FREDERICK J. H. MERRILL,
DIRECTOR & STATE GEOLOGIST

UNIVERSITY OF THE STATE OF NEW YORK
STATE MUSEUM

PLATE 2 BULLETIN 59

C. D. Walcott Director U. S. G. S.
Henry Gannett, Chief Topographer.
H. M. Wilson, Geographer in charge.
Triangulation by U. S. C. & G. Survey.
Topography by J. H. Jennings and W. M. Beaman.
Surveyed 1892 in cooperation with the State of New York.

Scale $\frac{1}{62500}$
1 ½ 0 1 2 3 4 Miles
1 ½ 0 1 2 3 4 5 Kilometers
Contour interval 20 feet.
Datum is mean sea level.

J. B. Lyon Company State Printers

MAP OF
THE EASTERN CATSKILLS
SHOWING THE LOCATION OF
BLUESTONE QUARRIES

H. T. DICKINSON
1901

PLATE 1, BULLETIN 59.

UNIVERSITY OF THE STATE OF NEW YORK.

NEW YORK STATE MUSEUM.

FREDERICK J. H. MERRILL,
Director and State Geologist.

MAP
OF THE
STATE OF NEW YORK
SHOWING THE LOCATION OF
BLUESTONE QUARRIES.
1902.

Lower Boundary of Hamilton Group, ...

The area south and west of this boundary is occupied by sandstones and shales of Hamilton, Portage, and Chemung age. In these formations are the beds quarried as bluestone.

Bluestone Quarries, ...

SCALE OF MILES.

SCALE: 12 MILES TO 1 INCH.

ECONOMIC GEOLOGY 11

Plate 1

Map of New York showing location of bluestone quarries

Plate 2

Map of eastern Catskills showing location of bluestone quarries

University of the State of New York

NEW YORK STATE MUSEUM

56th ANNUAL REPORT

1902

TRANSMITTED TO THE LEGISLATURE JAN. 7, 1903, BY THE REGENTS OF THE UNIVERSITY

ALBANY
UNIVERSITY OF THE STATE OF NEW YORK
1904

University of the State of New York

REGENTS 1902

'08. 7442. FEB

With years of election

1874 Anson Judd Upson L.H.D. D.D. LL.D. *Chancellor*, Glens Falls

1892 William Croswell Doane D.D. LL.D. *Vice Chancellor*, Albany

1873 Martin I. Townsend M. A. LL.D. - - Troy

1877 Chauncey M. Depew LL.D. - - - - New York

1877 Charles E. Fitch LL.B. M.A. L.H.D. - Rochester

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1893 Lewis A. Stimson B.A. LL.D. M.D. - - New York

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1895 Charles R. Skinner M.A. LL.D. Superintendent of Public Instruction, ex officio

1897 Chester S. Lord M.A. LL.D. - - - Brooklyn

1897 Timothy L. Woodruff M.A. Lieutenant Governor, ex officio

1899 John T. McDonough LL.B. LL.D. Secretary of State, ex officio

1900 Thomas A. Hendrick M.A. LL.D. - - Rochester

1901 Benjamin B. Odell jr LL.D. Governor, ex officio

1901 Robert C. Pruyn M.A. - - - - - Albany

1902 William Nottingham M.A. Ph.D. LL.D. - Syracuse

SECRETARY

Elected by Regents

1900 James Russell Parsons jr M.A. LL.D.

STATE MUSEUM COMMITTEE 1902

Regent T. Guilford Smith *Chairman*

Regent C. E. Smith, Superintendent of Public Instruction

DIRECTORS OF DEPARTMENTS

1888 Melvil Dewey M.A. LL.D. *State Library and Home Education*

1890 James Russell Parsons jr M.A. LL.D. *Administrative, College and High School Dep'ts*

1890 Frederick J. H. Merrill Ph.D. *State Museum*

STATE MUSEUM STAFF YEAR ENDING SEP. 30, 1902

Administration and geology

Frederick J. H. Merrill Ph.D. (Columbia)
Director and state geologist
Henry H. Hindshaw B.A. (Chicago College of Science)
Assistant in geology
Herbert P. Whitlock C.E. (Columbia). . Assistant in mineralogy
Frederick C. Paulmier M.S. (Princeton) Ph.D. (Columbia)
Assistant in zoology
Joseph Morje. . . . . Clerk and stenographer
C. Adelbert Trask. . . . . Junior clerk
E. C. Kenny. . . . . Stenographer

FIELD ASSISTANTS

In pre-Cambrian geology
Prof. H. P. Cushing, Adelbert College
In Pleistocene geology
Prof. J. B. Woodworth, Harvard University
Prof. H. L. Fairchild, University of Rochester
In economic geology
Dr Heinrich Ries, Cornell University
Prof C. H. Smyth jr, Hamilton College
Prof. I. P. Bishop, Buffalo State Normal School
Prof. T. C. Hopkins, Syracuse University
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C. J. Sarle, Rochester, N. Y.

Paleontology

John M. Clarke M.A. LL.D. (Amherst) Ph.D. (Marburg)
State paleontologist
Rudolf Ruedemann, Ph.D. (Jena, Germany) . . . .
Assistant state paleontologist
D. Dana Luther. . . . . Assistant
Philip Ast. . . . . Lithographer
G. S. Barkentin. . . . . Draftsman
Jacob Van Deloo. . . . . Clerk and stenographer
Martin Sheehy. . . . . Helper
H. S. Mattimore. . . . . Preparator

Botany

Charles H. Peck M.A. (Union). . . . . State botanist

Entomology

Ephraim Porter Felt B.S. (Boston) D.Sc. (Cornell)
State entomologist
Charles M. Walker B.S. (Mass. Agricultural College)
Entomologist's assistant
D. B. Young. . . . . Entomologist's assistant
George W. V. Spellacy. . . . . Page

Archeology

Rev. William M. Beauchamp S.T.D. . . . . Author of bulletins

STATE OF NEW YORK

No. 42

IN SENATE

JAN. 7, 1902

56TH ANNUAL REPORT

OF THE

NEW YORK STATE MUSEUM

To the Legislature of the State of New York

I have the honor to submit herewith, pursuant to law, as the 56th annual report of the University on the New York State Museum, the reports of the director of the museum and state geologist, of the paleontologist, of the botanist and of the entomologist, with appendix.

ANSON JUDD UPSON
Chancellor

CONTENTS

VOLUME I

56th Report of the Director and 22d of the State Geologist, 1902

Appendixes 1-3

Museum bulletins 56, 58, 61[a]

VOLUME 2

Appendix 4

Museum bulletins 63, 65, 69[a]

VOLUME 3

Appendixes 5-6

Museum bulletins 57, 59, 60, 64, 68[a]

VOLUME 4

Appendixes 7-9

Museum bulletins 55, 62, 66, 67[a]

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[a] Bulletins are grouped into appendixes according to subject, and each appendix is paged separately.

New York State Museum

REPORT OF THE DIRECTOR 1902

To the Regents of the University of the State of New York

I have the honor to submit herewith my reports as director of the State Museum and state geologist for the fiscal year ending Sep. 30, 1902.

Respectfully yours,

Frederick J. H. Merrill

Albany N. Y. Dec. 31, 1902

GEOLOGY

The work under the direction of the state geologist during the past fiscal year has, as usual, been prosecuted both in the field and the office, and its results are summarized in the following pages.

The large geologic map of the State described in Museum bulletin 56 was issued in June 1902, and has been received with much appreciation in all quarters.

In pure geology the survey of the crystalline rocks of the Adirondacks has been continued by Prof. H. P. Cushing, whose field work of the past season was devoted to the mapping of the Long lake sheet of the topographic atlas, some 30% of its area being mapped in detail. The rocks are mainly igneous intrusives and it was expected that detailed mapping would throw light on the complicated relations of the anorthosite, syenite and granite intrusions to one another. The portion of the sheet covered during this first season was, in the main, away from the anorthosite boundary, and showed syenite as the prevailing rock, more or less involved with granite. On the west slopes of Mt Morris this syenite is much cut by a granite, which is clearly younger. The syenite is found to vary much in composition, in grain and in degree of foliation, specially toward its peripheral portions. In Litchfield park it becomes very acid, grading into a granite, which is found to be cut by another granite, apparently the same as that which cuts the syenite about Mt Morris. Running north from Litchfield park, and forming the ridges between Little Simons and Follensby ponds, is a considerable area of a different granite rock, more gneissoid and richer in dark silicates than the preceding, but no exposures could be found which disclosed its relations to the surrounding rocks.

Two unexpected and very interesting little examples of anorthosite outliers were found in Litchfield park, some miles distant from the main mass. One was but meagerly exposed and gave no clue as to its relations to the surrounding rocks, which were of a dubious type and of uncertain affinity. The other was entirely surrounded by syenite, plainly an igneous intrusive, but showing considerable variation and also differing considerably from the usual syenite, so that it is a question whether it is properly to be correlated with that. This syenite appears to cut out the anorthosite on the north and west, at least the contact between the two rocks is an irruptive one, and apparently the syenite is the younger, though the evidence is not so decisive as one could wish. If the relations were properly apprehended, the syenite is the younger, and the anorthosite is of the nature of a large inclosure in the other rock. Besides the evidence derived from the character of the exposed contacts, the coarseness of grain of the anorthosite and its lack of tendency to become gabbroic, harmonize with this view.

Wherever the main anorthosite boundary was reached, the rock was found to be gabbroic, fine grained and gneissoid, these characters fading out with recession from the boundary. No gradation between it and the syenite was noted, the boundary between the two seeming everywhere sharp, but no contacts were noted.

The area of Grenville rocks lying south and southwest of Follensby pond was found to have much greater extent than had before been supposed, and to form much the largest area of these rocks yet found in the heart of the region. Only its north and west boundaries were mapped, but it was followed for 4 miles from north to south, and, where left, was running south with a breadth of at least 3 miles and possibly much more. At least 10 square miles of it were included in the area mapped, and it may be double that size or more. Compared with most areas of these rocks too, there was singularly little mixture with gneisses of doubtful or of igneous origin, the rather frequent outcrops showing distinctive sediments only. It is noteworthy that the area is not very remote from the considerable belt of similar rocks which Prof. J. F. Kemp has mapped as running east from Long Lake village, and which is also of unusual size for the heart of the Woods, and that both lie in what the writer has called the " lake belt," which he has regarded as a down faulted portion of the region. These larger Grenville areas here would seem to emphasize the correctness of that conclusion. In addition, two or three small patches of Grenville rocks, previously unknown, were discovered.

Glacial striae were noted in several places, always in valleys, and on surfaces recently stripped during road-making. They, as usual, show directions controlled by the minor topography and are of little value as indications of the general direction of movement of the main ice sheet.

In southeastern New York work has been continued in the study of the crystalline rocks by Mr E. C. Eckel. During October and November 1901 he was chiefly in Rockland and Westchester counties, short trips having been made into the adjoining portions of Connecticut and a few days being spent in the vicinity of Fort Ann N. Y. The winter was occupied with proof-reading on bulletins, and with the editing of reports on the Portland cement industry of the State and on the quarry industry of southeastern New York. During the spring and summer of 1902, Mr Eckel was engaged in field work on the Cambrian and Silurian formations in Columbia and Dutchess counties; on the pre-Cambrian and Paleozoic formations near Saratoga N. Y.; and in establishing points on the boundary lines between the Medina, Clinton and Niagara formations in western and central New York.

In Pleistocene geology, work has been continued in the Hudson and Champlain valleys by Prof. J. B. Woodworth in the study of the history of the postglacial marine invasion. During the winter and spring of 1901–2 he was engaged in the elaboration of his field notes and in the preparation of parts of a report on the evidences of submergence of the Hudson and Champlain valleys by the sea or by fresh water at the close of the glacial period. A short paper on the Northumberland volcanic plug was prepared with illustrative drawings, and is now in the hands of the printer.

June 16, 1902, Professor Woodworth went into the field and till the 28th of the month remained in the Hudson valley between Kingston and Newburg, studying the terraces of clay, gravel, and sand bordering the river and its tributaries to obtain further light on the nature of the water body in which the deposits were laid down and its relation to the retreating ice sheet. From this district he proceeded to Lake George to make a reconnaissance of the middle portion of that lake valley. On July 2 he proceeded to the Mooers quadrangle and began a detailed examination of the glacial deposits and the subsequently formed shore lines of that area. Two months were given to this examination, including a side trip to the reported shore lines of St Albans Vt., and a few days spent in the study of the postglacial scourways and gorge known as "The Gulf" in the vicinity of Covey Hill, Canada. On the completion of this map, he proceeded westward along the northern base of the Adirondacks, seeking for, and determining by means of the aneroid barometer, the elevation of the shore lines and deltas, in order to ascertain the extent and nature of the related water levels in the Champlain area. This extension of the investigation into the St Lawrence valley was made after a conference held at Washington, in February 1902, with Mr G. K. Gilbert of the United States Geological Survey, who kindly gave to the State Museum the use of his notes on that area. Before leaving the field Professor Woodworth extended his reconnaissance as far as Ogdensburg.

Of the definite results obtained by him during the past summer, the most important was the determination of shore lines marked by bars, embankments, or cut-shore terraces on the Mooers quadrangle at various elevations between 280 feet and 495 feet, again at 500, 530, 540, 580, 610, 620, 630, 640 and 720 feet. Those above 580 feet do not continue about the northern flank of Covey Hill and hence are regarded as interrupted by an ice dam in that direction and interpreted as made in a glacial lake or lakes. The highest well formed beach at Covey Hill lies at 450 feet; if the terraces lying above this level to 580 feet are interpreted as stream-made by waters flowing between the retreating ice and the till-covered slope of the hill, the upper marine limit on the northern border of the Adirondack mass at a point about 2 miles north of the international boundary, is 450 feet, a determination first made by Mr Gilbert. As confirming the marine origin of the beaches traced southwestward through Sun, Constable and thence to Norwood and Potsdam, marine shells (*Macoma groenlandica*) were found at an elevation of 350 feet (aneroid) in bottom deposits ¾ mile northeast of the railroad junction at Norwood (formerly Potsdam Junction). The highest water line measured in the vicinity of Norwood is 425 feet. These and numerous other data are to be worked out in the office in their relations to the shore lines traced on the east side of the Adirondacks.

Incidently Professor Woodworth discovered some remarkable slabs of Potsdam sandstone in the town of Mooers, bearing several well preserved crustacean trails (Climactichnites) the location and nature of which have been reported to this office and are discussed in the report of the state paleontologist.

Of the features mapped on the Mooers quadrangle, attention is specially called to the so called "Flat Rocks," bare areas of the Potsdam sandstone evidently denuded of glacial drift by powerful streams of water forming the drainage of the glacial lakes lying west of the Covey Hill axis. These barren areas are of interest commercially in that they produce large crops of huckleberries, the picking and sale of which forms a considerable industry. It is said that over $4000 worth of this fruit was shipped during the past season from Altona alone.

Professor Woodworth was so fortunate as to meet the party of Canadian and New York State engineers engaged this season in the resurvey of the boundary line from Lake Champlain to the St Lawrence, in charge of Mr C. A. Bigger representing the Canadian government and Mr H. P. Willis, representing the United States, and is indebted to these gentlemen for many favors in the prosecution of his work along the border. He is also indebted to Mr T. H. Henderson jr and Mr Rock, the postmaster of Mooers, for information concerning the occurrence of the fossil trails in that town and to Mr William Wray of Alder Bend for assistance in exploring the densely wooded tract on the north slope of Dannemora mountain.

During the year 1902 Professor Fairchild was in the field for 50 days and carried on his work in central New York in continuation of work done in the two previous years. The following is his summary of the work and his conclusions:

In the early spring and summer, visits were made to the region of Syracuse and Rome to complete the study of the lower and later glacial drainage. The results of this work are included in the 21st report of the state geologist.

Late in the summer two short visits were made to the vicinity of Clinton and Utica in continuation of the study of the earlier and high-level glacial drainage. It was found, as expected, that elevated channels, in continuation of those described in the paper published in the 20th annual report, are cut across the intervalley ridges east and west of Clinton and on the south slope of the Mohawk valley beyond Utica.

The main work of the year was in midsummer and late in the autumn in the extreme western part of the State, in the effort to complete the study of the glacial stream and lake phenomena in the Erie basin, which had been under way for several years. This investigation covers the history of the drainage across the divide and past the glacier front, as well as the phenomena of the vast lakes which later faced the glacier. The early snow of the past autumn, prevented the completion of the work. A few more days of driving will be required to map the channels of glacial flow east and west of the Oatka and Tonawanda valleys. The recently issued United States Geological Survey monograph 41, by Mr Frank Leverett, describes the area in a general way, but the maps of the present writer will give the channels and beaches with greater fulness and precision. It was found the past summer that all the way from Hamburg to the Pennsylvania state line, the steepest slopes facing the northwest had been swept and channeled by streams held up to their work by the ice front. It was also found that eastward from Hamburg and East Aurora all the intervalley ridges have been crosscut by the flow of the glacial waters. The correlation of these channels with the valley lakes is an interesting study. Where the lower of these channels opened into lakes Whittlesey and Warren,[1] deltas were formed of wide extent. These are specially prominent at Westfield, Portland, Fredonia, Silver Creek, Brant, Eden, Hamburg, East Aurora, Elma, Alden and Fargo.

The full history of the glacial waters and of the ice retreat in western New York will make a story of much interest. The prologue may be given here, as follows:

At its greatest advance in central-western New York the latest, or "Wisconsin," ice sheet had at its front a reentrant

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[1] See plate 1.

angle, the point of the reentrant being at Salamanca. On the west side of this angle the ice front had to recede only some 30 miles to allow the waters of Lake Warren to creep in from the westward. The entire drama of the glacial waters in this region occurred in that narrow belt. But north of the angle the ice had to retreat some 60 miles in order to let the Warren waters into the Genesee embayment. And to allow the same waters to escape eastward to the Mohawk, the ice had to uncover a breadth of land from the eastern side of the reentrant to Rome or Utica of about 150 miles. Across this broad tract of dissected plateau the ice removal was the recession of the continental glacier. In the basins of Erie and Ontario, on the contrary, vast lobes of the continental glacier were left as comparatively stagnant masses, to spread and steadily push against the bordering high ground for many centuries. Accretion, by local snowfall, doubtless prolonged their life.

In consequence of the relation of the land topography to the position and movement of the glacier masses, the drainage at the west was westward and at the east was eastward. The westward drainage slowly backed up, or extended eastward, while the eastward drainage extended westward. In other words, with the contraction of the Erie ice lobe, the land and glacial drainage in the Erie basin found escape westward to Lake Warren, and ultimately to the Chicago outlet and the Mississippi river, such drainage extending itself eastward as the ice receded, while the eastern waters found their outlet to the ocean by the Mohawk. These opposing movements met in the Syracuse region. This was the critical point, because here the ice lingered the longest at the Warren level. The latter fact is explained by the topography. Oneida and Onondaga lakes lie in a broad depression of the Ontario lowland which is abruptly bordered on the south by the northern edge of the Alleghany plateau and the Ontario ice mass rested long on this low ground, pressing against the steep north-facing slope.

Lake Warren had successfully crept past the glacier front from the Pennsylvania border of the State and had captured all the drainage on the north of the divide, sending it to the Mississippi, till finally it reached the Onondaga valley. Then it overreached itself, or, as it were, fell into ambush and defeat, for, when the ice south and southeast of Syracuse backed away a little more from the high ground, the Warren waters fell over and were captured by Mohawk drainage. Lake Warren there and then found its extinction. The slow eastward discharge of the vast body of the Warren water produced the great rock channels across the high ridges, which lead into the Onondaga and Limestone valleys from the west and outward on the east. These waters also cut the channels and bluffs bordering the low plain all the way from Syracuse to Rome, as described in the paper, "Later and Lower Pre-Iroquois Channels," in the 21st annual report of the State geologist.

The systematic treatment of the whole complex problem of the glacial waters in western New York will be covered, in a series of final papers, as follows:

1 Glacial waters in the Erie basin
2 Glacial waters in the Genesee basin
3 Glacial waters in the Finger lakes region
4 Pre-Iroquois glacial waters of Mohawk drainage
5 Lake Iroquois, in New York

Paper 1 is partly written and the field work relating to it will probably be completed early in the coming autumn or spring, and the manuscript of the paper be ready for the printer in 1904.

Economic geology

In this branch, Museum bulletin 44, the report on the cement industries of the State by Dr Heinrich Ries has been completed and will soon be issued from the press. Museum bulletin 61 on bluestone quarries is also in the printer's hands. Local observations have been made on the various economic industries in different sections of the State by Professors Bishop, Sarle, Hopkins, Smyth and Logan, and their communications printed herewith form a report of progress for the fiscal year.

MINERALOGY

In the division of mineralogy work has progressed along the following lines:

Publication

During the year Mr Whitlock has completed Museum bulletin 58 entitled *Guide to the Mineralogic Collections,* illustrated with 249 text figures and 77 halftone reproductions from photographs of specimens in the mineralogic collection. It is believed that this work will prove useful to teachers and students of mineralogy throughout the State as well as to those who visit the museum with the intention of studying its collections. The division is, at present, engaged in preparing for publication a detailed list of the mineral localities of the State, compiled from all available records and supplemented by facts obtained from a reconnaissance of the principal localities.

Curatorial work

Following out the policy of installation of educational exhibits, an introductory collection has been prepared with a view of furnishing the visitor with the elementary knowledge necessary to a more perfect appreciation of the main collection. This introductory collection, which serves also to illustrate the introductory section of the guide mentioned above, contains specimens and models illustrative of the formation, crystallization and physical properties of minerals.

