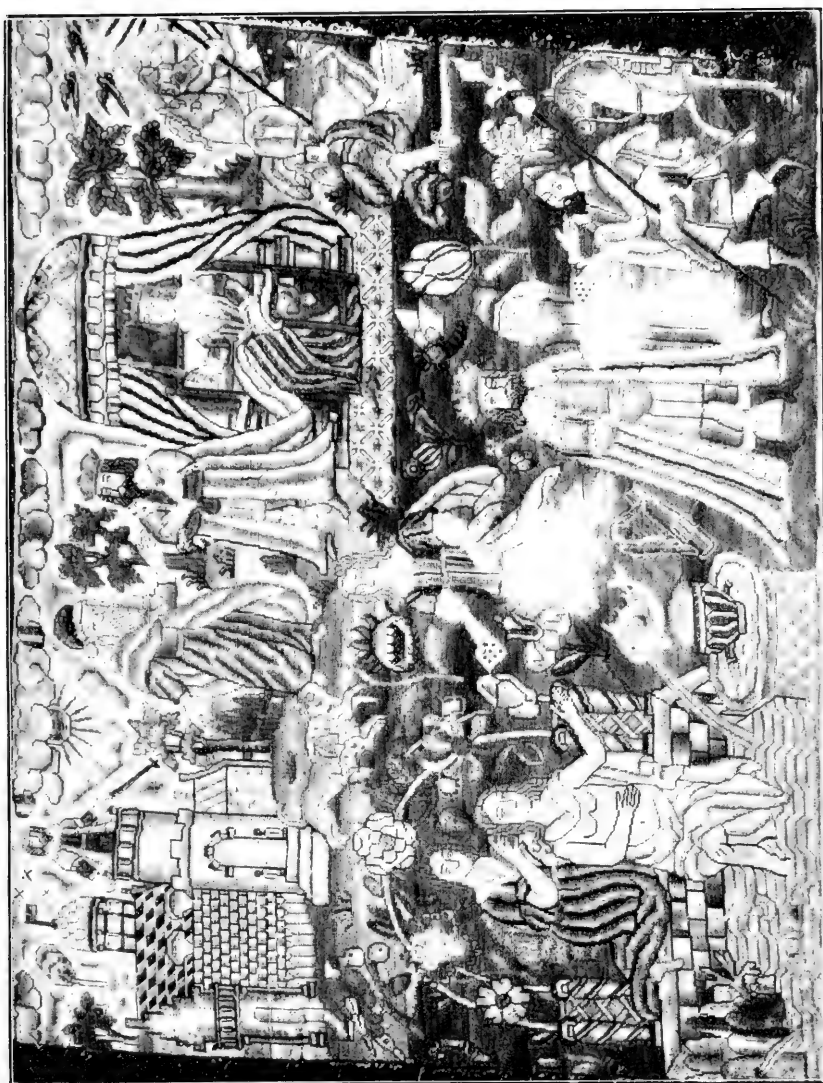
Spain.

Cat. No. 154616, U.S.N.M.



TAPESTRY REPRESENTING THE STORY OF SUSANNA.

Cat. No. 15610 U. S. N. M.



TAPESTRY REPRESENTING THE STORY OF JUDITH AND HOLOFERNES.

Greece,

Cat. No. 151807, U.S.N.M.

arms outstretched in deprecation. Silk embroidery. Made in Spain in the sixteenth century. Height, $11\frac{1}{2}$ inches; width, $14\frac{1}{2}$ inches. (Plate 32. U.S.N.M. No. 158349.)

59. THE JUDGMENT OF SOLOMON.—As related in I Kings iii, 16. French petit point tapestry. Height, $18\frac{1}{2}$ inches; width, $21\frac{1}{2}$ inches. (Plate 33. U.S.N.M. No. 158350.)

60. THE PROPHET ELIJAH PROVIDED WITH FOOD BY RAVENS.—As related in I Kings xvii, 6. Silk embroidery, with the face of Elijah painted. Made in Spain in the eighteenth century. Height, $11\frac{1}{2}$ inches; width, $9\frac{1}{2}$ inches. (Plate 34. U.S.N.M. No. 154616.)