Advantage was taken of the recent popular interest in volcanism aroused by the eruption of Mt Pelee by preparing a small exhibit to illustrate the theory of volcanic action and volcanic distribution and products. This exhibit, which consists of a small relief model in clay, maps, photographs and specimens and descriptive text, is installed in the section devoted to geology on the second floor.

The collection illustrating the mineral resources of the State which was displayed at the Pan-American Exposition is now permanently installed on the second floor. A series of photomicrographic transparencies, showing the appearance of typical rocks in thin section under the petrographic microscope, has been prepared, colored from the original sections, and will be added to as occasion demands.

A set of lantern slides prepared from the photographs used in Bulletin 58, was exchanged with the department of mineralogy of Columbia University for mineral specimens valued at $40.

The relabeling of the main collection with a view of obtaining a uniformity of label is now in progress, the work on one half of the collection having been completed.

Field work

The collecting and reconnaissance work of the division for the past year has been pushed during the open season, and mineral material has been collected as follows:

1 **Tilly Foster mine, Putnam co.** Interesting crystals of chondrodite and magnetite, brucite, magnesite and a good series of serpentine and serpentine pseudomorphs.

2 **New Rochelle, Westchester co.** An interesting series of serpentine and associated minerals from Davenport's neck.

3 **Ellenville, Ulster co.** Specimens of galena, sphalerite and chalcopyrite illustrating the occurrence and association of the lead, zinc and copper ores of this locality.

4 **Ancram, Columbia co.** Small but exceedingly interesting crystals of albite, resembling in habit the occurrence of the same mineral at Williamstown Mass.

5 **Staten Island, Richmond co., and Hoboken N. J.** A large and complete series showing the derivation of the serpentine of this locality. Advantage was taken of an extensive excavation in the vicinity of Tompkinsville to obtain unaltered material of considerable interest in this connection.

6 **North Russell, St Lawrence co.** A contact zone between the gneiss and limestone which has been recently excavated for mica furnished some large crystals of phlogopite, some of which contained pyrite inclusions; also pyroxene in large and, in one or two cases, well modified crystals, apatite, molybdenite, titanite and an interesting occurrence of a feldspathic mineral resembling labradorite.

GLACIAL WATERS FROM ONEIDA TO LITTLE FALLS

BY
HERMAN L. FAIRCHILD

CONTENTS

FREDERICK J H MERRILL
DIRECTOR & STATE GEOLOGIST

UNIVERSITY OF THE STATE OF NEW YORK
NEW YORK STATE MUSEUM

PLATE 1
22d ANNUAL REPORT STATE GEOLOGIST
56th ANNUAL REPORT STATE MUSEUM

EXPLANATION

Lake Warren was the vast glacial water held by the wasting glacier over the southern Huron basin, the Erie basin, and the southern part of the Ontario basin, as shown in this map.

Its outlet was westward across Michigan to the glacial lake Chicago and to Mississippi drainage. It invaded New York from the west, extending as a narrow belt along the retreating front of the ice sheet, with southward prolongations up the north and south valleys. When the receding ice had uncovered ground in the Syracuse region lower than the westward outlet across Michigan the water flowed eastward to Mohawk drainage; and when the westward outlet was abandoned the water ceased to be Lake Warren. The eastward flow of the Hypo-Warren (or Hyper-Iroquois) waters cut the remarkable series of canyons and cataract basins in the Syracuse region which are simply indicated on this map. [See 20th annual report, p. 122, 123, 126-30 and pl. 15, 25-33]. Finally the waters were lowered to the Iroquois level, falling through a vertical distance of about 440 feet. The land has since been lifted nearly 300 feet higher than it was during the life of Lake Warren and the elevation of the Warren level in the Syracuse region is today about 880 to 890 feet above ocean. The ice margin is generalized in this map and is somewhat hypothetic. The incipient stage of Lake Iroquois is shown, but the entire lake is mapped in plate 19, 20th annual report of state geologist.

GLACIAL WATERS FROM ONEIDA TO LITTLE FALLS

INTRODUCTION

This writing is in continuation of the article published in the 20th annual report of the New York state geologist [20th report, 1900, p. 112-30], and describes the succession and the work of waters held by the glacier in the valleys of Oneida, Oriskany and Sauquoit creeks and the Mohawk river. The phenomena were earlier in time than those described in the 21st annual report [21st report, 1901, p. 33-47].

The district is entirely beyond the territory invaded by Lake Warren [*see* p. r10-13 and pl. 1], though the earlier phenomena were contemporaneous with the Warren waters in the western part of the State.

The later glacial waters in these valleys found ultimate escape down the Mohawk valley, but in their flow past the ice front they cut channels or benches across the ridges between the valleys. The territory including these features is all mapped in the Oneida, Oriskany, Utica and Little Falls sheets of the New York State topographic map and is partly shown in plate 2.

The earliest waters in the valleys which we are to discuss were forced by the glacier into southward overflow across the divide to Susquehanna drainage. These primitive glacial lakes will be described first.

GLACIAL LAKES

Cowaselon lake

This glacial lake preceded the creek of that name in the valley west of West Stockbridge hill, covering the site of Merrillsville under 400 feet of water. In its higher phase, it was a part of the lake next to be described, as its waters were confluent with those in the Oneida valley. Oneida creek heads west of the Cowaselon valley and curves around past the head of the latter, so that the col or divide at the head of Cowaselon valley does not lead to southern drainage but into Oneida drainage. The highest altitude of the Cowaselon water was therefore the same as the higher Oneida waters, about 1170 feet. With the earlier falling of the Oneida waters the Cowaselon lake might have had the altitude of its own col, 1120 feet. The valley is narrow with steep walls, and not favorable to the preservation of delta terraces; but such are seen between Hobokenville and Merrillsville. The channels cut across the north end of West Stockbridge hill by the Cowaselon waters escaping eastward were described and mapped in the former paper, in the 20th report.

Stockbridge lake

This lake occupied the upper Oneida valley, covering the sites of Stockbridge and Munnsville villages, which were under 500 feet of water. Judging from the map the outlet was near White's Corners, over a mile south of Pratt's Hollow, with a hight of about 1170 feet, and leading to the Chenango river. The later escape of the Oneida waters was across the north end of Eaton hill, the effects of which will be described later.

Oriskany lake

Passing east, the next lake occupied the upper valley of Oriskany creek as far north as Clinton. The outlet of this lake was at Bouckville to Chenango drainage, with a hight of about 1150 feet. The depth of water near Clinton was 550 feet. The later, eastward, overflow was across the ground east of Clinton, and this later stage of the waters may be called the Clinton lake. The succession of lake levels and the resulting phenomena will be given later in this writing.

Sauquoit lake

The valley of Sauquoit creek, which joins the Mohawk river west of Utica, was flooded with glacial waters its whole length except the 3 miles below New Hartford. The outlet of the primitive lake was at Richfield Junction, to the Unadilla-Susquehanna, with altitude of about 1270 feet.

The ancient valley is largely filled with gravelly moraine drift from Sauquoit village up past Richfield Junction, and for some unknown distance beyond toward Bridgewater. The waters flowing from the receding ice front filled the entire width of the valley with an overwash gravel plain which heads northeast of the Richfield Junction station and declines southward toward the Unadilla valley. This was the primitive outlet of the Sauquoit glacial lake. The present creek has cut deeply into the gravel plain, and further artificial excavation behind the station gives an unusually good section of kame or glacial gravels [*see* pl. 3]. This section, 90 feet high above the railroad, shows coarse gravels dipping steeply southward (dip of 24° or more), capped by nearly horizontal beds of variable material.[1]

The railroad levels make the altitude of the track at the station 1172 feet. The top of the cliff is about 90 feet above the railroad, but the plain is somewhat higher toward the northeast, and this southern outlet of the Sauquoit waters is taken as 1270 feet.

As the surface of the Sauquoit lake was more than 100 feet higher than that of the Oriskany lake on the west, the recession of the ice barrier on the crest of the separating ridge allowed the Sauquoit waters to escape westward into the Oriskany waters. The channels cut by this westward flow, which drained the Sauquoit waters away from the Richfield Junction outlet, lie across the top and northwest face of Crow hill, 3 miles southeast of Clinton [*see* pl. 2]. The highest of these cuttings shows as a steep bluff between the two north and south roads. Naturally the altitude is but little under that of the Richfield Junction outlet, or about 1260 to 1250 feet. The two other cuttings, which are on the northwest face of the hill, have altitudes of about 1200 and 1160 feet.

The recession of the ice front from Crow hill lowered the Sauquoit waters to the Oriskany level, and of course no lower channels are found here. But the wave cutting by the Oriskany waters may possibly be found at about 1150 to 1140 feet on the exposed northwest spur of the hill.

This second stage of the waters in the Sauquoit valley was consequently only an extension of the Oriskany lake, with outlet at Bouckville. Probably this phase did not last long, as the opening of still lower escape by channels southeast and south of Utica drained the waters down to a stage which we may call the Clinton lake.

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[1] The writer is indebted to Prof. A. P. Brigham for indicating the location and character of this outlet.

Herkimer and Utica lakes

This name is applied to such standing waters as the ice front held in the Mohawk valley above Little Falls [*see* pl. 2, 13]. They were never large and their extent is uncertain. The possibility of lake waters in the valley has been recognized by former writers,[1] but the relationships and sequences have not been discussed.

A rock barrier, which will be described later in this writing, existed at Little Falls when the glacier melted away from the region, and probably some ice drift was left over it. But no such lake ever existed in the valley above Little Falls as would be produced there today if the rock barrier could be restored, for the reason that the present graded valley, under the 500 foot contour, is partly the product of river action, chiefly by the Iromohawk (contraction for Iroquois-Mohawk) with some effect of the modern stream. In other words the capacity of the present valley is greater by whatever amount of drift the rivers have removed.

The 7 miles of valley from Little Falls to Herkimer must have been partially occupied by glacial drift, and such lake as rested here when the ice was first removed, the Herkimer lake, might have been at least partly filled by the detritus of West Canada creek. Brigham suggested that the water-laid drift on the south side of the valley at Herkimer might be the front of the eroded delta. Even today the river is crowded to the south side of the valley. At Frankfort and Ilion the deposits were possibly sufficient to block the valley, for to the detritus of the side streams was here added that of the floods of glacial rivers which terraced the hills southeast of Utica [*see* p. r27].

The initial lake waters at Little Falls were probably not less than 600 feet altitude, as that is the hight of the water-swept rock on the north side of the barrier. The same sloping rocks on the south side [*see* p. r31] are about 500 feet, which may be

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[1] Chamberlin, T. C. Terminal Moraine, etc. U. S. Geol. Sur. 3d An. Rept. p. 361–62.

Taylor, F. B. Letter in Am. Geol. May 1892. 9:344.

Brigham, A. P. Topography and Glacial Deposits of the Mohawk Valley. Geol. Soc. Am. Buf. 1898. 9:188–210.

regarded as the hight of the wasteweir during the principal stage of the waters previous to Iroquois time. On the 500 foot contour the valley averages over a mile wide, the widest section being some two and one half miles, at Utica; and it is 36 miles long from Little Falls up to Rome. Such is the basin of the hypothetic lake waters, which probably had existence at the ice front, expanding as the ice front slowly retreated up the valley (northwest) and they probably shallowed or were locally supplanted by alluvial filling successively in the same direction as far as Frankfort. The waters above Frankfort, called the Utica lake, seem to have remained open, with a series of marginal deltas, at 520 feet altitude. The deposits and the river history will be considered later [p. r35].

GLACIAL DRAINAGE FROM ONEIDA VALLEY TO ORISKANY VALLEY

High-level channels on Eaton hill [*see* pl. 2]

The primary glacial waters in the Oneida valley, Stockbridge lake, were drained down to a lower level when the ice sheet uncovered Eaton hill, 7 miles southeast of Oneida. The bold north front of this great hill is conspicuously terraced and channeled by the rivers which curved about it, held in place by the ice front. These channels are mapped in plate 2. The highest of these channels is over 1100 feet altitude, and the lowest is 800 feet. North of the lowest channel is a moraine which was protected from stream erosion by the high ground on the west.

The two highest channels on the brow of Eaton hill had cataracts on the east slope, and the cutting reaches down to 1000 feet. This indicates that the receiving water on the east, in the Sconondoa valley (which we may call the Vernon Center lake), was standing at about 1000 feet. This in turn indicates that the ice front on the east had receded farther north, being south of Lairdsville and permitting flow into the Oriskany waters at the Clinton stage. The rather indefinite scourway leading east to Hamilton College grounds seems to correlate with the higher Eaton hill channels.

The above conditions imply still further that the ice front near Utica had receded far enough to allow overflow of the Clinton waters through an 800 foot channel east of Clinton, and a 740 foot channel south of Forest Hill cemetery and Devereux hill, southwest of Utica.

The above correlations prove that the general trend of the receding front of the glacier over this broad region was north of east and south of west. Such oblique direction was a condition necessary to the eastward escape of the glacial waters in the Syracuse-Utica district. This has been discussed in the former writing [N. Y. State Geol. 21st An. Rep't, p. 35, 36].

No channels occur on the slope of Eaton hill or the meridian of Vernon below the 800 foot channel. The ground is largely morainal, of the subdued type laid under water. Two miles northwest of Vernon occurs, however, a moraine tract of sharp relief. The absence of channels below 800 feet suggests that the Vernon Center waters must have preserved a level not much under that hight all the time that the ice was clearing away from the tract of ground in the neighborhood of Vernon.

Channels west and northwest of Clinton [*see* pl. 2]

The highest of these channels is a cutting across the back of Prospect hill, 4 miles southwest of Clinton. It lies across the north and south road, south of four corners [*see* pl. 2], with altitude according to the map contours of 1280 feet. As this is more than 100 feet higher than the southern outlet of Stockbridge lake, it is evident that it carried only the local waters held in the heads of valleys immediately west of the scourway.

The next pronounced channel is a small but sharp cut 1½ miles farther north, crossing the same highway at three corners just south of the town line, and continued east as a steep bank at nearly the same level across the north face of the hill. The contour hight is 1160 feet, which makes it competent to carry the Stockbridge waters, even if we make no allowance for northward differential uplift since the Glacial period. From here northward and northeastward are several channels or benches cut in the north-facing slope, as shown in plate 2. One of the higher scourways, and the one extending farthest down the slope into the Oriskany valley, leads southeast to the Hamilton College grounds. It forms the smooth slope behind the college hill, and terminates as two ravines, largely of recent cutting, north and south of the college grounds.

The lowest channels which lead across from the Oneida valley to the Oriskany valley are three or four ill defined scourways crossing the north and south road 2 miles northeast of Vernon, and parallel to the West Shore Railroad. They are spread over a breadth of more than a mile, and all lead into Deans creek. Their altitude, by the contours, is 660 to 640 feet. The weakness of the scourways is probably due not to deficiency of water, but to lack of eroding power, the streams being already graded to their base level in the Oriskany valley.

As the ice front receded still farther toward Rome, there was chance for yet lower escape of the Oneida valley waters, but the ground between Hecla Works and Stanwix has not been examined.

All the north-facing slope from Prospect hill to Lairdsville has been quite denuded of its drift by the stream action, and the cut banks and channels are mostly in rock. This is characteristic of all such slopes which have been subjected to stream erosion at the lower ice front. Examples are found all the way from Westfield in the Erie basin to east of Utica.

Low-level channels from Oneida to Rome

The latest and lowest channels cut by the east flowing glacial waters before Lake Iroquois was established are found on the line between Oneida and Rome. These latest pre-Iroquois channels are described in the last (21st) report.

GLACIAL DRAINAGE FROM ORISKANY VALLEY TO MOHAWK VALLEY

Channels east of Clinton [*see* pl. 2]

The channels on Crow hill have already been described on page r21. The only channel observed by the writer north of Crow hill is a broad scourway which heads less than 2 miles northeast of Clinton, at about 780 feet altitude according to the map contours [*see* pl. 2]. This channel leads northeast and then east, and passes to the south of New Hartford. It is a good example of the type of shallow channel or scourway made by water which had little fall to reach its receiving body or base level.

Careful examination of the area between Clinton and the Sauquoit may find other evidences of eastward stream flow.[1]

Channels south of Utica [*see* pl. 2]

The highest cutting observed lies above the 1000 foot contour, on the northwest-facing slope, over 1 mile south of the three reservoirs. Like nearly all the stream channelings on steep hillsides, it shows as a notch or terrace in the slope, with a steep, concave bank, the northern river bank having been the ice front. Another cutting occurs ½ mile to the north, between the 800 foot and 900 foot contours.

A capacious and typical channel lies south of Devereux hill, 1 mile south of Utica city line. It begins as a cut bank on the west-facing slope nearly a mile south of Forest Hill cemetery. Swinging around between the hills, it forms eastward a decided channel 40 to 60 rods wide at bottom and a mile long. Its eastward termination is a cut bluff south of the three reservoirs. The altitude of this channel is about 800 feet at the head and 700 feet at the east end. This channel carried the overflow of the later Sauquoit waters at the time when the broad, shallow channel east of Clinton was pouring a slow flood into the Sauquoit waters from the Oriskany lake at the Clinton stage.

Northwest of the head of the channel described above are two cuttings, one at about 640 feet lying on the road leading to Forest Hill cemetery, the other at about 600 feet following along the highway between New Hartford and Utica. These two banks curve around the slope and unite to make the elegant, smooth, concave bank of river erosion which forms the north base of Devereux hill, in the south edge of Utica, with hight about 600 feet.

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[1] Since the above was written, Prof. Charles H. Smyth of Clinton has noted several lower scourways on the east wall of the valley near Clinton. These are not mapped on plate 2.

Channels southeast of Utica [*see* pl. 2]

The steep north-facing slope of Frankfort hill, southeast of Utica, is one of the best examples of glacial stream work in central New York. The steepest part of the hill rises 700 feet in 1 mile (from 540 to 1200 feet, by the map). The whole north face, some 3 miles in breadth, is denuded of drift and the rock is carved into channels and very conspicuous bluffs, some of which are shown in plates 4-7.

The highest conspicuous evidence of stream cutting occurs near the 1200 foot contour on the spurs north of the Merry triangulation station [*see* pl. 2]. Some cutting in continuation of the same flow can probably be found southeastward, or south of Center. Conspicuous cut banks have been seen on the saliences at about the 1000 foot and 900 foot contours south of Center, toward the Moyer creek gulf.

On the north face of the Frankfort hill, below the 1200 foot channel, are not less than six strong cuts, appearing mainly as steep, concave bluffs, which give the hill from a distance a terraced profile [*see* pl. 7]. The most conspicuous bluff is at 900 to 1000 feet [*see* pl. 4]. A channel with its north bank in rock lies at 730 feet, the head of the cut being a bluff on the west face of a hill by Starch Factory creek. The two lower scourways lie either side of the east and west road, between Starch Factory and Ferguson creeks, and become one at the junction of the north-leading road. Plate 7 is a reproduction of a photograph taken ¼ mile east of the three corners and behind Mrs Lipa's house, looking toward the great hill slope. The bluff at the top is the 1000 foot cutting. The broad channel and high bluff in the middle of the view is the union of the two strong and far separated channels at the west, by the county line, illustrated in plates 5, 6. At the west end of the hill face, on the highway and county line, are seven bluffs or channels which are united eastward into the three stream cuttings, two shown in the view, plate 7, and the third lying northward below the east and west highway. Two higher cuttings, at 1080 feet and toward 1200 feet, do not appear in the view. The channels are all in Utica shale, Oneida-Medina rocks appearing toward the top of the hill.

East of Frankfort hill, and 5 miles southeast of Utica, is Dutch hill, forming the abrupt south wall of the Mohawk valley, with the river at its base. The steep north face of this hill is terraced by stream flow held up by the ice front. Plates 8-12, are views of the face of this hill. No glacial drift remains on the slopes, which are Utica shale. Plate 9 shows the face of the hill as seen from the electric railway (Utica & Mohawk Valley Railroad), near "stop 4." The highest stream cutting is not visible in this view from the foot of the steep slope, but is shown on plate 8. It is a bold, cut bank, some 30 to 40 feet high, facing a gently sloping terrace some 40 rods wide. The altitude of the angle or notch of the cutting is nearly 1000 feet. About 150 feet below the highest cut is an indefinite bank, indicated in plates 9, 10, by the banks of snow near the sky line. The lower and stronger bluffs are shown in these plates, the higher being at about 700 feet and the lower about 540 feet.

East of "stop 4" is a landslip on the face of the lowest bluff, that occurred in the spring of 1903, a few weeks before the photographs reproduced as plates 9, 11 were taken. This is significant in this connection, as showing the character of the hill slope and the entire absence of drift. The slide was produced by a veneer of the rotted shale slipping on its bed. Near the top of the steep slope is a hummocky belt, below the banks of snow shown in plates 9, 10, which is the product of old landslips.

The northeast face of Dutch hill is cleft by a deep notch or ravine. The eastern portion of the steep face of the hill shows from the base only two conspicuous bluffs, the two lower ones of the west end of the hill being eastward united into one. The union of channels toward the east is similar to that on the Frankfort hill.

The reader who is able to visit the locality (even a ride on the New York Central or the West Shore Railroads is sufficient) should observe the difference between the profiles of

Dutch hill and the steep hill across the river from Frankfort. The map contours represent the latter slope quite correctly, as a steep and fairly uniform slope. It was not cut and terraced by glacial stream flow like Frankfort and Dutch hills, though it may have been swept by water flow on the north side of the valley ice lobe.

There is a peculiar and interesting complication in the drainage about Dutch hill. It will be seen by the map contours [pl. 2] that the hill is somewhat isolated, being an outlier from the highland on the south. According to the contours the valley behind the hill has a hight at the col, east of Center, of 840 feet. It would be expected that all flow of high water past the ice front would take advantage of this pass, down to the level of the col, 840 feet. There are conspicuous evidences of water cutting on the valley side south of Center at about 1000 feet and at about 900 feet. But there is no sufficient evidence of any water flow across the col. It is positive that no considerable stream ever passed there. Yet there are unmistakable proofs of strong river work from 1000 feet downward on the north side of Dutch hill. What prevented the water from passing through the valley behind Dutch hill? The only explanation is that a block of ice, detached from the glacier front, rested for a long time in the valley, over the site of Center, and obstructed the drainage through the valley till the waters had fallen below 840 feet. Another confirmation of this theory is found in two small stream cuttings on the south side of the top of Dutch hill, along the north side of the east and west highway [*see* pl. 2]. These required a barrier on the south side of the hill. They represent the first cutting by glacial waters on Dutch hill, all the later flow passing on the north side.

It is probable that evidences of water cutting may be found further down the Mohawk valley on the valley slopes. They may be looked for specially west and south of Frankfort. Stream-cut cliffs on the high valley slope 4 miles southwest of Little Falls are plainly visible from the New York Central railroad. Also the peculiar phenomena found behind Dutch hill, where stream flow occurred either side of an ice block, which filled and protected the valley bottom, are to be expected in the Mohawk valley; along with the consequent ponding of the waters in side valleys and delta fillings. However, the writer's task of tracing the high glacial waters of western-central New York, in their flow past the receding ice front, around into the Mohawk valley with free course to the sea, is here completed.

It may be noted that the eastward flow of the waters proves that there was at this time no ice blockade in the lower Mohawk region.

MOHAWK VALLEY FEATURES

Barrier at Little Falls

Structure

The critical element in the drainage phenomena of the upper Mohawk valley is the rock barrier at Little Falls. Even the casual observer on the railroads must have noticed the narrow rocky gorge and the palisade character of the lower walls. The latter feature is partly artificial in places, as the lower, narrow gorge has been much cut to give room for the Erie canal and three railroads. The locality is interesting in itself, apart from its relation to the glacial waters, and it merits description.

The existence of this rock barrier at Little Falls is due to a great fault, the most westerly of a series of ancient faults which lie athwart the lower Mohawk valley from Little Falls eastward to Rotterdam,[1] and which produce the narrow places in the valley and the bold east-facing cliffs at several localities. Like the other faults, this one has the upthrow side on the west, thus forming a great scarp or steep slope of hard rocks facing east. The upthrow carried high into the air the strata of the region (Utica shale, Trenton limestone, and Calciferous sandrock) and even brought well up to view the Archean crystallines (augite syenite of the state map). Erosion has removed all the clastic rocks and has left the crystallines exposed at the valley bottom for a width of over half a mile.

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[1] *See* description by N. H. Darton in 14th An. Rep't N. Y. State Geol. 1894. p. 35. These faults are plainly indicated on the Geologic Map of New York by F. J. H. Merrill, state geologist, 1901.

This rock forms the foundation for the city of Little Falls, and the high terraces of bare rock [pl. 14-17] which extend east of the city for more than a mile to the fault cliff. These upper terraces have been produced by the cutting away of the Calciferous down to the basal crystalline; while the lower terraces [*see* pl. 18-25] have been made by the trenching of the crystalline rock by the Iromohawk (Iroquois-Mohawk) and the Mohawk rivers.

The upper terraces, representing the top of the crystallines, dip rather steeply to the southwest, like all the strata at that point, and in consequence the rock terrace on the north side of the river is about 100 feet higher than on the south side. For the same reason, the top of the crystallines is higher at the crest of the fault scarp than westward at the city, and west of the city it disappears under the Calciferous. The lower benches, which are product of river erosion, slope east or down stream. These relations of the rocks are shown in the plates.

The rear boundary of the north terrace, or the base of the Calciferous, is practically the 600 foot contour [*see* pl. 13]. On the south side the corresponding terrace is about the 500 foot contour. A road follows along the back of each terrace. So much for the structure and present form. Let us now translate the history.

History

It was suggested by Chamberlin that before the Glacial period there existed here at Little Falls a divide between Hudson and St Lawrence waters. Brigham has shown that probably the rock bottom of the valley, beneath the filling of drift and alluvium, slopes northwestward (up the present valley) to Rome. We may reasonably assume that the hard rocks at Little Falls formed an ancient col in the preglacial valley, and that the waters flowed away from this point in opposite directions. The form or hight of this col we do not know; but we may be sure that it was unlike its present form. It is possible that some Calciferous was in place on the Archean crystallines, and possibly the latter were not exposed at all. It is also probable that the glacier left some drift in this section of the valley. The form and dimensions of the valley, with its position and relations to the high ground and the ice body, do not favor the idea of very great erosion by the ice, though some ice abrasion seems quite probable. The surface form of the crystallines on the north side of the channel may possibly be due to ice abrasion, but no positive evidence was found by the writer. The present form of the rock channel at Little Falls is chiefly, if not entirely, the product of river erosion.

Stream erosion

The investigation of one other locality will determine the limit of hight for the Little Falls col as it was left by the glacier.

About 4 miles south of Little Falls is a low pass through the hills, leading to Newville village and the Nowadaga creek and to the Mohawk valley at Indian Castle. The writer has not been on this col, but the gap can be seen from the New York Central Railroad and from the electric road; and the fact that the pass carried glacial waters is proved by the conspicuous lines of stream cutting plainly to be seen on the slopes south of Jacksonburg and 4 miles southwest of Little Falls. This makes it certain that the Glaciomohawk waters found the col at Little Falls, as left by the ice, lower than the col among the hills on the south even after the stream-cutting of the latter; otherwise the waters could not have deserted the southern for the northern outlet. The Jacksonburg drainage cuts were made by the high-level waters escaping past the ice lobe resting in the valley. When the Mohawk valley was deserted by the ice, the Little Falls pass took the drainage. The present altitude of the southern pass, which is given by the map as 740 to 760 feet, makes the limit for the possible thickness of drift left on the 600 foot rock terrace at Little Falls as about 150 feet.

The Archaean rock has no drift on it now, and is apparently all water-swept [*see* pl. 15-19]. As the surface declines southward about 100 feet in the width of the channel, it seems evident that some kind of filling on the col was necessary to hold the stream to its work against the north side. It would appear that the postglacial stream began its work by cutting across the col on the north side; that the resistance of the crystalline rock prevented rapid down cutting, and, as the stream was forced to cut laterally it migrated southward, denuding the crystalline rock of its cover, either of rock or drift. The later erosion was concentrated on the south side, and the crystallines were finally trenched as we find them now. The earlier flow must have had a great cascade over the fault cliff, and the map contours in plate 13 show the wider valley below, headed by an amphitheater, but the cliff has been worn to a slope as shown in plate 24.

Altitudes

For correlation with the lake and stream phenomena up the valley, it is necessary to determine altitudes of the phases in the down cutting of the rock barrier. The base of the Calciferous on the north side, along Loomis street (the Dolgeville road), the highest visible cutting, is 600 feet. The Archaean is eroded into irregular benches, and near the city the lower strong terrace, carrying Burwell street, is about 500 feet. Eastern park, in the city on the south side of Burwell street, and "Lovers Leap" on the south side of the gorge, are about 480 feet. The main part of the city is on the lower terraces, from 500 down to 400 feet. Moss island is shown by the contours as 400 feet. The New York Central station is 376 feet. The river at the head of the rapids is 360 feet, and at the foot of the rapids 320 feet. The principal overflow on the rock barrier was at 500 to 400 feet. The more recent trenching is from about 400 feet downward.

The amount of down cutting by the present river is relatively small. In the western part of the city the broad plains, occupied by buildings and the railroads, and undoubtedly the work of its great predecessor, the Iromohawk, are only 15 or 20 feet over the present waters. At the dams the water is not many feet below the ancient rock platforms. The conclusion is that the Mohawk has made only a narrow and shallow cut in the older and broader channel, notwithstanding the fact, as pointed out by Dr Gilbert, that it is a loaded stream, provided with cutting tools.

Valley and river gradients

The present grade of the Mohawk flood plain is from 360 feet at Little Falls to 420 feet at Rome. This is 60 feet in 36 miles, or 1 foot and 8 inches slope a mile. The outlet or wasteweir of Lake Iroquois at Rome has been somewhat obscured by alluvial deposit of the present Mohawk. The amount of filling is not determined but is thought to be of small depth. The present altitude of the col south of Rome is about 430 feet. If we allow 20 feet depth of water over the present broad plain at Rome, we have an altitude of the Iroquois waters at the outlet of 450 feet, at the closing phase. The present Mohawk river has not greatly changed the rock channel at Little Falls from the condition in which the Iromohawk left it, and if we take the water surface of the latter as about 390 feet, or 30 feet over the present Mohawk flood plain, we have a gradient of the Iromohawk the same as given above for the present river.

It is quite certain that postglacial deformation of the area has not depressed the Rome region relatively to Little Falls, as such movement would be in opposition to all the changes of level over the Great lakes and New York State. It may be assumed that the Iromohawk, a volume of water like the St Lawrence, did not have any steeper gradient than the present valley would allow. Indeed such gradient far exceeds that of the great rivers in their graded sections. It is more likely that the Iromohawk slope was less than the above estimate and that the river was broad and shallow at the head and narrow and deep at Little Falls. However, there are reasons connected with the lacustrine levels, as will appear later, and with the Iroquois levels in central New York, which make it probable that the Rome locality has not been much, if at all, lifted relative to Little Falls. Our working theory is that the present Mohawk valley shows a gradation plain of the greater river, which in form and altitude is practically as that greater river left it. The early Iromohawk had a higher head, by whatever amount the Rome outlet has been cut down, but on the other hand it had a higher base-level, by whatever amount the rock barrier at Little Falls has been trenched.

Deposits in the valley. Lake plains

The valley deposits are somewhat complicated and can not be completely differentiated without detailed study. The ice sheet undoubtedly left considerable drift in the valley bottom and along the sides, both till and kame. The drainage from a stretch of the glacier front was concentrated in the valley to make kames, moraine terraces and glacial deltas. The streams from the side valleys spread their detritus on or alongside the ice lobe or built deltas in the open lakes in front of the ice. When the ice lobe had receded to near Utica, the waters were greatly augmented by the inflow of the floods past the ice front which cut the many channels described earlier in this paper. But the volume of drift was correspondingly increased and it seems likely that a lower section of the valley may have been entirely filled with detritus to the level of the Little Falls barrier.

In 1892 Taylor referred to the broad detrital plains at the mouths of the larger creeks as deltas, indicating standing water in the valley. Brigham described the deposits briefly in 1898 [see reference p. 22]. The writer's judgment, based on considerable study, is as follows regarding a few localities. The irregular gravel plains stretching 3 miles east of Herkimer and some distance west are the eroded delta of West Canada creek, the largest tributary of the Mohawk in the section under discussion. The area southeast of Ilion, showing the crinkled contours, is not a kame area but eroded silts. The surface has free drainage and no kettles [*see* pl. 26]. It might be a slack water deposit accumulated in an embayment behind the Herkimer delta; but its altitude is high. The suggestion is offered here that possibly some deposits like this may represent lacustrine beds of interglacial epochs, or deposits made in lakes of ice advance.[1] Any deposit in water impounded by the first oncoming of the ice sheet, and derived from the land wash, should consist of fully oxidized material of atmospheric decay, and with no material from the northward (unless some rare ice-rafted inclusions). To diagnose such deposits will require care-

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[1] Geol. Soc. Am. Bul. 1899. 7:430, 10:30.

ful physical and chemical examination, but they will sometime be found.

The broad gravel plains west and south of Frankfort are a delta plain derived from Moyer creek gulf and the glacial stream cuttings on Dutch and Frankfort hills. The plains seem more level than shown by the map contours. Plate 12 shows only the north end of the plain northwest of Frankfort, looking toward the east end of Dutch hill.

The area west of Utica in the Sauquoit valley is probably in part delta material of Sauquoit creek.

Southeast of Oriskany, extending to near Whitesboro, is a broad tract of gravel which in relation to the creek should be delta, but the western end, near the creek, has a high relief with knolls rising to 600 feet, according to the contouring. The portion lying along the river valley, about 1½ miles long and ½ mile wide, is leveled at 540 feet. The present suggestion is that it is partly delta and partly a kame area leveled by lake or river action. Southwest of Oriskany village is another gravel plain at 540 feet, according to the map. [See Oriskany sheet]

Opposite Oriskany, on the north side of the valley, is another level gravel plain, 2 miles in length, with altitude 520 feet by the map. Other areas appear along the north side of the valley, toward Rome. The largest one is a delta plain along the west side of Ninemile creek, with altitude somewhat over 520 feet. The elevated tracts from 2 to 5 miles east of Rome, which on the map appear similar to the gravel plains, are morainal tracts, chiefly kame gravels.

As named earlier in this paper, the standing water in which these plains were built is the Utica lake, the level of which was determined by the rock barrier at Little Falls; or possibly for a time by a delta barrier built in the valley between Frankfort and Herkimer.

It is assumed that these plains of nearly uniform altitude (at least within 20 feet) represent constructional lacustrine levels. It seems quite impossible that the accordance could be produced by accident to or deformation of originally discordant levels.

Drainage history

The continental glacier did not uncover this upper Mohawk valley all at once, but the ice front slowly receded up the valley. In other words, the valley was slowly opened from Little Falls successively westward. The primitive waters, held between the barrier at Little Falls on the east and the retreating ice lobe on the west, lengthened out after the ice. At the same time the open part of the valley was filling with stream detritus and the outlet was being lowered by the down cutting of the rock barrier. In addition to the broader delta plains described above, the evidences of standing water in the valley up to 500 feet and over are abundant to the eye of the trained observer in the almost continuous terraces and benches of wave-washed accumulation along the sides of the valley which are now gullied by the modern stream drainage.

The earliest lake level was probably about 600 feet, the altitude of the bare crystalline rock on the north side of the Little Falls channel. But this higher level would hold only for the lower section of the valley. Up the valley, toward Utica and Rome, the highest level of standing water would be less than 600 feet, by whatever amount the Little Falls outlet had been lowered by down cutting while the valley was opening by ice recession.

In the narrow Herkimer-Frankfort section of the valley the open waters may have been only temporary, as the detrital inwash from side streams and the ice drainage possibly kept this part of the valley filled with gravels, specially at the lower water levels. Above Frankfort the valley was wider and probably deeper and held lake waters up to Iroquois time. In the section from Utica to Oriskany the lake plains are about 540 feet in altitude. Further up the valley, at Ninemile creek, they are somewhat less, being given only the 520 contour on the Oriskany sheet. And, when the ice sheet had withdrawn from the ground south of Rome, the Utica lake had still lower level; for the latest pre-Iroquois cuttings at Stanwix are 460 feet and lower [*see* 21st annual report, pl. 10]. Soon after the Stanwix stream-cut banks were made, the flood of the Iroquois overflow took possession of the pass at Rome, and the vast Iromohawk river proceeded to grade the valley.

The later level of the Iromohawk planing is represented by numerous remnants of its flood plains. So far as observed, these are about 20 feet over the present Mohawk flood plain. A good fragment of the Iromohawk plain may be seen on the west side of Ninemile creek, 2 miles north of Oriskany village; also along the north side of the valley between Frankfort and Utica. Doubtless these remnants of the Iromohawk plain may be identified in numerous localities. The difference in altitude between the Iromohawk and the Mohawk plains, only about 20 feet, agrees well with the apparent amount of down cutting by the present river at the head of the rapids in Little Falls [*see* p. r33].

Summary. There are three stages which we can clearly recognize in the history of the valley drainage since the valley was buried under the ice sheet.

1 The Pre-Iroquois or Glaciomohawk waters. These were held in the valley during the ice retreat. They would have been lacustrine except for the detrital filling, but were probably fluviatile in the section below Utica.

2 The Iromohawk river. This great river, draining Lake Iroquois and the area of the Great lakes, was the predecessor of the St Lawrence and was the equal of that river in size and possibly in length of life. For some thousands of years it swept the valley, trenching the rock barrier at Little Falls and grading its channel to that falling base level. The grade of the river has been discussed [p. r34].

3 The Mohawk river, the present shrunken successor of the Iroquois flood.

It would be interesting if we could apportion with some certainty the work of the three stages. It seems likely that the work of the last stage, the present river, has been comparatively small. The diminished river has cut only about 20 feet into the channel which it found, and is meandering in a discouraged and listless way over the broad plain of its gigantic ancestor. It is unable to lower greatly for itself the rock barrier. But between the effects of the first two stages the decision is not so clear. The Glaciomohawk waters were large in volume and long in life, with great erosive power. Perhaps they not only denuded the Archean rocks at Little Falls, but cut these down to the terraces under 500 feet. Then the Iromohawk used the remaining drift in the valley as an abrasive to rasp down the rock barrier to near its present condition; cutting away the valley deposits of the earlier stage and grading its channel to the falling outlet.

The above writing assumes a fair permanence of relative levels throughout the whole area under discussion, or that the whole upper Mohawk valley has been equally lifted by the Postglacial continental uplift with no evident deformation.

THEORETIC LEVELS IN THE ORISKANY AND SAUQUOIT VALLEYS

In this chapter it is proposed to indicate in a broad way the stream and lake phenomena which should, according to our theory, be found in the connected valleys. This will enable the student of the subject to follow out the matter with more detail and system, and to verify the theoretic history.

1 **Mohawk gradation plains.** The writer supposes that both the Oriskany and Sauquoit creeks are now graded to the Mohawk river as their base level. The Sauquoit, being the smaller stream, should have the steeper gradient. Artificial damming of the streams has interfered with the uniform current and grade, but the natural flood plains can generally be determined.

2 **Old plains correlating with Iromohawk as base level.** By taking the present flood plain of either stream as a datum plane, the ancient flood plain which the stream formerly built when it was adjusted to the Iromohawk river as its base level, may be found some 20 feet higher. Such plains of the older stage in the stream history may be recognized in the level stretches of alluvium, decidedly above the possible reach of the present stream.

It must be recognized that the actual hight of these parallel planes will rise as we proceed up the stream valley.

3 **Delta plains of the Utica lake.** Through the area of lower ground, north and northeast of Clinton and north of New Hartford, will be found level stretches of gravel or sand at altitudes of 520 to perhaps 550 feet. These represent the stream accumulations in the waters of the " Utica lake." They will have some

variation in level, because the Utica lake was not a permanent level, but had a falling surface, and because stream deltas are themselves of variable altitude.

4 **Delta plains of the Clinton waters.** These levels will range from about 600 feet up to perhaps 1100 feet. The most conspicuous will be at about 600 up to 800 feet, and correlate with the lowest of the glacial stream channels that drained the Clinton waters eastward. On plate 2 these channels are shown. The lowest cutting forms the concave slope heading near New Hartford and passing around the north base of Devereux hill, through the south edge of the city of Utica, with altitude of about 600 feet. The next higher level is about 700 feet, the channel being an earlier cutting on the same slope as the one just mentioned. The strongest level will be at 750 to 800 feet, produced by waters held for a long time at about 740 feet altitude, while the escape was through the strong channel south of Devereux hill and the Forest Hill cemetery, called here the "Reservoirs channel." For the Clinton valley the level at this stage was determined by the outlet having nearly the same altitude and heading about 2 miles northeast of the town. This level in particular will be found in many places, but running to higher than 800 feet in the smaller stream valleys. The level constitutes a conspicuous plain and terrace in the Sauquoit valley above and below Chadwicks.

5 **Delta plains of the summit levels.** The highest water level to be found in the upper or southern section of the Oriskany valley must be at about 1150 feet, correlating with the southern outlet near Bouckville. In the Sauquoit valley the corresponding level will occur, but a higher, summit level there will be about 1270 feet, correlating with overflow at Richfield Junction.

There are reasons why the phenomena of the water planes are weaker at the higher levels. The lakes were less stable, new outlets opening on the steep slopes; the valley walls are steeper, giving less foothold for the delta accumulations; and the amount of available detritus in the grasp of the lateral streams was less.

In all these several stages of lacustrine levels considerable variation in the hight of the deposits must be expected; due

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PLATE 2
22d ANNUAL REPORT STATE GEOLOGIST
56th ANNUAL REPORT STATE MUSEUM


MAP OF DISTRICT
BETWEEN
ONEIDA AND LITTLE FALLS
SHOWING THE
EASTWARD GLACIAL DRAINAGE.
H.L.FAIRCHILD
1903.