61. SUSANNA AND THE ELDERS.—As related in the "History of Susanna" (the apocryphal chapter xiii of the book of Daniel). Brown tapestry. Height, 3 feet $8\frac{1}{2}$ inches; width, 2 feet 2 inches. (Plate 35. U.S.N.M. No. 154610.)

62. TAPESTRY, PROBABLY REPRESENTING THE STORY OF JUDITH AND HOLOFERNES.—As related in the (apocryphal) book of Judith, chapters x-xiii. Made in Greece. Height, $14\frac{1}{2}$ inches; width, 18 inches. (Plate 36. U.S.N.M. No. 154807.)



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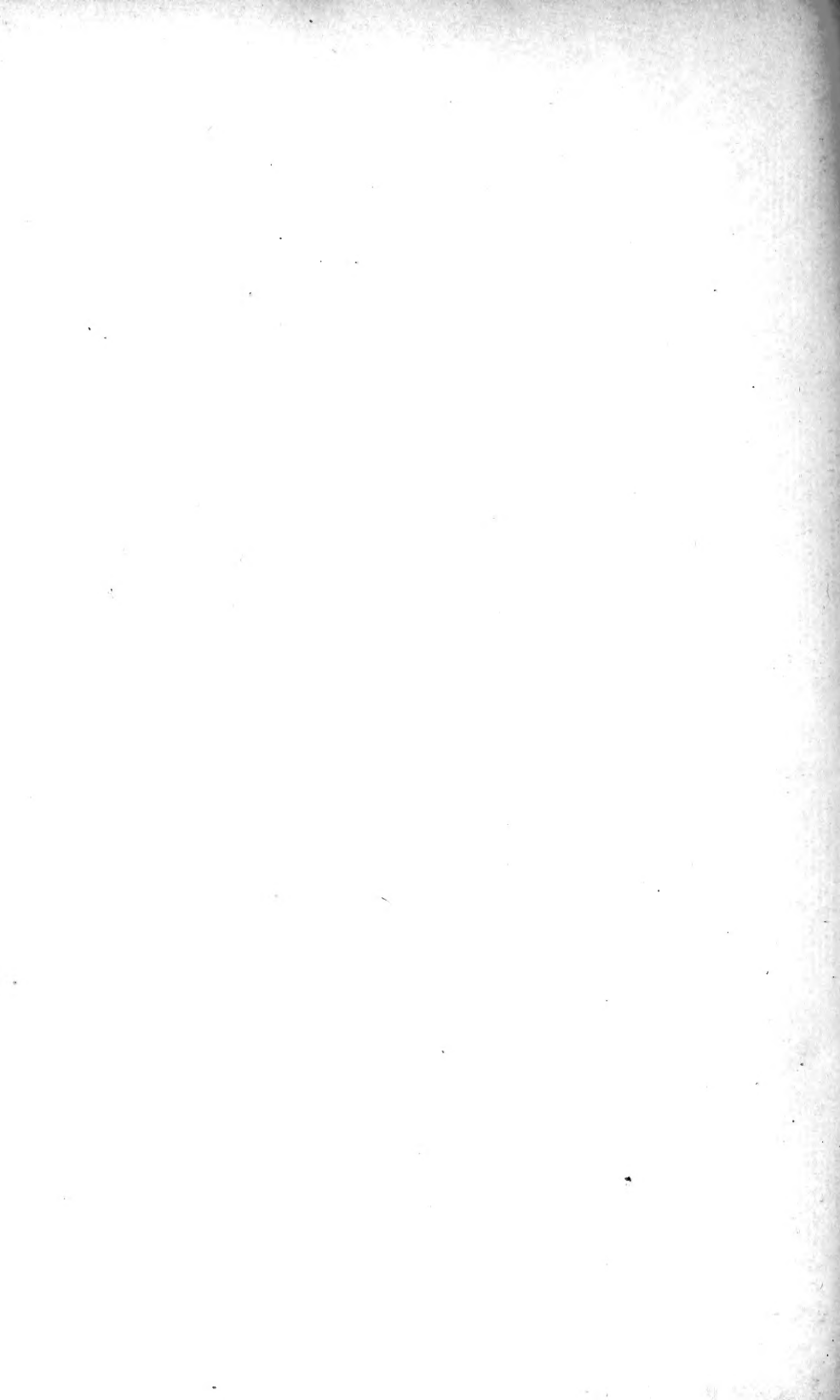
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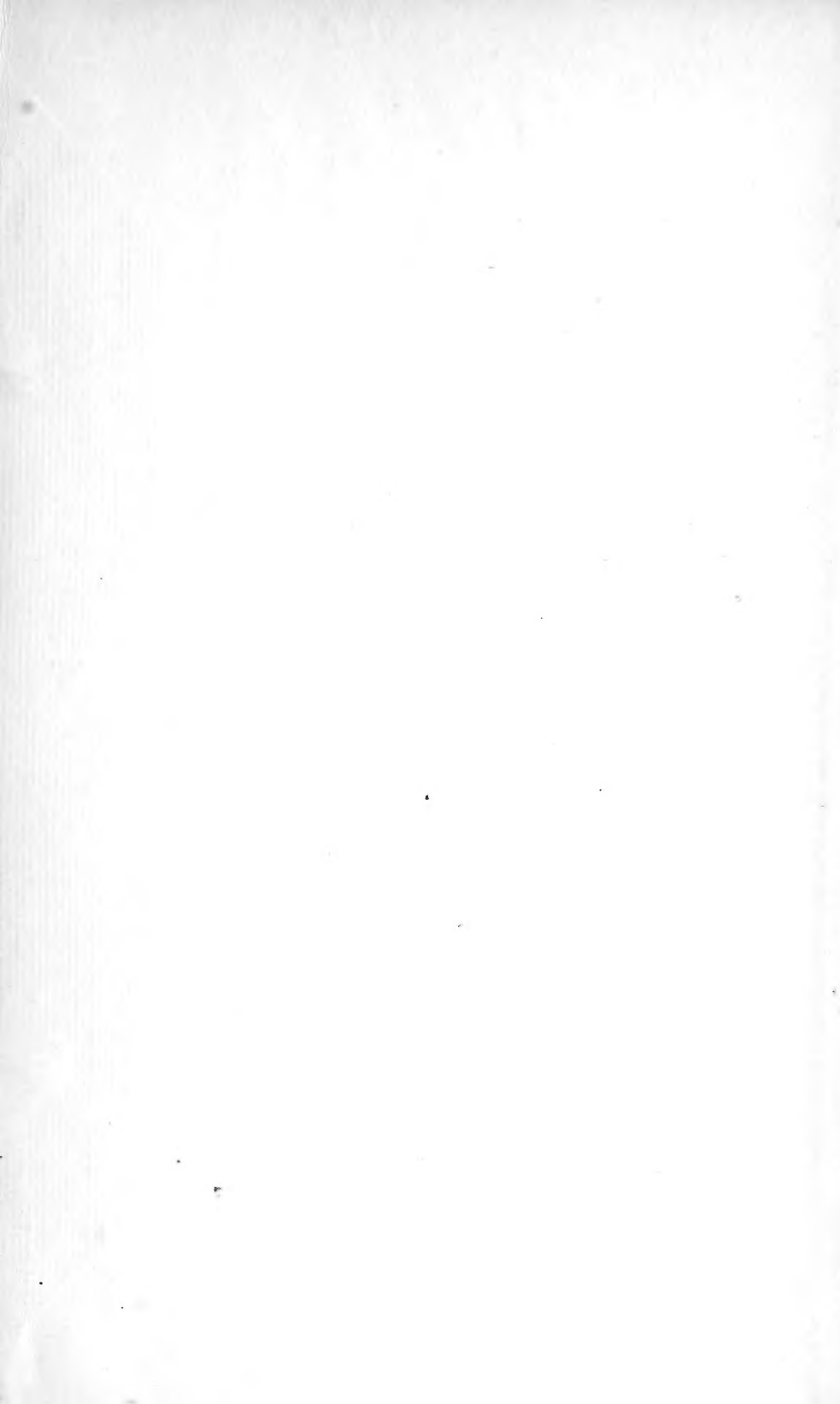
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