H. L. Fairchild, photo.

SECTION OF GRAVEL DEPOSIT, RICHFIELD JUNCTION

The top of the cliff, 90 feet above the railroad, is the head of the outlet of the Sauquoit glacial lake

H. L. Fairchild, photo.

STREAM-CUT BANK

North slope of Frankfort hill, southeast of Utica. Looking east, 1000 foot elevation [compare pl. 5–7]

H. L. Fairchild, photo.

STREAM-CUT BANK

North slope of Frankfort hill, southeast of Utica. Looking south of east, 800 foot elevation [compare pl. 4]

(The cutting in the foreground is recent)

Plate 6

H. L. Fairchild, photo.

STREAM-CUT BANK

North slope of Frankfort hill, southeast of Utica. Looking south of west, 600 foot elevation [compare pl. 7]

H. L. Fairchild, photo.

STREAM-CUT SLOPE

Northeast face of Frankfort hill, southeast of Utica. Looking southeast [compare pl. 4-6]

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New York State Museum

Plate 8
22d Report of State Geologist
56th Report of State Museum

H. L. Fairchild, photo.

STREAM-CUT BANK

North face of Dutch hill, 6 miles southeast of Utica; near the summit, 1000 foot elevation. Looking west

H. L. Fairchild, photo.

STREAM-CUT SLOPE

North face of Dutch hill, 6 miles southeast of Utica. Looking east of south, from electric railroad. Landslip on lower slope [compare pl. 10–11]

Plate 10

H. L. Fairchild, photo.

STREAM-CUT SLOPE

North face of Dutch hill, 6 miles southeast of Utica. Looking southwest. Landslip on steep slope [compare pl. 9, 11]

H. L. Fairchild, photo.

MOHAWK VALLEY

Looking northeast from slope of Dutch hill, at top of landslip shown in plates 9, 10

Plate 12

H. L. Fairchild, photo.

FRANKFORT DELTA

Looking northwest across a portion of the delta west of Frankfort; showing profile of northeast (stream-eroded) slope of Dutch hill

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PLATE 13
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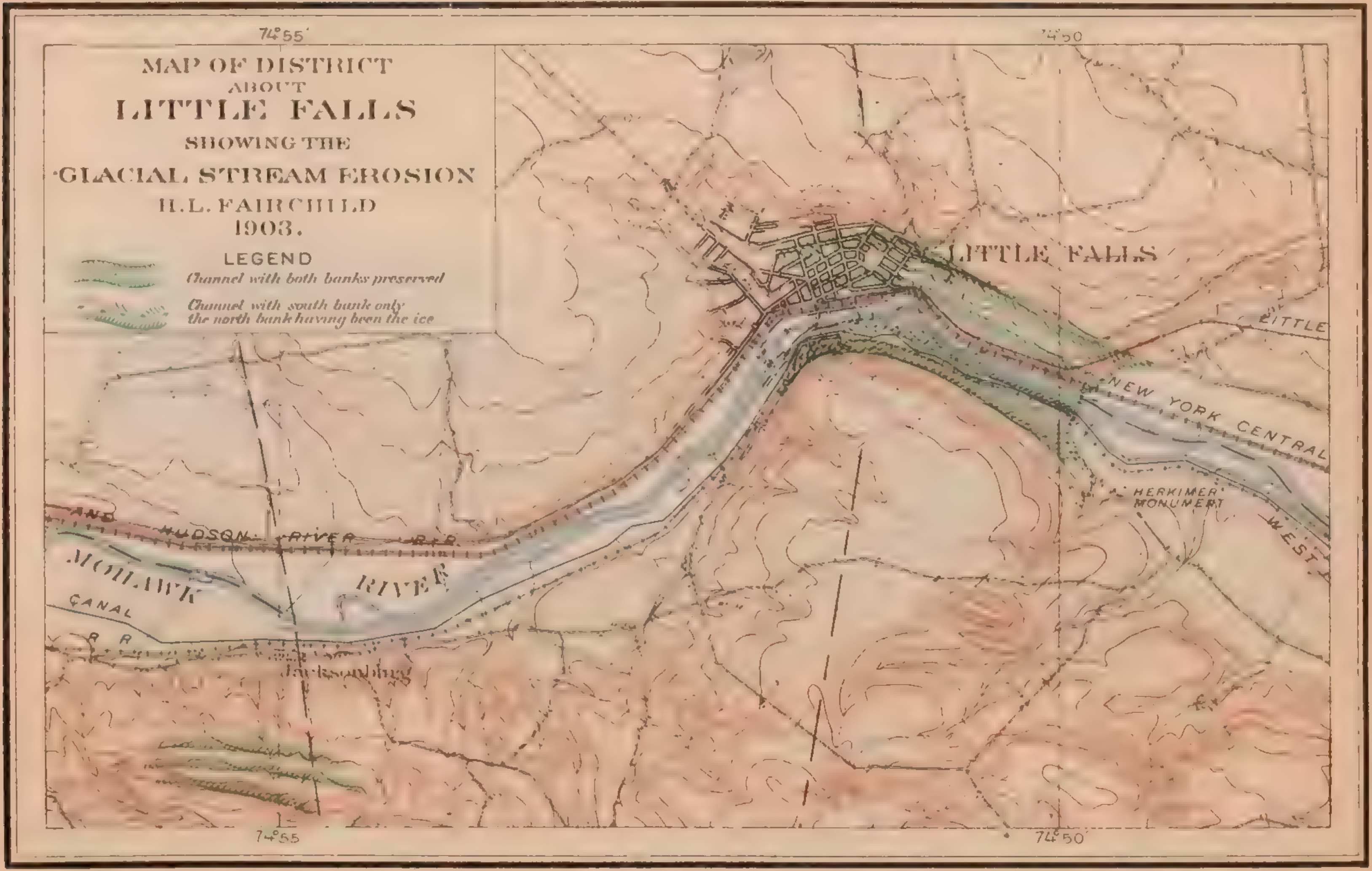


Scale $\frac{1}{62500}$

Contour interval 20 feet

Plate 14

H. L. Fairchild, photo.

ROCK CHANNEL AT LITTLE FALLS

One half mile east of city. Looking northeast from the 500 foot terrace on south side of channel toward the 600 foot terrace of crystalline rock, on the north side. Mohawk river shows in foreground at right. Nearly the reverse of view in plate 17

H. L. Fairchild, photo.

ROCK CHANNEL AT LITTLE FALLS

One half mile east of the city. Looking south, toward mouth of channel, from same position as plate 16. Terrace on south side is shown in the background.

H. L. Fairchild, photo.

ROCK CHANNEL AT LITTLE FALLS

One half mile east of the city. Looking west (upstream) over the river-swept crystalline rocks, from 600 foot terrace on north side of channel. Terrace on south side shown at left [compare pl. 14]

H. L. Fairchild, photo.

ROCK CHANNEL AT LITTLE FALLS

Looking south of west from position nearer the city than in plate 16 [compare pl. 19]

Plate 18

H. L. Fairchild, photo.

ROCK CHANNEL AT LITTLE FALLS

Looking south of west from the lower terrace, at east edge of city (Burwell street) [compare pl. 17]

H. L. Fairchild, photo.

ROCK CHANNEL AT LITTLE FALLS

Looking south of west, from east edge of the city across the lower benches of the greater channel [compare pl. 15–18]

Plate 20

Abbott & Hall, photo.

ROCK CHANNEL AT LITTLE FALLS

Looking west (upstream) toward the head of the rock gorge [compare pl. 23]

Plate 21

Abbott & Hall, photo.

ROCK CHANNEL AT LITTLE FALLS

Eastern edge of city; looking southeast across Moss island, from New York Central Railroad [compare pl. 22]

Abbott & Hall, photo.

ROCK CHANNEL AT LITTLE FALLS

Eastern edge of city. Looking east (down stream) in the later channel. Upper terrace, top of the crystalline rock, **seen at right [compare pl. 21]**

H. L. Fairchild, photo.

ROCK CHANNEL AT LITTLE FALLS

Mouth of gorge; looking northwest. Erie canal at left; Mohawk river at right [compare pl. 20]

H. L. Fairchild, photo.

ROCK CHANNEL AT LITTLE FALLS

Mouth of gorge. Looking s. 20° w. at end of crystalline rock on south side, eroded to a slope. Mohawk river in the foreground [compare pl. 23]

H. L. Fairchild, photo.

ROCK CHANNEL AT LITTLE FALLS
Waterworn cliff, north side of gorge

H. L. Fairchild, photo.

ERODED DELTA
East of Ilion. Looking west

to variation in volume or velocity of the contributing stream; to differences in the amount and coarseness of the detritus; and to varying distance from the lake (or base-level) of the point where the detrital burden was dropped. But, after all the factors producing variations are considered, the student will yet be surprised to find how readily and with what assurance many phenomena can be quite positively correlated.

Beach or wave-produced features should not be expected in these waters, as the latter were too narrow and insufficiently stable.

ECONOMIC GEOLOGY OF WESTERN NEW YORK

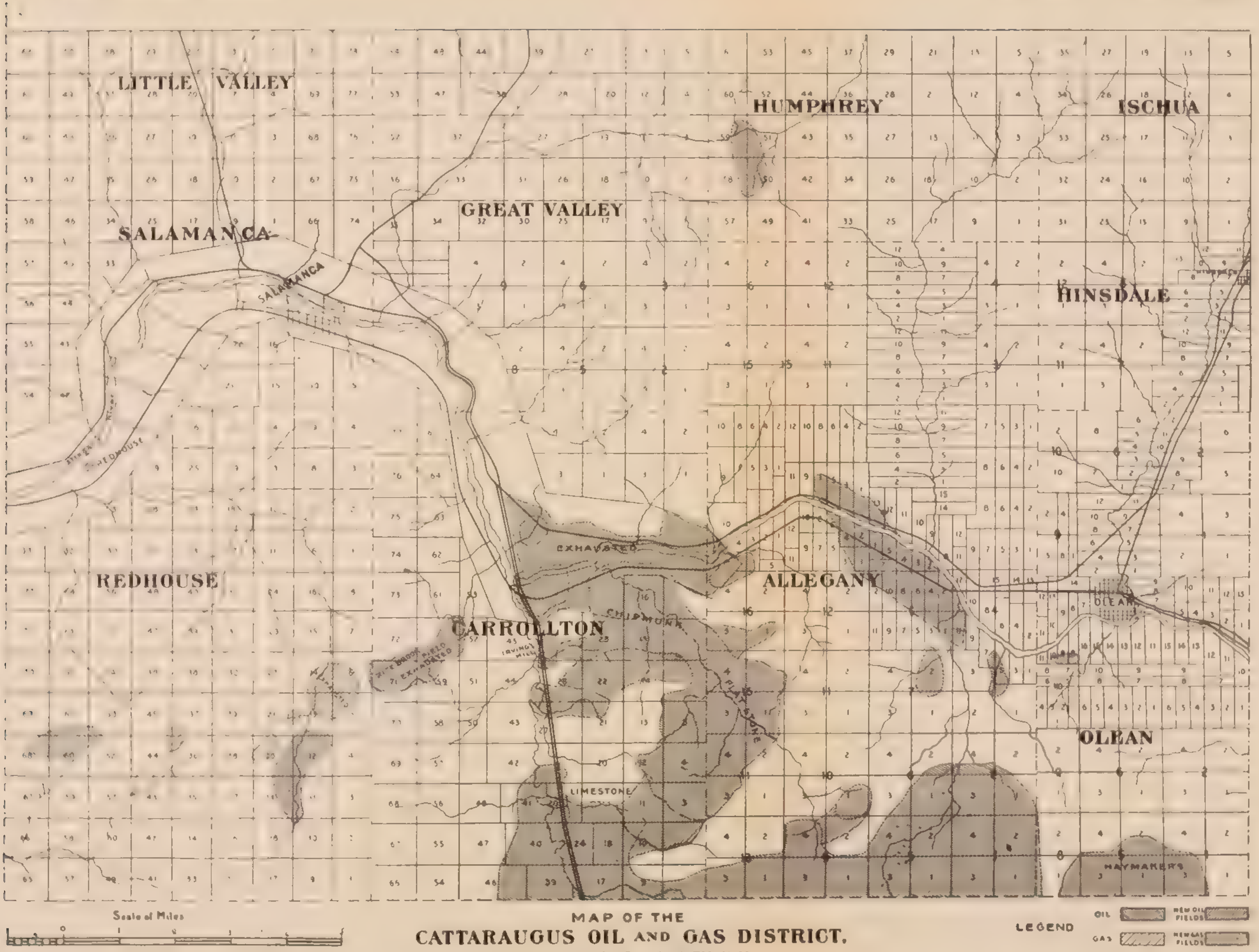
BY IRVING P. BISHOP

Building materials

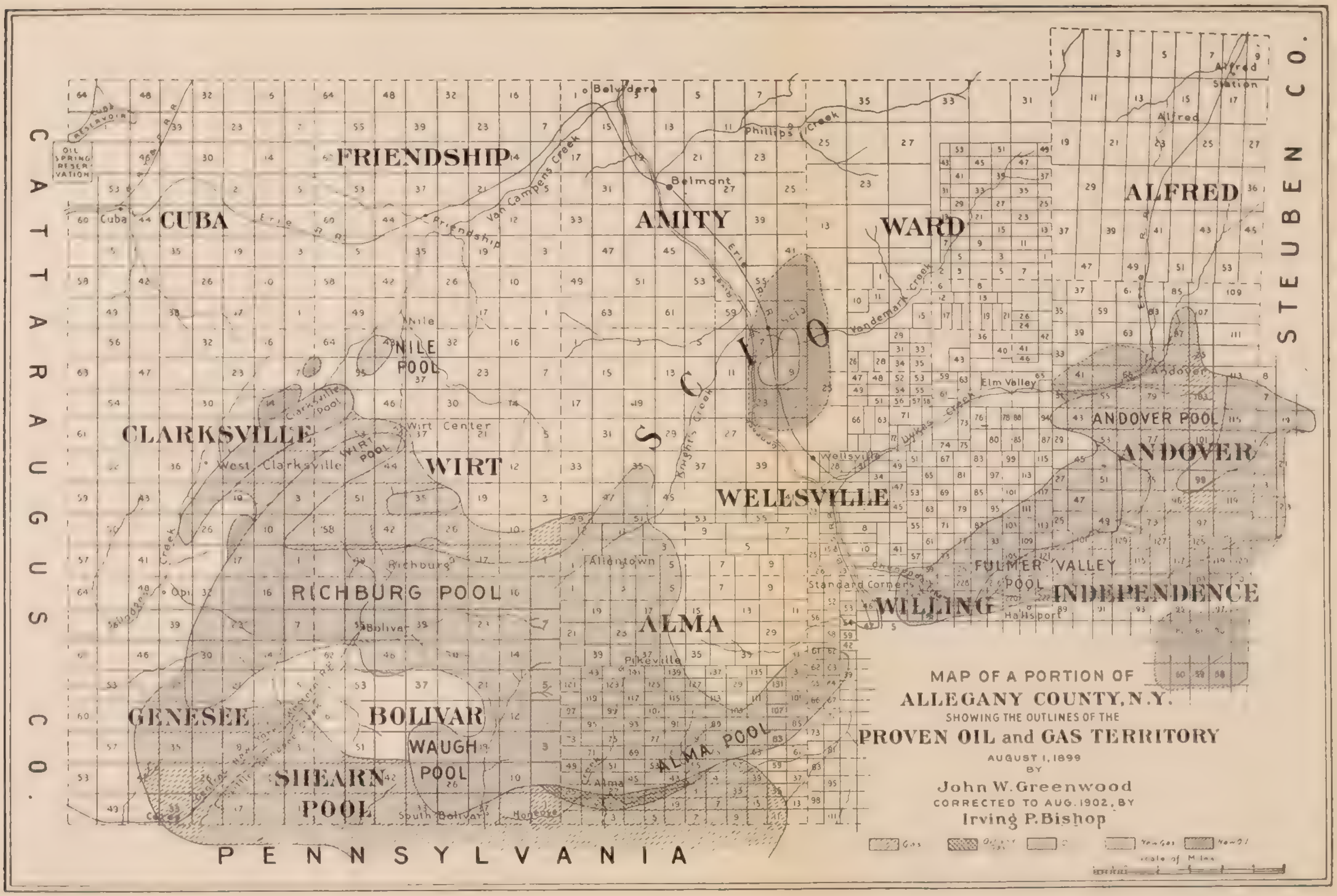
The territory in which information on the above topic has been collected includes the counties of Chautauqua, Cattaraugus, Allegany, Erie, Wyoming, Genesee, Niagara and Orleans. In Erie county the mineral producers were known to the writer: in the others they were reached by correspondence. Though some small quarries or deposits may have been overlooked, the lists which follow will be found to include everything of importance.

Trade conditions

The establishment in Buffalo during the past year of many great business enterprises, including a $40,000,000 steel plant, has caused increased activity in the production of all lines of building material, specially stone, sand, brick and cement. The construction of breakwaters, grade crossings and other public improvements has also called for large quantities of these materials. The result has been that the producers who have facilities for handling large contracts have had all the business they could take care of, while some of the smaller quarries and factories have been idle. Therefore, though the number of producing quarries has decreased, the total output of stone will probably be above that of last year. That the increased demand for building materials is due to better conditions in Buffalo is shown by the brick industry. In Buffalo, though the local plants are working to their full capacity, the old stock of brick and all of the product of 1902 have been exhausted. At Dunkirk and Olean the market is reported as dull. Small quarries and brickyards in districts remote from the city report also a limited demand, usually too light to warrant the starting up of the kiln or quarry. Cement, which is marketed outside, quite as much as at home, seems to be affected less by local conditions. The demand for it is generally good.



MAP OF THE
CATTARAUGUS OIL AND GAS DISTRICT.
CATTARAUGUS COUNTY, N.Y.
CORRECTED TO AUG 1902
BY
IRVING P. BISHOP.



MAP OF A PORTION OF
ALLEGANY COUNTY, N.Y.
SHOWING THE OUTLINES OF THE
PROVEN OIL and GAS TERRITORY
AUGUST 1, 1899
BY
John W. Greenwood
CORRECTED TO AUG. 1902, BY
Irving P. Bishop

Stone

For convenience this material will be considered under the headings Medina sandstone, argillaceous sandstone, and limestone, divisions into which nearly all the stone quarried in the district under observation naturally falls.

Medina sandstone. Within the past year several quarry owners in Orleans county have formed an organization under the name of the Medina Quarry Co. with offices at Albion N. Y. and 80 Broadway, New York city. The officers are: President. Bird S. Coler, New York; vice president, J. A. Roberts, Buffalo N. Y.; treasurer, W. E. Scarritt, New York; secretary, J. C. Rogerson, New York; general manager, L. A. DeGraff, Albion N. Y.; superintendent of quarries, William O'Brien, Holley, N. Y.; assistant treasurer, Michael Slack, Medina, N. Y.; superintendent street paving, E. F. Fancher, Albion, N. Y.

Mr John J. Ryan, Medina N. Y., attorney for the company, has furnished the following list of quarries controlled by the organization:

Medina. Halloway estate, Horan estate, Adelbert McCormack, ——— Reynolds (leased).

Eagle Harbor. DeGraff & Roberts. The company also buys output of the Skinner quarry for 1902-3.

Albion. Goodrich estate, DeGraff & Roberts, Joseph Brady.

East of Albion toward Holley. Fancher & Cornwall, Fancher & Newsome, Fancher & Vincent, Baldwin & Hinds, Hebner & Son, Chadwick Bros.

North of Holley. Jerome McCarthy, Keyes estate.

South and east of Holley. William O'Brien *et al.,* Michael Slack.

Hulberton. Marcus H. Phillips.

Since its organization the company has expended $50,000 in new and improved machinery, including a channeling machine, four traveling steam derricks and three or four extra large derricks of the usual form. The sawing plant at the DeGraff & Roberts quarry at Eagle Harbor has also been doubled. The Phillips and Halloway quarries have also crushers for reducing waste to road metal.

In October 1902, the company was operating six quarries, one each at Medina, Eagle Harbor, Albion, Transit road and Erie canal, Hulberton and Holley.

It produces rough and dressed building stone of all kinds and rough and dressed street-paving material. As the company has been organized only a short time, the general manager was unable to state, even approximately, the production for the year 1902.

The following table gives the names of Medina sandstone producers not in the above organization, together with the information furnished by them in reply to letters which were sent out. The list of names was obtained at Medina.

Independent producers of Medina sandstone

NAME	Address	Location of quarry	Condition of quarry	Product 1902	Remarks
C. B. Whitmore	Lockport.....	Mill st. Lockport.........	Worked	110 cords.....	
Dr Downey............	Middleport....	1 m. e. of Middleport.....	....	....	No report
John Levalley...........	Shelby Basin..	....	....	....	"
Joseph Servoss..........	"	80 rods north of canal, S.B.	Worked	250 cords.....	
Kearney & Barrett.......	Medina........	Medina...................	Worked	550 cords.....	Also about 200 sq. ft of flagging
A. L. Swett.............	"	North of canal, Medina...	Idle ...	....	Formerly known as the Howell quarry
James Bros..............	"	Medina...................	....	....	No report
E. S. C. Bowen..........	"	N. E. of Medina.........	Idle ...		
Fred Perry..............	"	"	....	....	No report
Dr C. H. Whiting (Filkins & Gorman, lessees)	"	"	....	....	No report. Filkins & Gorman also have quarry at Albion
Reed & Allen............	Albion........	(2) East of Albion.......	....	....	No report
Ford....................	"	Albion...................	....	....	"
Miss M. Katherine Hinds..	Hindsburg....	N. of canal, Hindsburg....	Worked	Product unsold	Crosswalks, gutters, blocking, etc.
John Moore..............	Albion........	E. of Albion?............	....	....	No report
Orleans Sand Stone Co....	Holley........	Hulberton	....	....	"
A. R. Squires & Son......	Albion.......	East of Albion...........	....	....	"
William H. Farrand......	Holley........	Holley...................	Idle ...	....	Controls three quarries
Jones & Co..............	Hulberton.....	Hulberton................	Worked	Product unsold	Curb and block paving
Fancher & Delaney	Albion........	Albion...................	....	....	
Newsome & Co............	Lockport?.....	....	....	....	No report
Matthew Ryan...........	Eagle Harbor?	Eagle Harbor............	....	....	"
Estate of C. Gwinne.....	Medina.......	....	....	....	"

Argillaceous sandstone. The American Bluestone Co. and the Warsaw Bluestone Co. operate large quarries near the Erie Railroad between Rock Glen and Warsaw, Wyoming co. The Genesee Valley Bluestone Co. has also a large plant near Portageville in the same county. These are the largest producers in the district under observation. The following tables show the location of quarries whether in operation or not, with such information as the owners could furnish.

Quarries in actual operation

OWNER OR LESSEE	Address	Location of quarry	Grade of stone	Amount	Geologic formation	Remarks
American Bluestone Co.	Warsaw	1 m. n. Rock Glen or 3 m. s. Warsaw	Blue argillaceous sandstone, cut, sawed, rough	Cut 16,000 c. ft sawed 185,000 c. ft rough 33,000 c. ft	Portage gr.	
Genesee Valley Bluestone Co.	Portageville	At Bluestone, Wyoming county	Sawed, block, ashler, rough	Not given	Portage gr.	
Squire White	Fredonia	Water st., Fredonia	Rough	200 cords	Portage gr.	Expects to quarry 1000 cords, 1903
George R. Moore	Fredonia		Rough	100 cords	Portage gr.	
William Cook	East Aurora	½ m. e. of East Aurora	Building		Portage gr.	Has 100 cords left from 1901
Joseph Rounds	Olean	4 m. s. of Olean	Rough white sandstone.	500 cords	Chemung	
Warsaw Bluestone Co.	Warsaw	1 m. n. of Rock Glen	Block, sawed, cut	25,000 c. ft	Portage	
William Brondart	Franklinville	½ m. w. of village	Building and curb	75 cords	Chemung	Gray sandstone
Henry Kamery	Olean	South of Olean	Building, cut and curb.	?	Chemung	Amount not given. Has had 3 to 6 teams drawing all the season

Quarries not in operation 1902

OWNER	Address	Location of quarry	Grade of stone	Geologic formation	Remarks
Charles M. Brayton	South Wales	South Wales	Building	Portage	No report
Edward Cook	Olean	Olean	Building	Chemung	No report
Dudley H. Beadle	Westfield	Westfield	Building	Portage	No report
Daniel Calkins estate	E. Aurora	1 m. s. e. of East Aurora	Building	Portage	Idle two years. Report from Charlotte A. Calkins, East Aurora
Frederick A. Clarke	Springville	2 m. w. of Springville	Building and bridge	Ithaca gr.?	Idle in 1902
B. Wheeler	Springville	2 m. w. of Springville	Building and bridge	Ithaca gr.?	No report
W. D. Leet	Fredonia	Laona	Building and bridge	Pórtage	
F. Mabbett	Fredonia	Lambertson, town of Pomfret	Building	Portage	
Joseph Mayer estate	Wales Center	Wales Center	Building	Portage	Report from widow
Joseph Rounds	Olean	2 m. s. of Olean	Building	Chemung	Silicious sandstone
John Napier	Franklinville	½ m. w. of Franklinville	Building and curb	Chemung	
Frank Riggs	Franklinville	"	Building and curb	Chemung	No report
Smith & Reap	Rochester	N. Clymer, ¾ m. from Panama	Building and curb	Chemung	Not worked for four years
J. W. Kales M. D.	Franklinville	Franklinville		Chemung	
A. Searl	Rockville	Rockville		Chemung	
Eugene Hamlin	Perry	Perry	Building	Portage	No report

Limestone. As has already been stated, the principal demand for limestone has been for grade crossings and breakwater construction. Much of the stone for the latter purpose, specially riprap, has been brought from Canada. Below follow lists of quarry owners with such information regarding the industry as I have been able to gather. The word "Onondaga" is here used to embrace the divisions "Onondaga" and "Corniferous" employed in the writer's report of 1895.

Limestone quarries in operation 1902

OWNER OR LESSEE	Address	Location of quarry	Grade of stone	Amount 1902	Geologic formation	Remarks
E. J. Ambrose, John B. Rupp, lessee	2135 Fillmore av. Buffalo	Kensington av. Buffalo	Dimension ..	4000 to 5000 cords	Onondaga ..	
Appenheimer estate, John L. Appenheimer, lessee	Appenheimer st. Buffalo	Appenheimer st. and Fillmore av. Buffalo	Building.....	750 cords to Nov. 1, 1902	Onondaga ..	
American Stone & Lime Co.	Buffalo............	Woodward farm, 1 mile e. of Lockport	Building and flux	....	Niagara....	
Barber Asphalt Co.........	Ellicott Square, Buffalo	Delevan and Fillmore av. Buffalo	Building.....	20,000 c. yd...	Onondaga ..	
Buffalo Cement Co.........	Austin building, Buffalo	Main st. and Belt line, Buffalo	Building.....	50,000 c. yd...	Onondaga ..	
Cutter & Bailey, Edward T. Voisard, lessee	1903 Fillmore av. Buffalo	Fillmore av. Buffalo	Building and cut	2000 cords	Onondaga ..	
Anna Gehres..............	1968 Fillmore av. Buffalo	Fillmore and Kensington av. Buffalo	Building and dimension	....	Onondaga ..	Does not close books till Jan.1
John Gesl jr..............	331 Leroy av. Buffalo	Kensington av. Buffalo	Building.....	....	Onondaga ..	No report
S. Schrier................	285 Herman st. Buffalo	Fillmore av. Buffalo	Building.....	2864 cords to Oct. 1	Onondaga ..	
A. G. Erisman............	Wilhelm...........	Wilhelm	Building.....	100 cords......	Onondaga ..	
J. Hiller.................	Akron..............	Akron	Building.....	40 cords.......	Onondaga ..	
M. Souter................	Cheektowaga.......	Cheektowaga	Building.....	100 cords......	Onondaga ..	

Martin Kieffer	Depew	227 B'way, Depew	Building	....	Onondaga	Not quarrying; has 100 cords on hand
N. B. Keeney	Leroy	Two quarries n. e. of Leroy	Building, concrete, ashler	2000 c. yd.	Onondaga	Crushed some stone for Leroy streets
Standard Oil Co.	Lockport	Near Canal, Lockport	Building	100 cords?	Niagara	Used for own office building
C. N. Stainthorpe & Co.	126 Main st. Lockport	Lockport	Building	(?)	Niagara	
Michael Crowe	87 Lock st. Lockport	Lockport	Building	250 cords	Niagara	
Thomas G. Watson	129 Price st. Lockport	Lockport	Building and cut	$800 to $1000 worth	Niagara	
Charles E. Mabon	Pekin	¼ m. w. of Pekin	Bridge and building	80 cords	Niagara	
Henry Witkopf	Pekin	Pekin, n. side of Mountain road	Cellar, curb, cut	50 cords	Niagara	
A. R. Carl	Lewiston	On mountain between Lewiston and Niagara Falls	Bridge and building	....	Niagara	
B. Schoof	Akron	Akron	....	....	Onondaga	No report
Barney Messing	Niagara Falls	On junction railroad, N. F.	....	....	Niagara	No report
L. D. Howell	Leroy	Leroy	....	....	Onondaga	No report
Horace M. Fish W. Dawson, lessee	Batavia	2m. n. of Batavia	Building	$43 worth at 35c a load	Onondaga	Burnt for lime Kiln at Batavia
Theodore Gutenbury	Batavia	2½ m. n. of Batavia	Building	....	....	No report

Quarries not in operation 1902

NAME	Address	Geologic formation	Remarks
Ernest Bowen	Bowmansville	Onondaga	
P. H. Nice	Akron	Onondaga	
X. Friedman estate	Buffalo (Fillmore av.)	Onondaga	
R. & H. Fogelsonger	Williamsville	Onondaga	
J. S. Youngs	Williamsville	Onondaga	
C. B. Whitmore	30 Market st., Lockport	Niagara	Quarry foot of Hawley street
J. B. Vogt	Niagara Falls	Niagara	
J. Biller	Clarence Center	Onondaga	No report
John Hilton	Mill Grove	Onondaga	No report
Lawrence Kaeser	Cheektowaga	Onondaga	
N. Setter	Cheektowaga	Onondaga	
A. W. Haskell	Bowmansville	Onondaga	
J. B. Vogt	Niagara Falls	Niagara	Quarry south of Devil's Hole
Buttery quarry	Niagara Falls	Niagara	No report. Quarry in north part of city
Buffalo, Bellevue & Lancaster R. R. Co.	Bellevue, Erie co	Onondaga	
[a]Straub & Meyer	Gunnville	Onondaga	Quarry abandoned
[a]George Bingham	Lancaster	Stafford, limestone.	Quarry abandoned
[a]Grattan & Jennings	D., L. & W. Railroad foot Main st. Buffalo	Onondaga	Not used for several years
[a]Forest Lawn Cemetery	Buffalo	Onondaga	Not used for several years
[a]—Manser	Leroy av., Buffalo	Onondaga	Abandoned
[a]Leroy Stone Co.	Leroy av., Buffalo	Onondaga	Abandoned
[a]C. Uebelhoer	2135 Fillmore av., Buffalo	Onondaga	Abandoned
[a]Schumacher & Liederman	Fillmore av., Buffalo	Onondaga	Abandoned
[a]Charles Steinwach	Fillmore av., Buffalo	Onondaga	Abandoned
[a]"Syndicate" quarry	Williamsville	Onondaga	Abandoned

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[a] N. Y. State Geol. 15th An. Rep't 1895, p. 334–35.

Crushed stone

The market for crushed stone has been active all through western New York. The new steel plant at South Buffalo has used large quantities for concrete construction; the breakwater has also consumed an enormous amount; and it is in great demand also for asphalt work and railroad ballast.

This season Erie county has begun the use of convict labor for the purpose of making better roads. The plan originated with Supervisor William H. Conboy, of Grand Island, who urged that the employment of convicts in quarrying and crushing stone would lessen the cost of maintaining the penitentiary and would give the men needed physical exercise, thus conducing to their better health and morals. Short term prisoners dig the stone at the almshouse quarry on Main street and wheel it to the crusher, which is a double one operated by a 50 horse power engine. From 25 to 50 prisoners have been employed in this work continuously for four months, with an average daily output of about 300 cubic yards. The cost of quarrying and crushing is about 20c a yard, and the stone is sold for 60c a yard. The county has taken the contract for the construction of good roads within its limits from the State and sublets the contract under the condition that the stone shall be purchased of the county at 60c a yard.

The stone crushed this season has been used in surfacing the road between the city line and Williamsville and also two sections of the Transit road in Amherst and Clarence. It requires about 2700 cubic yards of stone for a mile of road, the average cost a mile being, in 1902, $9688.75, of which the county pays half. The county has nearly 22 miles of road under contract this year.

Producers of crushed stone

MANUFACTURER	Address	Production 1902	Geologic formation	Remarks
E. J. Ambrose, John B. Rupp, lessee	2135 Fillmore av. Buffalo.	5000 c. yd.	Onondaga limestone	
Barber Asphalt Co.	Ellicott square, Buffalo	114,000 c. yd.	Onondaga limestone	
Buffalo Cement Co.	Austin building, Buffalo	100,000 c. yd.	Onondaga limestone	
Clarence Stone & Lime Co.	408 Morgan bldg. Buffalo.	80,000 gross tons	Onondaga limestone	Weighs about 1.1 tons to the c. yd. 4000 tons of this used for road metal; the rest as flux for smelting
Dickerson & Bell, lessee	Akron	2000 c. yd.	Onondaga limestone	Lease the quarry dump from H. L. & W. C. Newman
Forest Lawn Cemetery	27 Erie County Savings Bank, Buffalo	1000 yd.	Onondaga limestone	
General Crushed Stone Co.	Leroy	480,000 tons.	Onondaga limestone	Weighs about 1.1 tons to the c. yd.
N. B. Keeney	Leroy		Onondaga limestone	Crushes a small amount for corporation purposes
C. B. Whitmore	30 Market st., Lockport	12,000 c. yd.	Medina sandstone	Given as 40 carloads
Medina Quarry Co., L. A. DeGraff, manager	Albion		Medina sandstone	
Erie County Penitentiary	Buffalo	300 c. yd. a day.	Onondaga limestone	[*See* p. r51]

Flux

Only one firm, the Clarence Stone & Lime Co., makes a specialty of flux for furnace use. The bed of limestone worked by the company occurs nearly in the middle of the outcrop of Onondaga limestone, 2 miles west of Clarence, and is of remarkable purity. The greater part of the product is sold to the Tonawanda Iron & Steel Co. The new iron and steel plants now in process of erection will create a market for large amounts of flux. The immediate supply for this expected demand will be furnished by Carroll Bros., Buffalo, from their Point Abino quarries in Canada.

Clay products

The conditions producing increased demand for stone, sand and other building material have extended to clay products as well. Almost every manufacturer reports a good market for his wares and in many cases, orders beyond his ability to fill. The exceptions are to be found in the case of small kilns intended for local use in the smaller towns, and in the cities of Olean and Dunkirk, where the market is reported dull. The explanation appears to be that in Buffalo and Rochester increased building has caused an unusual scarcity of material; and this has brought about a brisk demand for home products, with which the remote manufacturer can not compete on account of the additional cost of transportation.

The largest brickmaking interests in western New York are located in East Buffalo and in the townships of West Seneca, Cheektowaga, Lancaster and Alden in Erie county. The following constitute the Buffalo Brick Manufacturers Association, office, cor. Pearl & Court streets, Buffalo: Henry Bender, Ebenezer; Berrick's Sons, Brush Bros, Dietschler's Sons; William J. Graaf, Pine Hill; Haake & Son; Lancaster Brick Co. Town Line; C. H. McCutcheon, Lancaster; George W. Schmidt; E. A. Schuesler.

In 1901 the association sold and delivered 50 millions of brick. Aug. 1, 1902, it had delivered 32,500,000 and had orders for 30,000,000 more, all that the managers believed the association could make during the season with the means at hand. It had also refused orders for several millions more.

Producers of clay products[1]

MANUFACTURER	Address	Material	Amount 1902	Product	Remarks
Attica Brick & Tile Co	Attica	Clay and loam	1,680,000	Common brick	
Alfred Clay Co	Alfred	Shale	Not given	Roofing, tile and trimmings and face brick	Demand in excess of ability to make
Buffalo Brick Mfgrs. Ass'n	Buffalo	Clay	62,000,000	Brick and tile	
Craig colony for epileptics	Sonyea	Clay	275,000	Common brick	For own use. Usually make 500,000
Celadon Roofing Tile Co	Alfred	Shale	1,250,000	Artistic and roofing tile	Demand beyond capacity
Frontier Brick Co	Niagara Falls	Clay	3,000,000 to 4,000,000	Common brick	
W. E. Hilton	Dunkirk	Clay	1,700,000	Common brick	
John Hilton	Dunkirk	Clay	1,202,000	Common brick	Demand beyond capacity
Jewettville Pressed Brick Co.	Jewettville	Shale	3,000,000	Dry pressed brick	
Jamestown Shale Paving Brick Co.	Jamestown	Shale	12,000,000	Dry pressed building brick and paving brick by wet process	Demand beyond capacity
Mat. McCusker	Levant	Shale and clay	Not given	Common and paving	Has two plants making common and one making paving brick; the latter from shale
John Lyth & Sons	Angola	Shale		Fireproofing hollow tile	107,000 tons in 1901; probably more in 1902
C. Morley	Levant				No report
Aaron Moselle	Lockport	Clay	275,000	Common brick.	
J. C. & A. McMurray	Olean	Clay	1,120,000	120,000 common, the rest pressed	Burn with natural gas. May make a kiln of 60,000 later this season
Page & Brainard	Avon	?	No report		
O. W. Weyer & Co.	Wanakah	Shale	Not given	Common brick	New plant, hardly in operation
Hall & Sons	Buffalo	Clay from N. J.	Not given	Fire brick	No report
Tonawanda Brick Co.	Tonawanda	Clay	No report	Common brick	

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[1] The small kilns at East Evans, Springville and Angola are not in operation this year. The Buffalo Sewer Pipe Co. has stopped manufacturing—probably permanently.

Lime

Nearly all the lime now used in Buffalo comes from kilns in the vicinity of Point Abino and Ridgeway in Canada. The kilns of R. & H. Fogelsonger and J. S. Youngs at Williamsville are idle. The Straub & Meyer plant at Gunnville has been abandoned. The Tonawanda Lime Co., which formerly made lime from stone brought from Kelly's island, Lake Erie, is also closed. The small kilns of A. Fiegel, Harris Hill and of ——— Shaw near Mill Grove, Erie co., have not reported. In July they were said to be in operation.

C. N. Stainthorpe & Co. of Lockport make about 30,000 bushels of lime a year from their quarry of Niagara limestone in the northern part of that city. The following are said to be making lime, but have not answered my letters of inquiry: Barney Messing, Niagara Falls; C. H. Holmes, Leroy; John Heimlech, Leroy.

Cement

There has been a good demand for cement through the year, and the manufacturers have been able to dispose of their product at good prices as fast as it could be made. The table below shows the production in the several factories.

Cement manufacturers

MANUFACTURER	Location	Product 1902, barrels	Materials	Remarks
Buffalo Cement Co............	Buffalo.......	300,000	Waterlime	
Akron Cement Co.............	Akron........	150,000	Waterlime	
H. L. & W. C. Newman........	Akron........	125,000	Waterlime	
Cummings Cement Co..........	Akron........	240,000	Waterlime	
Wayland Portland Cement Co....	Wayland	80,000	Marl and clay..	
Lily Dale Portland Cement Co..	Lily Dale.....	....	Marl and clay..	Not running 1902
a Empire Portland Cement Co ..	Warners......	....	Marl and clay..	Burned in 1902, expect to make 160,000 barrels in 1903

a Not in district on which this report is made.

Sand and gravel

Large quantities of sand are brought to Buffalo from Point Abino and other places on the Canadian shore of Lake Erie. Two or three concerns also obtain these products from the bed of the Niagara river at Strawberry island above Grand island. The sand and water are pumped together from the bed of the river into scows, and the water drained off, by which process the sand and gravel are left clean.

The firms mining sand and gravel are given below. The product does not include material brought from Canada.

PRODUCER	Address	Location of deposit	Production for 1902	Remarks
Carroll Bros............	Virginia & 4th st. Buffalo..	Pumped from Niagara river.	20,000 c. yd....	Import 60,000 yd. from Canada. Make also road metal and lime in Canada
J. E. Carroll	57 Coal & Iron Exchange, Buffalo	Gowanda.................	15,400 c. yd	
John Bergtold..........	Lancaster...............	3 m. e. of Bowmanville	500 c. yd	
Fox & Holloway........	Cor. Court & Pearl st. Buffalo	Niagara river..............	5338 c. yd.....	To Oct. 1. Expect to dredge as much more in November
Point Abino Sand co.....	Foot of Pennsylvania st. Buffalo	Niagara river..............	25,000 c. yd..	Also import from Canada
John Burgess...........	Eggertsville	Pine Hill, Buffalo..........	1000 ? c. yd	
Samuel Rapier	Pine Hill	Pine Hill, Buffalo..........	1000 c. yd	
C. N. Stainthorpe & Co ..	Lockport...............	3 m. e. of Lockport.........	5000 c. yd	
Scranton Sand Co.......	Waverly................	....	5200 c. yd.....	Estimated
George Beiser	Wilhelm	....	....	No report

Ballast

The materials used by the railroads for ballast, filling etc. are not easily classified because separate accounts are not usually kept with each kind. The table below gives the amount of each where distinction was made. Otherwise all sorts are grouped together.

It was my original intention to ascertain the amount of geologic material mined by the railroads in western New York. Later it was found necessary to extend the limits so as to include the divisions terminating as far east on the New York Central system as Syracuse, and as far as Binghamton on the Lackawanna and Erie roads. The material excavated from their tunnel and wheel pit extension by the Niagara Falls Power Co. I have also included in the same table.

Geological materials excavated by railroads Sep. 1, 1901–Aug. 31, 1902

RAILROAD	Location of deposit	Amount	Remarks
Buffalo Creek	Lake Erie shore, Buffalo	6000 c. yd sand	Erie and Lehigh Valley, lessees. Use mostly cinders from elevators for filling etc.
Delaware, Lackawanna & Western	Nichols	153,450 c. yd	151,100 yd gravel; 2350 yd earth
Erie	....	....	No report
Lehigh, western division	....	47,500 c. yd gravel	Also buys crushed stone for ballast
Lehigh Valley, Auburn division	Brookton	60,000 c. yd gravel.	
Lehigh Valley, Auburn division	Perryville	2000 c. yd of limestone for riprap	
Lehigh Valley, Auburn division	Groton	20,000 c. yd gravel and clay	
Lake Shore & Michigan Southern	....	....	Get gravel from pits in Ohio
Lackawanna Steel Co.	Bay View	639,450 c. yd	Shale and clay for building railroad and filling yard. To Sep. 1, 1902
New York Central	Walworth, New York Central; Newark, W. Shore	250,000 c. yd gravel	
New York, Chicago and St Louis (Nickel Plate)	....	....	Obtain supply of gravel from Pennsylvania
Pennsylvania R. R. B. & A. V. division	Ischua	96,500 c. yd gravel	
Buffalo, Rochester and Pittsburg	Scottsville	59,883 yd	39 698 yd gravel 5 965 yd sand 14 220 yd earth 59 883
Niagara Falls Power Co.	Niagara Falls	81,426 c yd rock	Excavated from wheel pit and tunnel. Used for filling

SALT

While nearly all other mineral industries have been in a flourishing condition, that of salt-making has suffered a marked depression. The present state of affairs is not due to any sudden change in supply or demand, but is rather the culmination of disasters the causes of which have existed for many years.

Salt was first discovered in the Oatka valley in 1878. In 1883 it had been demonstrated that the rock salt bed extended beneath the whole of the Oatka and the greater part of the Genesee valleys, and in a few years both were dotted with salt factories and mines. Active competition soon lowered the price of the product to a point which gave very little margin to the manufacturer. Investigation showed that the total capacity of the factories and mines was more than double the amount required by the market which they would legitimately supply. To remedy this, the National Salt Co. obtained control of nearly all the evaporating plants, and by closing unnecessary factories reduced both the cost of making and the amount of the product. About the same time, and for similar reasons, the Retsof Mining Co. acquired title to the four salt mines at Retsof, Greigsville, Leroy and Livonia, and working only one or two at a time controlled the price and the output of rock salt.

For a time the price of salt improved, and salt-making again became profitable. But with better prices came renewed competition from new factories, till the past year has witnessed a repetition of overproduction and consequent stagnation of trade. In the summer of 1902, the National Salt Co. passed into the hands of a receiver. It is now expected that early in 1903 the stock of the National Salt Co. and that of the Retsof Mining Co. will be merged into that of the International Salt Co., which will take the place of the first two organizations.

In February 1903 only one factory, the Yorkshire, was being worked by the National Salt Co. in the whole Warsaw-Genesee field, though the Warsaw and Hawley works were expected to resume in the spring. Of the four mines, only the Retsof was in operation.

In the same district two firms, the Worcester Salt Co. of Silver Springs, and the Genesee Salt Co. of Piffard, which also owned the Livingstone plant, were not absorbed by the National Co. and were actively engaged in salt-making up to the end of 1902. In the early part of 1903 the Genesee Salt Co. passed into the hands of a receiver. The Iroquois Salt Co. of Perry N. Y. has purchased of the National Salt Co. the plant at that place. A large part of the salt made here has been marketed by the National Co. Feb. 14, 1903, the bins were full of the product, and the works were temporarily shut down till the congestion could be relieved.

In 1901 the National Salt Co. sold its Leroy plant to the Empire State Salt Co. of that place. The stock of the latter company is principally held by the butchers and meat-packers of Buffalo, who consume the greater part of the salt which the factory produces.

A new salt mine

Early in 1903 the Oatka Mining Co., an organization including several members of the Worcester Salt Co., announced its intention to sink a shaft for salt in the Oatka valley. The exact location of the works has not yet been made public; but, since several cores have been taken with a hollow drill near Wyoming, it is probable that the site will be in that vicinity. The plant will have a capacity of 1500 tons a day and will be in charge of Mr John H. Duncan, assistant superintendent of the Worcester Co. The principal office will be in New York.

Processes

In the methods of evaporating brine the grainer and pan processes still hold the lead. The vacuum process appears to be gaining ground, as is shown by the fact that it is now used by four factories —the Worcester of Silver Springs, the Glen Salt Co. of Watkins, the Yorkshire of Warsaw and the Cayuga of Ludlowville. Neither open nor steam-jacketed kettles are now employed in the western New York field.

Independent salt manufacturers, western New York field

Name	Location
Empire State Salt Co.	Leroy
Genesee Salt Co.	Piffard
Iroquois Salt Co.	Perry
Remington Salt Co.	Ithaca
Watkins Salt Co.	Watkins
Worcester Salt Co.	Silver Springs

Plants operated by the National Salt Co.

Name	Location
Cayuga Salt Co.	Ludlowville
Glen Salt Co.	Watkins
Hawley Salt Co.	Warsaw
Ithaca Salt Co.	Ithaca
Warsaw Salt Co.	Warsaw
Yorkshire Salt Co.	Warsaw

Plants abandoned or not in use for several years

Name	Location
Globe Salt Co.	Wyoming
Crystal Salt Co.	Saltvale
Pavilion Salt Co.	Pavilion
Pearl Salt Co.	Pearl Creek
Miller Salt Co.	Warsaw
Atlantic Salt Co.	Warsaw
Gouinlock & Humphrey Salt Co.	Warsaw
Empire Salt Co.	Warsaw
Bradley Salt Co.	Warsaw
Castile Salt Co.	Castile
Gainesville Salt Co.	Gainesville
Bliss Salt Co.	Bliss
York Salt Co.	York
Phoenix Salt Co.	Cuylerville
Lackawanna Salt Co.	Mount Morris
Royal Salt Co.	Mount Morris

Production of salt

The total production of all the factories belonging to the National Co. and independent salt companies in the western New York field is stated by Mr N. S. Beardsley, receiver of the National Salt Co., at 2,000,000 barrels for the year ending Sep. 30, 1902. Of this amount 40% was table, the rest common salt. On the same authority the production of rock salt was 250,000 tons, the equivalent of 1,800,000 barrels. The portion of this produced by persons outside the National Salt Co. is shown by the following table.

Company	Location	Product	
Genesee Salt Co.	Piffard	1378.9	tons[1]
Empire State Salt Co.	Leroy	34,258	"
Remington Salt Co.	Ithaca[2]		
Watkins Salt Co.	Watkins	38,848	"
Worcester Salt Co.	Silver Springs	64,635	" [3]
Iroquois Salt Co.	Perry	13,478	"

Caustic soda and bleaching powder

In 1901 the National Salt Co. sold its salt works at Rock Glen to the American Electrolytic Co., of which W. C. Gouinlock, Warsaw N. Y., is president. In the spring of 1902 the company began the manufacture of caustic soda and bleaching powder by the Moore electrolytic process. Both products were successfully made and marketed at current prices. Hardly was the enterprise under way when the great strike in the coal regions occurred, rendering it difficult to obtain fuel, and, at the same time, the price of bleaching powder fell 50%. The two causes rendered manufacture unprofitable, and work was suspended awaiting more favorable conditions.

At Niagara Falls there are two companies making caustic soda and bleaching powder by electrolytic methods. The Castner Electrolytic Alkali Co., office, 33 Wall street, New York city, uses the wet method. The raw material is rock salt obtained from the Retsof Mining Co. of Piffard N. Y. Lime is

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[1] Given as 491,640 bushels to Dec. 31, 1902.

[2] Not in operation before Sep. 30, 1902.

[3] Given as 2,326,859 bushels.

procured from various places mostly outside of New York State. The Acker Process Co., office, Niagara Falls N. Y., makes the same products by the dry process. The raw material is all obtained outside the State, the salt coming from Ohio, and the limestone from Pennsylvania, Canada and elsewhere. The details of manufacture are not given to the public by either concern.

For the year ending Sep. 30, 1902, the Acker Process Co. made 14 tons of caustic soda and 28 tons of bleaching powder a day, counting 350 days to the year, a total of 4900 tons of caustic and 9800 tons of bleaching powder.

GYPSUM

The United States Gypsum Co. of Chicago Ill. has two mills 1 mile from Oakfield, Genesee co., where stucco and other gypsum products are made from rock mined in that vicinity. The combined output amounts to 500 tons a day.

The plaster mill of S. Gilmore at Indian Falls in the same county was not in operation in 1902.

NATURAL GAS

The inquiry regarding natural gas has extended over that part of New York which lies west of the Auburn meridian, essentially the territory covered by my report of 1899. In the counties bordering on Lake Ontario, very little exploration for gas has been made, and that little has been unsuccessful. One deep well was put down at Eagle Harbor, Orleans co. The drill touched Trenton rock at 1814 feet and stopped in the top of the Potsdam at 2300 feet. The well was barren.

At Warners, east of the meridian mentioned, no drilling has been done since 1899, and no improvement in gas production is reported. Letters addressed to the local gas company at Jordan have not been answered. At Seneca Falls the gas supply has failed, and the wells have been abandoned.

In the Ontario field deeper drilling has increased the production. Mr A. Miner Wellman, of Friendship N. Y., has drilled six new wells in the western part of the field, all penetrating the Medina. Of these only three were sufficiently productive to pay. The best well showed a rock pressure of 590 pounds per square inch, and an output of 1,000,000 cubic feet of gas a day. The only extension of this field has been a small addition in the extreme northwestern part of Yates county. Mr D. M. Page of Hornellsville has two productive wells at Rushville, the gas from which is piped to that village and supplies 140 stoves or their equivalent. Mr Page has also two unproductive wells at Rushville and a third at Gorham.

In Livingston county very little new territory has been exploited. In 1900 the Westcott Natural Gas Co. bored a well at Avon. Gas to the amount of 200,000 cubic feet a day was found in the White Medina (quartzose sandstone) at 1400 feet. To the Caledonia group of wells only one has been added since 1899. This was located about 3 miles south of Leroy. It was 1500 feet deep and passed through the Medina sandstone. In the salt group were found salt water and about 20 feet of rock salt. Mr J. C. Tennant, of Caledonia, was, in October 1902, sinking another well for the purpose of increasing his supply. He reports that the gas pressure in the Caledonia wells has not appreciably changed since 1899. The shallow Marcellus shale gas pool south of Caledonia has not been enlarged since the same year. In October 1902 a well was completed on the Whitmore farm at the Highbanks, 2½ miles from Mount Morris. The boring penetrated the Medina sandstone but contained neither oil nor gas.

At Corfu in Genesee county no new wells have been drilled since 1900. Mr H. W. Francis, superintendent of the local gas company, reports that there is no falling off in production, but that the six original wells show a slight increase of gas pressure over that of a year ago.

In Wyoming county few changes are noted. The Attica Natural Gas Co. has not added to its number of wells. The Attica Water, Gas and Electric Co. has drilled two new holes, one in 1901 and the second in 1902. Both were small producers. The gas pressure in this field is decreasing, and, unless new productive wells are found, the supply will soon fall below the demand.

The Iroquois Salt Co. of Perry has bored a well near the outlet of Silver lake. No gas was found, but a show of oil was reported.[1] A boring for water on the farm of Paul Armstrong near Perry is said to have shown a small vein of gas. Thin seams of gas-producing rock are not uncommon in shallow wells about 2 miles east of Perry.

At Johnsonburg in the same county a well was completed in October 1902 by J. W. Stearns, of Akron N. Y. In this the drill found,

Corniferous (Onondaga) limestone at	1230 feet
Passed through Corniferous (Onondaga) limestone at	1430 feet
Top of salt at	1853 feet
Bottom of salt at	1893 feet
Bottom of well at	1898 feet

No gas in the well.

Since 1899 a large area of gas territory has been developed in Erie county. The Alden field has been extended westward nearly to Lancaster and is increasingly productive in that direction. The Alden and Batavia Natural Gas Co.,[2] which now controls the greater part of this field, has 27 wells, the greater part of which produce from 100,000 to 1,000,000 cubic feet of gas each a day. The company has laid a 6¼ inch main to Batavia by way of Crittenden. At the latter place a branch owned by the Akron Natural Gas Co. takes gas for Akron village to supplement the supply from the Akron wells. My letter to the Batavia office has not been answered, but, from the best information at my disposal, I judge that these lines supply about 1200 taps. The United Natural Gas Co. has also lately drilled eight dry and five producing wells south and east of Lancaster toward Elma and Springbrook. The producing wells give a daily output of 200,000 to 750,000 cubic feet each. The gas from these and other local wells is kept in reserve and used only in very cold weather. The main supply for the city of Buffalo is piped from Pennsylvania.

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[1] After lying idle for some months this well was cleaned out and yielded 15 barrels or more of petroleum.

[2] Office at Batavia; president, Robert Rose; superintendent, C. C. Rose.

The Lancaster-Depew Natural Gas Co. (J. W. Stearns president, 98 White building, Buffalo) has found a productive field of undetermined extent at Bowmansville. At present (October 1902) the company has four wells with an average production each of 250,000 cubic feet a day. The gas is carried to Lancaster and Depew in a 4 inch main and is now being distributed. The Lancaster Light and Conduit Co. (E. Feyler manager, Lancaster) is also piping in gas to the same village from two or more wells located in East Lancaster toward Town Line.

On account of the decreasing productiveness in the home wells, the Clarence Gas Co. began a search for gas south of that town. In June 1902 a well on the Erisman farm, 3 miles east of Bowmansville, reached a vein of gas which is said to yield 200,000 cubic feet a day. Another well drilled for the same company on the Marley farm, 5 miles east of Bowmansville, in August–October 1902, is reported to be good for 300,000 cubic feet a day. In all these wells the gas occurs, as is usual in this county, in the white or quartzose Medina sandstone.

In the Getzville group the pressure appears to be diminishing. The Niagara Light, Heat and Power Co. (office, 3 Niagara street, Tonawanda N. Y.) has drilled four new wells since 1895 with unsatisfactory results. One completed in August 1902 produced at the start less than 11,000 cubic feet a day.

In the city of Buffalo, the small reservoirs of natural gas are nearly exhausted. The Buffalo Cement Co. has six wells which are still producing, the daily output aggregating from 600,000 to 700,000 cubic feet. In these wells the pressure is steadily declining. The gas is used entirely for domestic purposes.

The Richardson group of wells at East Aurora has proved inadequate for the demands of that village and Orchard Park and has passed into the hands of the United Natural Gas Co., which supplements the local supply from its Pennsylvania main, which is near the latter place.

At North Collins two new wells were added to the group in 1902, and the supply of gas has been increased. It is hoped that the additions will furnish gas enough for cold weather, at which season in the previous years the old wells have proved inadequate.

The Boro well, 1½ miles northeast of Collins, now furnishes gas to that village and to houses along the route of the line. The Boro Gas Co. is now (October 1902) setting up a rig to drill well no. 2 near the first one. The same company is also connecting to their line, a well drilled in 1900 on the F. Willette farm near Collins to meet present demands.

The two wells at the State Homeopathic hospital near Collins are now supplying to that institution about 35,000 cubic feet of gas a day. The pressure has fallen from 120 pounds at the start to 65.

The gas supply at Springville has been increased by a well at "Coon hollow" 2 or 3 miles from Springville toward Zoar. Mr J. W. Stearns reports the well as capable of producing from two million to three million feet a day.

In the vicinity of Gowanda, partly in Erie and partly in Cattaraugus county, a little additional drilling has been done. A well was put down by the Gowanda Gas Co. on the Frank Taylor farm toward Perrysburg in May 1901. Another was sunk between Gowanda and Dayton about June 1902, and a third on the Fred Unger farm east of Gowanda in October 1902. The first two were light producers. The third is not yet completed. The Willette well near Collins, previously referred to, was drilled in December 1900.

Chautauqua county

The geology and history of the Lake shore gas belt have been treated very fully by Professor Orton in his admirable monograph on petroleum and natural gas.[1] The development since 1899 has been in the utilization of gas from already known fields, and therefore the data acquired have not contributed much to our previous knowledge. The wells all through this belt are shallow, small producers, and generally designed, like water wells, for the use of one or two families. The gas pressure runs from 1 to 2 pounds up to 50 or 60 pounds. A pressure of 25 pounds is considered good.

Around Fredonia a few wells have been drilled since 1899, none proving very productive. If enough gas is obtained for

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[1] Orton, Edward, LL.D. Petroleum and Natural Gas in New York. N. Y. State Mus. Bul. 30. 1899.

heating and lighting a house, it is considered a paying well. At Westfield several borings have been made. Hon. S. F. Nixon sunk one for domestic purposes in August 1900, to the depth of 400 feet. Charles E. McEwen sunk another in November of the same year to the depth of 440 feet, getting a supply of 2500 cubic feet a day.[1]

Around Ripley the gas industry has been more active. Mr Charles Keith of that village within the last two years (1901-2) has put down 16 gas wells all within 4 miles of Lake Erie and mostly in Chautauqua county. Two were nearly barren, the others produce from 500 to 20,000 feet of gas a day. There are no large wells in this vicinity, but those found thus far seem well adapted to private use.

There are three companies in Ripley which supply gas to consumers. Gas pressure in wells runs from 5 to 60 pounds.

Only one new well, that belonging to Orton Smith, is reported from Brocton. Professor O. C. Presler, of Stockton, informs me that two wells have been sunk near that village, each of which gave a small flow of gas. One was located on the estate of Mortimer Ely, and the other, which was 2400 feet deep, on the Andrew Munger farm. At Busti three wells were drilled during the fall of 1900 and the spring of 1901. One of these on the farm of A. Philips was piped, producing enough gas for two stoves. The others were barren.

Since my last report several wells have been drilled in the vicinity of Mayville and Chautauqua. The old McConnell well north of the former place has been deepened to 2929 feet, but without increasing materially the yield of gas. The following record of the extension, furnished by Mr G. B. Keith, the contractor, is interesting as showing the presence of lower Devonian rocks.

Brown shales at	1100 feet
Gray shales at	1320 feet

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[1] Mr W. B. Duff, of Darlington Pa., who has drilled about 14 wells around Westfield, reports that 90% of them produce some gas. It is generally found above 750 feet and mostly between 100 and 450 feet. The Westfield wells, he says, produce from 2000 to 7000 cubic feet in 24 hours. The gas pressure holds up well when the hole is free from water.

Black (Marcellus?) shales, 150 feet, at	1850 feet
Limestone, Corniferous (Onondaga), at	2000 feet
Sulfur gas at	2300 feet
Salt water at	2600 feet
Still in limestone at	2900 feet
Bottom of well at	2929 feet

A well 1100 feet deep was sunk in 1901 on the farm of George Hewes about midway between Mayville and Chautauqua. Bed rock was reached at 85 feet. At 1050 feet gas with a confined rock pressure of 85 pounds was found. It is now used to heat two houses.

Another well on the farm of J. F. Hunt, ¼ mile west of the Chautauqua grounds, is 1200 feet deep. The original gas pressure was 80 pounds, which has now fallen, when the well is used, to 60 pounds. The gas was found in a 50 foot stratum of sand at a depth of 810 feet. In the same sand was found a small quantity of amber oil, a barrel of which Mr Keith says was bailed from the well. The gas Mr Hunt uses in his kitchen stove.

A well belonging to the Chautauqua Assembly is located in the rear of the assembly grounds. Its total depth is 1500 feet. A small supply of gas with an original confined pressure of 80 pounds was obtained. It furnishes power to pump water from three artesian wells near by which supply the assembly grounds with water.

Still another well, 935 feet deep, is on the farm of W. J. Connell 1 mile south of the Chautauqua grounds on the Panama road. A small flow of gas was found with a pressure of 45 pounds. The gas is not utilized.

The above wells were drilled in 1901-2. A group of six wells, ranging from 500 to 800 feet in depth, was also drilled in 1901-2, in the township of Carroll not far from Frewsburg. All have a small showing both of gas and oil. One well has produced to the extent of ½ barrel of oil a day.

The following record of well located in Kiantone township, 3 miles south of Jamestown, was furnished by G. B. Keith. Well drilled in August 1901.

Drive pipe to rock	86 feet
Casing	208 feet

Total depth	739 feet
First gas at	290 feet
Second gas at	611 feet
Third gas at	632 feet

The well had an original confined gas pressure of 140 pounds which has since increased to 185.

The Pope Hollow well, drilled in 1895, was 1800 feet deep. It contained a 20 foot layer of sand at 500 feet, which, after being shot, gave a small showing of both gas and oil.

Mr Keith has also drilled a well 900 feet deep on the farm of Dennis M. Jenks, 2 miles north of Kennedy. It proved barren save a little gas at 900 feet.

The old well owned by Broadhead & Son at Jamestown was sunk to the depth of 5000 feet.

Cattaraugus county

There has been comparatively little exploration for gas in Cattaraugus county within the past three years. In the fall of 1902 a test well was drilled on the farm of Ezekiel Kelly, lot 57, township of Mansfield, 1 mile northwest of the village of Little Valley. The well had a total depth of 900 feet. Gas with an estimated flow of 110,000 cubic feet a day was found at 575 feet. It has not yet been utilized.

A group of five wells with an aggregate production of three million feet a day has been drilled on lots 52, 60 and 68 in the southwest part of Red House township. The field, on lots 5, 6, 13 and 14 in the same township, known as the Red House gas field, is exhausted and is practically abandoned. There are no other changes of importance, either in the source or distribution of gas in this county.

In 1897 the Mud Creek Oil & Gas Co. drilled a well on the Walker farm at Mud creek, town of Randolph. At a depth of 500 feet gas was found in a 50 foot stratum of good sand. The well was left open for a month, then cleaned, and 30 days later showed a pressure of 240 pounds. Another well, drilled by the same company on the Goodspeed farm 100 rods northeast of the first, found a flow of oil and a small supply of sand at the same depth as in the other. Both wells are now abandoned.

Allegany county

The Canaseraga Oil & Gas Co. drilled a well in the winter of 1901-2 on the Miles-Harvey farm near Birdsall. The following data are furnished by O. S. Pratt, one of the stockholders:

Depth of well	1140 feet
Gas with an estimated pressure of 150 pounds at	550 feet

The producing rock, as shown by the sample of drilling sent me, was a micaceous clay sandstone, 12 feet thick. No oil was found in the well.

Another well, drilled about three years earlier, was located ¾ of a mile away from the preceding. It had traces of both oil and gas. Still another in this vicinity showed a trace of oil but no gas.

The Andover gas field has been increased by two small extensions. The first lies northwest of Andover village and includes the greater part of lots 41, 42, 55, 56, 57, 64 and 65, township of Andover. The other lies southeast of Independence village and includes nearly all of the lots 103, 105 and 119, township of Independence.

A well drilled for gas in May 1902 on lot 77, Andover, in the old Andover field, showed a pressure of 150 pounds in one minute and 400 pounds in four minutes, without shooting.

In the gas companies distributing gas, one or two changes are to be noted. The Allegany Gas Co. Limited, of Friendship is now absorbed by the Producers' Gas Co. of Olean. The latter company has made no further extensions since 1899. The Empire Gas & Fuel Co. Limited, of Wellsville has also acquired the plant of the Cuba Gas Co. It has, however, made no other additions to its producing territory. The Natural Gas Co. of Andover has not extended its lines, though the additions to its producing oil and gas wells, elsewhere noted, have naturally added to the productiveness of the gas territory.

Steuben county

Except in the extension of the Allegany field into this county, no drilling of any consequence for either oil or gas has been done since 1899. The Corning Fuel & Heating Co. drilled a second well to the depth of 2000 feet and, finding no gas, abandoned the project. The Page & Darrin well, lot 19, Erwin township, is filled with water and has ceased to produce.

PETROLEUM

The high price of petroleum during the past three years has greatly stimulated production. Search for oil has been vigorously prosecuted along the borders of known fields, and abandoned pools have been revived and worked. Old wells have been cleaned out and refitted and new ones drilled between, sometimes at intervals not exceeding 50 feet. The new wells are shot with heavy charges of nitroglycerin, 200 quarts being a common quantity, and often start off with a suprisingly large flow. The production soon drops to an amount varying from ½ barrel to 4 or 5 barrels a day.

The wells are pumped in multiple by what the operators call a "power." To the periphery of a horizontal disk several radiating wire ropes are attached. The ropes rest on X-shaped rockers, placed at short intervals, and are connected, at the remote end, with the pumps, which may be half a mile or more distant from the power. By means of a gas engine the disk is made to turn half revolutions, thus tightening the ropes and pumping several wells simultaneously. By operating a power for a few hours and then passing to another, a single man may care for a large number of wells and thus decrease the cost of production. The gas for the engine is either obtained from the oil wells or from a "gasser" in the vicinity and costs very little. By the above means, wells producing only ¼ barrel of oil a day are pumped, and are considered remunerative.

The little oil pool at Humphrey has not greatly increased in productiveness. The wells in this group are small producers, and the field does not, at present, give promise of further profitable extension. A new well was drilled about Aug. 15, 1902. It was located on the Edwin Guthrie farm about 450 feet northeast from another well, which has been pumped since 1898. At last accounts the well had 100 feet of oil in it, but had not been pumped.

No change is reported from the field near Allegany village. The Rice brook pool is practically exhausted and has almost ceased to produce. About 1898-99 several good wells were opened on the Indian reservation north and northwest of the Chipmunk field. This accession has now so fallen off in productiveness that its owner, the South Pennsylvania Oil Co., regards it as "played out." Important additions which appear to be permanent have been made farther south. The little pool at Irving's Mills has been connected toward the east with the Chipmunk field, which has been also extended on the south so as to include the greater part of lots 6, 14, 22 and 28, Carrollton. Another spur from the eastern end of the Chipmunk field extends the line of this addition easterly into lots 3 and 1, Allegany. The Chipmunk-Flatstone pool has also been connected by paying wells with the Bradford field near Limestone. The small pool on lot 1, near the headwaters of Flatstone creek, has also been connected with the main oil field on the south.

Allegany county

In 1901, five wells were drilled within a mile of Short Tract village. In all of these amber oil was found at depths ranging between 600 and 800 feet. Only one well was pumped and that has since been abandoned. It was said to yield three barrels of oil a day, but this I have been unable to verify. Concerning this well, Mr W. S. Mills of Fillmore writes: "The casing is full to overflow, but whether its contents are all oil or partly salt water, I can not say."

Exploration for oil has also been carried on about 1½ miles northeast of Friendship. A well on the McCarthy farm on the east side of lot 30 struck a vein of oil at 1200 feet which yielded ½ barrel a day. Another well with similar conditions and yield was bored on lot 22. These wells are not considered important.

A small pool consisting of about 15 wells has been opened at Dry Brook about 2 miles northeast of Scio, on lots 56 and 41, Amity, and lot 12, Ward, townships. These are small producers—1 to 5 barrels, but pay at the present price of oil.

Scio Oil & Gas Co.'s no. 9 on the Fuller farm, lot 56, Amity, was completed about Oct. 25, 1902. It filled a 65 barrel tank at the first pumping and had to be shut down till more storage tanks could be erected. A well on the Reese farm, southeast of the Fuller well and belonging to the Baldwin & Norton Oil Co., completed about the same time, gave 57 barrels the first head. As in the previous case, pumping was delayed for lack of storage. These two wells, the best drilled in Allegany county for many years, indicate that the center of the Scio pool may lie between the old Scio and Dry Brook fields.

In October 1902, the Norton Oil Co. of Wellsville put down a well on the Miles farm, southwest of Scio toward Albertson, in the hope of connecting the Scio field with the northern spur of the main oil field toward Allentown. The well, however, proved to be a light producer.

The Andover field has been extended slightly on the eastern side, so as to include two tiers of lots on the southwest corner and side of Greenwood, Steuben co. The extension north includes, also, lot 8 in the first tier. In 1901 three wells were drilled on lots 23, 25 and 48, Greenwood, the last or most easterly being nearly barren. A notable extension, also, has been made south of the village of Independence, where 60 wells have been drilled within two years. The new wells are located mostly on lots 80, 81, 75, 74, 97 and 96, Independence. Two small wells have also been drilled east of the new extension on the northwest part of lots 7 and 8, West Union. The Independence wells are all small — 1 to 3 barrels. Oil comes from the Fulmer Valley sand, which is 200 feet lower than the Penney sand. These small wells are shot with heavy charges—200 to 300 quarts—of nitroglycerin.

Three or four wells have also been drilled in the south part of Granger township. A fair show of oil was obtained, but not enough to pay for drilling.[1]

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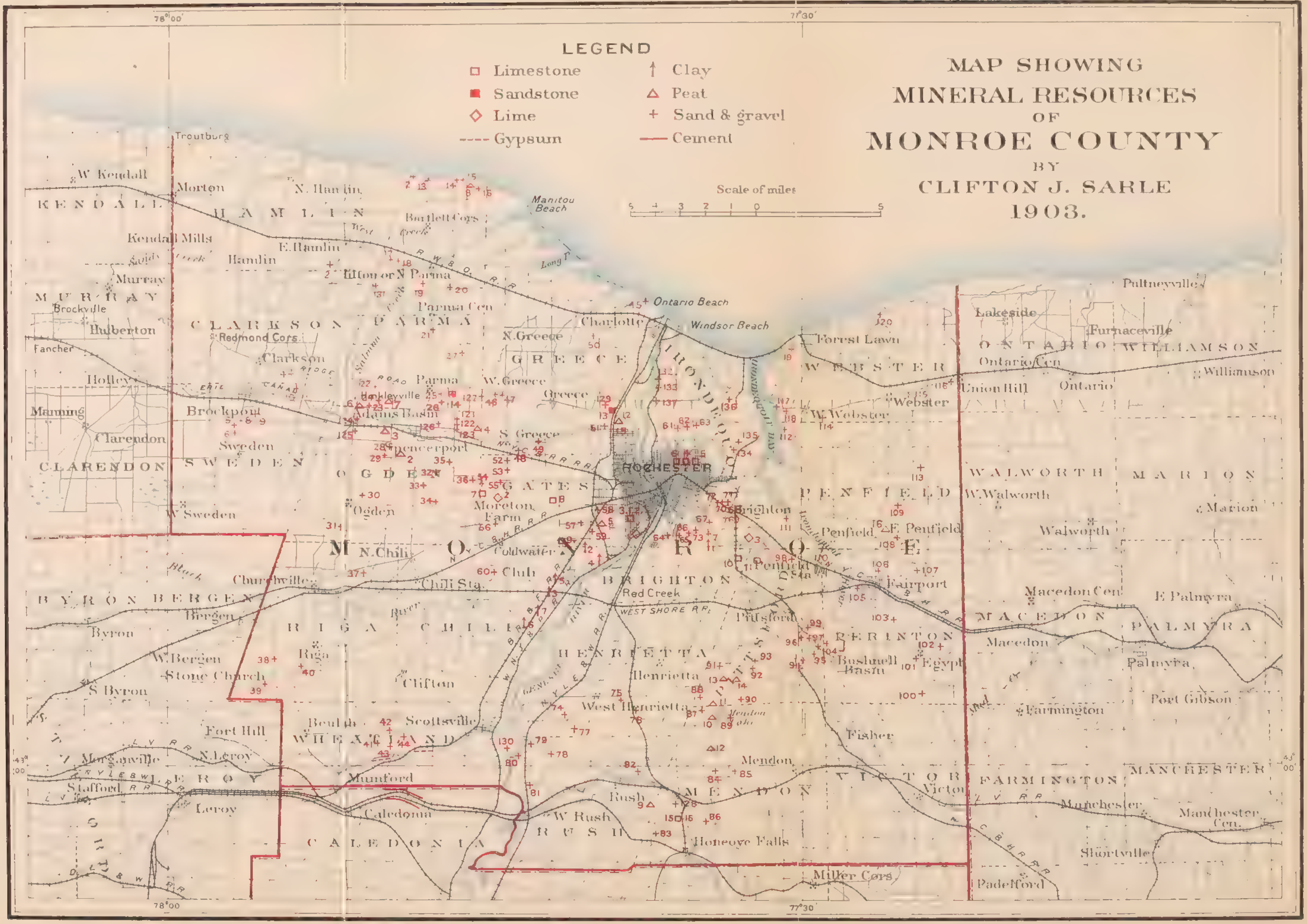
[1] Information from W. J Penny, president Natural Gas Co., Andover.

PLATE 29
22d ANNUAL REPORT STATE GEOLOGIST.
56th ANNUAL REPORT STATE MUSEUM.



MAP SHOWING
MINERAL RESOURCES
OF
MONROE COUNTY
BY
CLIFTON J. SARLE
1903.

ECONOMIC GEOLOGY OF MONROE COUNTY AND CONTIGUOUS TERRITORY

BY CLIFTON J. SARLE

Monroe county, in western New York, has an average length from east to west of 32 miles, and a greatest breadth of 26. The total area is 682 square miles divided into 19 towns. It may be roughly compared to an inclined plane, having an elevation in the southern portion of about 700 feet above tide, and in the northern, at Lake Ontario, of 246 feet, the local base level.

The broad topographic features of the county are due to the varying character of the underlying rock formations and the consequent difference in the rate of their destruction. Within the area there are one sandstone and four important limestone horizons alternating with five shale horizons. These lie in nearly horizontal layers, their successively truncated edges facing northward and stretching eastward and westward through the county. The shales which weather most rapidly, produce areas of depression, while the others cause areas of prominence and shelves or platforms.

Superimposed on these features are those due to the distribution of the drift, often more conspicuous because of their limited extent. The drift, while reproducing in a general way the broad features of the underlying rock surface, is irregular in its distribution. It is usually arranged in more or less well defined east and west ridges, or moraines, though in some parts of the county, it is raised into elongated north and south mounds, or drumlins, both of these forms being the result of direct deposition from the glacier. In addition to these, are other features, the result of the sorting and arranging by water of the material freed from the glacier, such as serpentine north and south ridges of gravel known as eskers, supposed to have been formed beneath the ice sheet by running water; mounds of sand and gravel formed by the *débouchure* of streams from the ice front into ponded water; beach and bar structures formed in connection with the glacial lake history of the region; gravel lobes formed at the mouths of streams flowing into these glacial lakes from the valley sides; and clay and sand plains formed in the deeper portions of these lakes. Subsequent erosion has done much to modify the original features.

From the rock formations and the overlying drift are obtained stone, lime, gypsum, sand and gravel, clay and peat. In Livingston county, ½ mile south of the Monroe county border, is an extensive deposit of marl which is used in the manufacture of cement. Though there are in Monroe county smaller deposits of this material, no attempt has been made to utilize them.

Beginning at Lake Ontario, the first hard rock exposed is the Medina sandstone. It underlies a belt of country averaging about 5 miles in breadth and has a total exposed thickness along the Genesee river of about 150 feet. In the basal 100 feet it is a red shale or clay with some benches of argillaceous sandstone. The shale rapidly disintegrates on exposure and is suitable for brick manufacture. In the upper 50 feet or more the formation is a red sandstone with shale partings, the less argillaceous parts being suitable for building purposes. This sandstone is developed on a small scale at various places along its outcrop.

The next formation is the Clinton, which underlies a belt of country averaging 1½ miles in breadth. It consists of two shales and two limestones, aggregating nearly 80 feet in thickness. The shales alternate with the limestones, the group beginning with a shale. The shales have never been used, but experiments show that they could be utilized in making brick. The lower limestone, 20 feet thick, is a thin layered, silicious limestone with shale partings. At one time it was quite extensively quarried along the Genesee. The upper is a thin layered limestone 18½ feet thick, with shale partings. Though it disintegrates rapidly on exposure, it also has been quarried to some extent along the Genesee.

Above the Clinton is the Rochester shale, forming a belt averaging about 1½ miles in breadth. It is a calcareous shale or very impure muddy limestone, about 80 feet in thickness.

On this rests the Lockport dolomite (limestone) underlying an area about 4 miles in breadth. It has a thickness in the neighborhood of 100 feet. It varies somewhat in its character, but may be described as a magnesian limestone of drab color. It furnishes the best stone in the county, both for building purposes and for making lime.

Following on this is the Salina formation. It is 600 or 700 feet in thickness and underlies a belt of country 10 to 12 miles in breadth. In the basal portion it is a soft shale, variously colored, disintegrating rapidly when exposed to a clay which might be used for brick. In the upper portion it carries beds of gypsum, succeeded by the Waterlime or Bertie beds. The gypsum beds are worked in the southwestern part of the county, and the Bertie limestone at one place in its southern part.

Succeeding this in the two extreme towns, is the Onondaga limestone. Like the Bertie it forms fair building material, but owing to its remoteness from a market, is only quarried at one place.

The distribution of the sand and gravel of the county is extremely irregular. Their occurrence can be only roughly indicated by locating the more extensive deposits. These comprise the Turk hills, partially included in the southeast corner of the county; an area of deposits extending from these hills, northwestward to Irondequoit bay; mounds and eskers of the Mendon pond region; the Pinnacle hills, which begin southeast of Rochester, in Brighton village, and extend along the southern outskirts of the city to the Genesee; a continuation of these which can be traced westward, though less clearly, to Brockport, a distance of 18 or 20 miles; an area of sand and gravel hills in the northern part of the town of Chili; another partially included in the southwestern corner of the county; the Ridge road which extends eastward and westward throughout the entire length of the county, passing along the northern outskirts of Rochester; and the beach of Lake Ontario. Besides these are hundreds of smaller deposits scattered over the areas between.

Of these areas, the material obtained from the Pinnacle range is undoubtedly the best, notably the sand. Much of the gravel in the southern part of the county carries a large admixture of material from the upper calcareous portions of the Salina shale, often amounting to over 50% of the deposits. It is of interest to note, as pointed out to the writer by Mr E. P. Clapp, of North Rush, that all of the gravel deposits in the southern part of the county lying along the east side of the Genesee valley, are located on the southeast side of drift hills, while those on the west side are on the southwest side of the hills. Several large gravel deposits at the sides of the valley, for example, the one used by the Buffalo, Rochester & Pittsburg Railroad, at Scottsville, were probably formed by large streams debouching into the deeper water of a glacial lake once filling the valley.

The clay deposits of the county are found in low lying areas or depressions. The most extensive lies at the foot of the Pinnacle range and extends with irregular narrowing outline southwest along the Genesee.

The peat deposits lie in depressions formed by stream erosion or by the irregular deposition of the drift.

The location of the marl deposits, like those of the peat, may be either in natural depressions in the drift or in basins formed by stream erosion. These deposits are of two kinds: those formed by precipitation from hard water and those resulting from the accumulation of the shells of fresh-water mollusks. The former are limited to the regions underlain by the Salina and Onondaga formations. Their origin is due to the large amount of calcareous shale and limestone in the drift, from which the water derives its lime. The latter are not limited in their distribution and usually occur beneath peat deposits. So far as known, they are comparatively shallow.

Rochester, having a population of upward of 163,000, or over three fourths that of the entire county, is, so far as the areal distribution of these natural products permits, the center of the various industries based on them.

Quarry industry

All the important or regularly worked quarries of the county are within the limits of Rochester. The Lockport dolomite which underlies the greater part of the city furnishes 99% of its house foundations. The remaining material is either shipped into Rochester or comes intermittently from two or three small quarries in the Medina sandstone northwest of the city. The last is of little importance.

The limestone quarries are mainly located in two regions, the Frost avenue and neighboring quarries in the southwestern part of the city, and the North Goodman street quarries in the northeastern. The Frost avenue quarries are in the upper portion of this formation, while those of Goodman street are in the lower. Pike's quarry(1), on Frost avenue, is probably the largest excavation of its kind in the city, though not the most extensively developed at present. The property is owned by James D. Pike, of 158 Genesee street, and is worked for building stone by Herman Miller, of Susse street, formerly of the Miller & Jones Co., contractors. About 1000 cords of stone and 300 loads of rock chips have been drawn this year. Adjoining this quarry and on the corner of Frost avenue and Snyder street is located that of E. R. Tanner(2). The output for the past year, for building purposes, was 1000 cords of stone and for street improvement, 400 yards of macadam and 200 yards of chips. J. B. Nellis, 818 Plymouth avenue, has worked the old Nellis quarry(3) (located on Arnett avenue off Genesee street) some this year; also considerably, during the latter part of the season, the old quarry on the corner of Flint street and Jefferson avenue. About 80 cords were taken from the latter.

The Goodman street quarries are three in number. The most extensively worked is that of Foery & Kastner(4), located at the end of Central park, office, 315 Joseph avenue. The output for the past year was 7000 yards of macadam and 400 cords of building stone. Just north of this is the quarry of Whitmore, Rauber & Vicinus(5), office, 279 South avenue. The quarry of Lauer & Hagaman(6), the southernmost on Goodman street, adjoins the above. The output from this was 583 cords for building purposes, and 242 yards of macadam. The amount of macadam for street repairs obtained by crushing the cobblestones and Medina blocks of old pavements on streets improved, often exceeds in amount that taken from the quarries. For this work, the company has a large Gates portable crusher.

H. S. Brown, 334 Hudson avenue, has a quarry in the thin basal beds of the Lockport dolomite. This quarry has been worked but little this year.

In the three quarries on Goodman street, the stone for macadam is crushed in stationary Gates crushers; the drilling is done by steam; and the blasting with dynamite. In the other quarries of the city, with the exception of Pike's, where steam is occasionally used, drilling is done by hand and blasting with black powder.

No dressed stone is sold from these quarries. Building stone sells at $3.50 to $4 a cord; macadam at $1 a yard when sifted, when not, at 75 cents to 80 cents; the siftings at 90 cents a yard. In the smaller quarries rock chips, or quarry rubbish, sell at 20 cents a load.

A few miles west of Rochester are several small quarries in the Lockport dolomite. One of these owned by Henry Trabold and Vogt Bros.(7), 1½ miles northeast of Coldwater station in the town of Gates, has been worked by Chambers & Casey, contractors, of Rochester. From it 1100 yards of stone were used for macadamizing the Buffalo road. From another(8) just west of Gates Center, on the site of an old limekiln near schoolhouse no. 6, Gates, on the north side of the Buffalo road, 800 yards of macadam were used by the above mentioned firm for the same purpose. A quarry(9) on a small creek ½ mile south of Gates Center is owned by Edward Marsh. It is worked irregularly.

East of Rochester, in the town of Pittsford, Whitmore, Rauber & Vicinus of Rochester have taken out 5254 yards of Lockport dolomite from the bed of West branch of Allen creek, on the lands of J. Christ(10) and C. Teare(11), for macadamizing Monroe avenue.

The Medina sandstone quarries are located west of the Genesee, near the Ridge road. In the town of Greece, ⅛ of a mile north of the Ridge road and just west of the Charlotte branch of the Buffalo, Rochester & Pittsburg Railroad, is a quarry belonging to Bishop McQuaid(12). The rock is taken from a massive tier about 45 feet from the top of the formation. During the past year a considerable amount has been removed for monument foundations and for private building purposes. A quarry adjoining this is owned by J. A. Rainesford(13). It is only worked shallowly. About 75 cords have been sold during this year.

George A. Allen and William Britton own quarries south of the Ridge road, just west of the Scott road, and ½ mile west of the above quarries. These quarries are at a little higher level in the Medina. This year the owners have only worked them for their own purposes.

In the town of Parma, on the farm of Luther T. Bradshaw, south of the Ridge road, is a quarry which is worked irregularly(14).

One mile north of Honeoye Falls, on the south side of Honeoye creek, on the Honeoye branch of the Lehigh Valley Railroad, are two quarries owned by John Tinker. The one east of the railroad is in the basal beds of the Onondaga limestone(15), the one west is in the top of the Bertie limestone(16), with the weathered Onondaga as a capping. These are worked but little.

Contracts for macadamizing roads of Monroe county

During the past season contracts for macadamizing 48 miles of road in Monroe county have been let. The following list gives the contractors' names, sections of the road, material used and its source.

West Henrietta road. 6 237 miles; 13,000 yards of Leroy limestone (Onondaga); contractors, Anderson, Thomas & Brown, Glens Falls.

Scottsville, section 1. 2.254 miles; 4700 yards of Leroy limestone; contractors, John Dunfee & Co. Syracuse.

Scottsville, section 2. 7.537 miles; (contract only) 16,000 yards of crushed stone. Stone may come from quarry just south of Scottsville or from Leroy. Contractors, Anderson, Thomas & Brown, Glens Falls.

Clifton road. 3.623 miles; Leroy, 7700 yards (contract only); contractors, John Dunfee & Co. Syracuse.

Hamlin road, section 1. 4.637 miles; 6600 yards of crushed Medina sandstone boulders used as foundation, and 3300 yards of granite boulders used as dressing; contractors, Casey & Murray, Rochester.

Hamlin road, section 2. 4.057 miles; 5830 yards of sandstone boulders for dressing; contractors, Casey & Murray.

Buffalo road, section 1. .0364 miles; 800 yards of limestone from the Doty quarry north of the road and just west of Gates Center; contractor, George Chambers, Rochester.

Buffalo road, section 2. 5.089 miles; 1100 yards of Lockport dolomite from conjoined quarries of Henry Trabold and Vogt Bros.; contractor, George Chambers, Rochester.

Monroe avenue. 4.226 miles; 8200 yards of Lockport dolomite, in part boulders and in part from the bed of West branch of Allen creek, Pittsford; contractors, Whitmore, Rauber & Vicinus, Rochester.

Webster road, section 1. 1.576 miles; 3450 yards of Lockport dolomite from Foery & Kastner's quarry, Goodman street, Rochester; contractor, Horace M. Cowles, Rochester.

Webster road, section 2. 2.96 miles; limestone from fields on what is known as Atlantic avenue, road east of the Irondequoit creek and in the vicinity of the Black Oak tavern; contractor, F. A. Brotsch, Rochester.

Webster road, section 3. 3.398 miles; for foundation, 5000 yards of macadam made from field stone, for top, 2500 yards of granite boulders; contractor, Henry L. Smith, Long Island City.

Webster road, section 4. 2.879 miles; will use 4200 yards of macadam made from limestone boulders; 2100 yards from granite boulders.

Clay industry

The clay industry of the county is entirely centered in and about Rochester. The supply of clay used, excepting some imported from outside the State for pottery and sewer pipe manufacture, is obtained from an area of country about 10 miles in breadth and with a greatest length from north to south of about 7 miles, its northern edge abutting the Pinnacle range. The deposit lies in the towns of Brighton, Henrietta and Chili. The clay is of Quaternary age and was formed as a fine sediment at the bottom of the glacial waters ponded against the ice front at the time of the formation of the Pinnacle range. Though generally red, it varies somewhat in color, being in some places yellowish or limonitic.

Its distribution is irregular, its depth running from nothing to 10 or 12 feet. The average thickness at the various places where it is worked is something under 4 feet. It may be thick or thin on a knoll; in some cases it is covered by sand, in others it underlies gravelly knolls. Some of that along Black creek may be connected with the history of that stream. The beds in its vicinity are underlain by quicksand. At other points it is usually underlain by hard pan or argillaceous gravel. At points in the clay, boulders are found in heaps or ridges of small size known as "hogbacks."

The clay is worked in two regions; one 3 miles east of the Genesee and the other a short distance west.

The Rochester Brick & Tile Co. office, 243 Powers block, Rochester, is located at the eastern of these localities(1), in Brighton, on Monroe avenue, about 3 miles from the center of Rochester. It manufactures brick, draintile, flue linings, fire brick and building materials. The clay bank of this company is ½ mile south of the works and is of a red color with a little sand or loam over it at some points. This sand is utilized with the strong clay, so that no sand need be added. If too much sand is found in the clay at one point, it is equalized by mixing it with clay from another. As high as one fourth sand can be used. The clay at the present point of the working is 12 feet deep. It becomes a little lighter colored toward the bottom and passes into a hard pan or argillaceous gravel. Occasionally a small hogback of boulders is struck in this bank, though none have been uncovered this year.

The material is plowed down as wanted and shoveled into cars, which are drawn by horses to the works, where it is dumped out on a platform in front of the machines. If bricks are to be made, it is shoveled into a two roll crusher and passed through once and out on an elevator or belt, which carries it to the pug mill, where it is tempered and prepared for the brick machine. From the end of the pug mill, it is fed directly into the upright soft mud machine. The material is worked down through into molds by means of a series of horizontal knives set at an angle and turned about a vertical axis. From the molds, the bricks are dumped on wooden pallets, trucked away and placed in the racks to dry. There are three of these soft mud machines, placed on a line shaft at convenient distances from the rack system. Thirty-five thousand bricks can be manufactured by a machine in a day. The bricks, when dry enough to handle, are "edged up" in the racks, where they remain till dry enough to go to the kiln.

The principal part of the burning is done in the Wingard and continuous kilns. The Wingard is an up-draft kiln consisting of side walls and stationary fire boxes. There are six of these kilns at the factory. Bricks are piled into them 52 to 54 high, the capacity being 500,000 to 600,000 each. When filled, the open ends are scoved up, that is, sealed with a layer of burnt brick plastered over the outside with clay. About eight days are required for burning and six for cooling. The bricks are left in the kiln till sold. The continuous kiln is square in form and is divided into 16 chambers, eight on a side, holding about 35,000 bricks each. The process of burning this kiln is firing down one side, crossing over and back on the other side, continuing this process around indefinitely, the filling and drawing of the different chambers of the kiln proceeding as the contents are ready. The bricks in all stages of burning from green brick to the finished product ready for delivery, are found in the chambers at one time. The firing of the kiln is done from the top, the heat passing through several chambers before going into the chimney flues. Soft coal slack is used.

The company has a machine for the manufacture, by the stiff mud process, of hollow ware such as draintiles, flues and fireproofing material. This machine is called an auger stiff mud machine and has a capacity of 100 or more tons a day. The number of feet of tile manufactured in a day depends on its size, it being possible to make more of the small tile, in case of two inch draintile, about 40,000 feet. This product is burned mainly in two round down-draft kilns. The time required for burning is four or five days and for cooling, three days. The clay for this ware is prepared in a like manner to that for the soft mud machine with the exception that four roll crushers are used instead of two. The pugging process is the same as in the brick, the material going directly from the mill to the auger machine. These tiles are dried in racks, and, owing to their being hollow, do not have to be edged up.

In the busy season the company employs an average of from 100 to 140 men. The men work by stint and, if making brick, are given 35,000 a day to do; so, starting at 7 o'clock a. m., taking a half hour nooning, they are through at 3 o'clock p. m.

The end of the brick season for this year was Oct. 19.

Whitmore, Rauber & Vicinus formerly had two brickyards, one(2) on the Buffalo, Rochester & Pittsburg Railroad, about 4 miles from the depot in Rochester, the other on Monroe avenue east of the Rochester Brick & Tile Co.'s yard. They have now consolidated their works and carry on business at the former locality under the name of Rochester German Brick & Tile Co. The company manufacture brick, draintile and hollow ware.

Its clay bank is located ¼ mile from the buildings. The material at present runs about 3 feet deep. The clay is brought to the yards by a small steam engine. It is prepared in the same way as by the Rochester Brick & Tile Co. The company has four stationary up-draft Philadelphia kilns and one Wilford continuous kiln, the latter being used almost exclusively. The Philadelphia kiln, like the Wingard kiln used by the Rochester Brick & Tile Co., consists of side walls and open ends, but, instead of confining four fires in one chamber, the Philadelphia kiln is fired under each arch. The number of men employed in the busy season is between 100 and 140.

The Maplewood brickyard(3), belonging to the Hiram Sibley estate, office in Triangle building, Rochester, is located at Maplewood, on the Buffalo, Rochester & Pittsburg railroad, 2 miles south of the Rochester German Brick & Tile Co.'s yard. This company confines itself to making common building brick. The works are superintended by Robert Gay.

The bank is located a mile farther south along the railroad. The clay at present runs about 3 feet thick and is underlain by quicksand. It is lighter colored than that of the Rochester Brick & Tile Co., and the lower portion is lighter colored than the upper.

The clay is spaded into cars, and drawn to the works by a small steam engine. It is mixed with sand and tempered by hand in a pit, a process known as puddling, and then shoveled into the soft mud machine. The company has one Wilford continuous and four Wingard up-draft kilns.

On an average 50 men are employed during the brickmaking season, which is from April to October or November, according to the year. Boys are employed in bringing pallets and in edging brick. The pallet racks are arranged as at the Rochester Brick & Tile Co.'s yards. The teaming is done by contract.

The output during the past year was 4,923,500 bricks, bringing on an average $6.83 a thousand.

Pottery industry

One pottery is owned by John Schmidt. The shop is located at 166 Scio street, Rochester. The bulk of the material used is Quaternary clay obtained in the town of Chili, at a point(4) 4 miles south of the center of Rochester, between the Scottsville road and the Western New York & Pennsylvania Railroad. In addition to this, clays from New Jersey and Ohio are used for glazes. The product consists of flowerpots, some of which are glazed by slipping. The large pots are made on a potters' wheel, the small, in presses with changeable dies. One kiln is used. Four men are employed.

Sewer pipe industry

There are two sewer pipe manufactories in the county, both located at Rochester. The New York Sewer Pipe Co., (office in German Insurance building, Rochester) disposes of the entire output. The factory of the Rochester Sewer Pipe Co. is located at 545 Oak street, and the office is at 247 Powers building. The president and general manager is R. H. Gorsline; director, W. H. Gorsline. Most of the clay used in this factory comes from the town of Chili, 1 mile south of Maplewood station(7). With this is used a New Jersey fire clay from Raritan river (Cretaceous), as the Chili clay will not stand vitrifying alone.

The Chili clay is yellow or limonitic, averaging 3 feet in depth, and is underlain by quicksand. In some parts of the bank the clay becomes sandy, too sandy for use, 10% to 15% being the limit at which it can be used. When sand is needed, it is obtained in stripping this bank. The material is brought to the works on the Buffalo, Rochester & Pittsburg Railroad. At the bank the cars are run in on a siding, and the clay is thrown in from the spade. The New Jersey clay is shipped by boat on the Erie canal. Thirty boat loads, or 5000 tons of this clay and 8000 tons of the Chili clay, it is stated, were used last year.

The process of manufacture of sewer pipe is as follows. The clay, roughly proportioned by wheelbarrowfuls, is dumped into combination wet pans, where it is ground, mixed and tempered. The apparatus consists of two large rotary crushers or mullers, which, turning, rotate a large pan beneath them, the material being crushed against the bottom. This is then shoveled out on a horizontal belt conveyor, which dumps it into a pocket, from which it is conveyed by a belt elevator to the top of the building; from there it is dropped on other belts, by means of which it is carried to the presses. These presses consist of two cylinders of different sizes, the larger, or upper, being a steam cylinder which drives a piston and disk down into the smaller one beneath, into which clay is fed. By this pressure, the clay is forced down through dies and comes out as green tile. It is said that a pressure of 117 pounds to the square inch is exerted on the 42 inch steam head of the press, which, transmitted to the 20 inch clay head, gives a resulting pressure on the latter of nearly 30 tons a square inch, and insures a close bodied product. In one press any sized pipe can be made by changing the dies. The sizes made range from 3 to 30 inches, the 30 inch being rarely made. After leaving the press the pipes are conveyed to the drying room and set on slat floors, underlain by steam pipes, to air-dry. When the clay leaves the press, it is in a comparatively soft state and is allowed to stiffen till of the proper temper, after which the pipes are turned and trimmed and, when necessary, are rounded by putting a circle inside and "drawing them back." The junction work, or putting in Y and T branches, is all hand work and is done the same day that the pipe leaves the press, as it is then at the proper temper. The time required for drying varies according to the size of the pipe. For the 24 inch, three weeks are needed. After being completely dried, they are put in kilns and burned. In the kilns the pipes are "nested," that is, the smaller set within the larger to economize space, but not too close, as it would interfere with the glazing. When the ware shows a sufficient amount of burning, salt is thrown on the fire, when a fusion of the surface of the pipes takes place, which constitutes salt glazing. The larger pipes require six nights and five days, or 132 hours of continuous burning, called a six day run. Approximately the same time is required for cooling as for burning. When a kiln is cooled, the pipes are wheeled into an open yard.

The company has 10 square down-draft kilns. Soft coal is used, about 100 tons being consumed in a week under the boilers and in the kilns.

Sixty men are employed the year through. Last year the factory was run for 49 weeks, three weeks being lost owing to the lack of coal, due to delay of traffic, from the heavy snows and thaws.

The output for the last year was about 600 carloads, seven kilns, holding two carloads each, being burnt each week. Twenty per cent of this is consumed locally.

The Standard Sewer Pipe Co., on Lexington avenue, office, 8 Caledonia avenue, uses clay obtained mainly from two beds in Chili, one(5) just west of the Maplewood brickyard, the other 1½ miles farther south and just beyond Black creek(6). Both beds are connected by sidings with the Buffalo, Rochester & Pittsburg Railroad, which runs past the works. The bed at Maplewood is a red clay about 3 feet deep, underlain by an argillaceous gravel; the other is a light colored clay about 4 feet deep and underlain by quicksand. The clay is dug up with spades. The company also uses the New Jersey fire clay. The process of manufacture is the same as that of the Rochester Sewer Pipe Co. This company has five square and four round, down-draft kilns, with six to eight fireplaces each, some fired on grates, others on the floors. The fires are separated from the contents of the kiln by fire walls.

This year the company has been mainly making conduit pipes and has a double conduit press, or one feeding two dies, one on each side. Six hundred carloads of material have been put out during the past fiscal year. Local trade takes about one tenth of the output.

Lime industry

In Monroe county there are at present but three limekilns burning: one(1) in the southern part of Rochester on the corner of Jefferson avenue and Cottage street; one(2) about 3 miles west of Rochester in the town of Gates, $\frac{1}{3}$ mile north of the Buffalo road;

and one(3) in the town of Brighton, about a mile east of the village, on the south side of the Brighton-Pittsford highway.

The one in Rochester is owned by Lamson & Leason, who work it themselves under the name of Hurd Lime Kiln Co. They have a single center-draft kiln, with four fireplaces, two on a side. The kiln, with a capacity of 600 or 700 bushels, is filled from a bucket raised by steam. Soft coal is used in burning. The rock is obtained from J. B. Nellis who quarries it a little farther west on Cottage street from a level which is but a few feet below the zone of silicious concretions carrying the Guelph fauna. It is mainly made up of drifted bryozoan fragments.

The amount of stone used during the last year was 429 loads, or about 107 cords. A cord of Lockport dolomite weighs, according to Lauer & Hagaman, 14,000 pounds. Mr Lamson says that two pounds of stone when burned make one pound of lime. From this it is estimated that the output of lime was about 10,700 bushels (70 pounds to the bushel). Besides selling quicklime in the ordinary commercial form, the company grinds part of it with millstones, for use in the glass works of F. E. Reed, 380 Plymouth avenue. Three loads of about 37 to 38 hundredweight each are used in a week.

The two remaining kilns burning belong to the Rochester Lime Co. of 209 West avenue, Rochester. The principal proprietor is Mr F. C. Lauer, of Portland avenue. The kiln in Brighton is known as the May kiln and is in charge of Charles Rambert. That in Gates is known as the Snow kiln, and is in charge of R. Wakelee. At each of these factories there are two kilns, each having four fireplaces, two on opposite sides, and a central draft. Their capacity varies from 300 to 500 bushels. Wood and coal are used in burning. The stone is drawn in cars, by steam power, up an inclined track to the top of the kiln. When first started, the kiln runs from 16 to 24 hours before the first draw of lime can be made. It can then be filled at the top as fast as the lime is drawn from beneath. Ten to 12 men are employed at the Snow kiln and 8 to 10 at the May kiln. This, of course, does not include help drawing in lime or distributing it. During the last year 150,000 bushels were sold at 25 cents a bushel. A considerable part of the lime is shipped out of town.

The level from which the rock is obtained at the May kiln is about 12 feet below the level of the silicious concretions; that at the Snow kiln probably a few feet lower.

Cement industry

The Iroquois Portland Cement Co., with headquarters at Cleveland O., has erected an extensive plant 1 mile east of Caledonia, Livingston co., and ½ mile south of the Monroe county line and has been operating during the latter half of the year.

The plant is equipped on the most modern plan, having laboratory, engine house, machine shop, storehouse for raw material and mill, all in separate fireproof buildings.

In the mill are clay and marl shed, drying room, room for grinding the raw product, burning room, room for grinding the burnt product and storage and packing room. The equipment of these is as follows: two rotary kilns, 30 by 50 feet, for drying marl and clay; two tube mills for raw grinding; 2 rotary kilns, 60 by 6 feet, for burning; and two tube mills and one Williams mill for grinding and refining. The works are run by electricity, the power plant consisting of three 250 horse power boilers and two 250 horse power engines, tandem compound, directly connected with two 200 kilowatt alternating current generators, by which power is distributed to all parts of the plant where it is to be used. Alternating motors, inclosed in dust-proof cases, are used.

The marl deposit of the company begins just east of the plant and extends in an easterly direction along both sides of the tracks of the New York Central & Hudson River Railroad and Lehigh Valley Railway for a distance of about 2 miles. It lies in a narrow valley 80 feet above the Genesee, inclosed by hills of gravel, 25 to 100 feet high, and drained by Dugan creek, a small stream. The deposit covers an area of 400 acres and runs from 5 to 15 feet in depth, averaging 7. It is a very pure, cream-colored calcium carbonate, which appears to have been formed by precipitation or incrustation on vegetation in this swamplike area. It is usually very fine grained, but in some portions it is said to carry layers, from a few inches to several feet in thickness, of grit or coarse travertine. This however is usually fine enough to go directly to the mill without grinding. In some places, at the bottom of the deposit, there is a mixture of marl and moss, at others there are intercalated layers of muck ranging from a few inches to 4 feet in thickness.

Owing to the fact that there is very little vegetable mold at the top, and that all the organic matter burns out, there is no need of stripping. In the marl are large numbers of the shells of fresh-water snails, common in the region, while bones and deer horns are frequently found. In this connection it is interesting to note the uncovering at a depth of about 7 feet of a tree which showed evidences of fire.

The material is excavated by means of a steam dredge and loaded into trolley cars, which convey it up an inclined track to the works.

The company has 70 acres of clay on the flood plain of the Genesee, at Canawaugus. The clay is very homogeneous and of bluish color, running about 12 feet in depth. It is spaded into cars and shipped by the Erie Railroad to the works.

The clay and marl are both stored till perfectly air-dried. From the storage bins, the raw material is thrown into hoppers, which lead into comminuters of the coffee mill type, from which it is taken by a bucket conveyor to rotary drying kilns, through which the heated gases from the calcining kilns are conducted, the temperature being about 1700° Fahrenheit. The time consumed in drying a given quantity of clay or marl is about 20 minutes. The clay and marl are then conveyed by bucket elevators to separate storage bins from which they are admitted to hopperlike scales and proportioned for mixing. From here they are conveyed to a tube mill and ground, and then to storage bins. The mixture is next introduced into the upper end of the large, nearly horizontal, rotary kilns. The material is gradually worked down through these inclined tubes by rotation, and in about an hour falls into cooling bins in the form of clinkers. The cooled clinker is conveyed to ball mills and ground, then pulverized in a tube mill. This material is then carried to the storage room, where it is prepared for shipping.

The kilns are fueled by blowing into them pulverized coal and are heated to a temperature of about 3000° to 3900° Fahrenheit. The capacity of the mill is 450 barrels of cement a day.

AVERAGE ANALYSES OF THE CLAY AND MARL, IROQUOIS PORTLAND CEMENT CO.

	Marl	Clay
Lime (CaO)	53.5	.8
Silica (SiO_2)	.4	62.5
Alumina (Al_2O_3)	.2	20.2
Iron Oxid (Fe_2O_3)	.2	7.5
Magnesia (MgO)	.3	1.8
Sulfuric anhydrid (SO_3)	1.7	.4

Sand and gravel industry

The sand and gravel supplies of Rochester are secured from two main sources, the Pinnacle hills, which border the southern and southeastern side of the city, and the Ridge. Sand is also obtained in small amounts from a thin mantle strewn over the intermediate territory in the village of Brighton. Some is brought on the Erie canal from Bushnell's Basin. The greater part comes from the pits in the Pinnacle hills. Of these, the one near the Eastern Wide-waters, just beyond the city limits, in the town of Brighton, and known as Cobb's hill sandpit, is worked the most extensively. It is owned by William Cobb and leased and worked by Thomas Lynn, of Alliance avenue. More business is done at this pit than at all the others about Rochester combined. The output for the fiscal year just closed could not be ascertained exactly but was approximately 30,000 yards of sand and gravel. Of this, 3000 yards were used for repairing the towpath of the Erie canal. This pit affords the sharpest sand and also the greatest variety, ranging from the finest molding sand through brick, paving, plaster, coarsest core, to stone sand, and yields an excellent gravel for concrete.

The various grades of material found here are arranged in such a way as to exhibit all the features of cross bedding, oblique layering, high inclination of beds and rapid changes from one material to another, which would be expected in sections of deposits formed where a swiftly flowing stream debouched into deep standing water. It is probable that the succession of peaks or hills which make up this range mark the points of *débouchure* of streams which drained the ice sheet and

Plate 30

By courtesy of E. A. Fisher, city engineer, Rochester.

Cobb's hill sandpit, town of Brighton, Monroe co.

By courtesy of E. A. Fisher, city engineer, Rochester

Cobb's hill sandpit, town of Brighton, Monroe co.

By courtesy of E. A. Fisher, city engineer, Rochester

Cobb's hill sandpit, town of Brighton, Monroe co.

dropped their burden at the edge of the glacial lake. Many of these peaks may have been formed by the shifting of but a single stream. The range is marked by kettlelike depressions which are commonly known as kettle holes, usually supposed to have been formed by the melting away of large bodies of ice buried in the earthy mass. The material in the range, though irregularly distributed, exhibits a tendency, in most cases, to become finer on the lakeward side, in the general direction of dip. The section made by the Cobb's hill pit is upward of 100 feet at the back and affords a good opportunity to study the character of the range on the iceward or northern side. A succession of step-faults shown here may be mentioned as a usual feature in pits in the north side of the range. These faults are due, it has been supposed, to the settling of the mass on the removal of the ice support from that side.

J. Y. McClintock, commissioner of public works, says the amount of sand and gravel removed from the Cobb's hill pit is about 360,000 cubic yards all told. As this has been taken away since 1891, it will serve as a means of determining roughly what the output has been each year.

Mr Barnard states that a little over 4000 yards from this pit were used on the Erie canal towpath last year.

The sandpit next in quality of material is that of J. S. Sheehan, located ⅛ of a mile south of the Erie canal in the village of Brighton, at the end of the range and about a mile from the above pit. Mr. Sheehan has also a large gravel-pit just west of his sandpit. The output from these pits for the year was 7000 cubic yards.

Michael D. Sheehan has a small sandpit adjoining the above mentioned sandpit on the north.

This year Mr J. Schrader has developed a pit on Highland avenue ¼ mile southwest of Monroe avenue on the southeastern side of the Pinnacle range. At the present stage of excavation, there is a good road gravel in the upper portion and a fine brick sand in the lower. The output for the last year was about 800 cubic yards, most of the material being used for roads in Brighton and Henrietta townships. This coming year, Mr Schrader expects to open the bank at a second point just north of the present site, to facilitate loading.

Casper Schwalbach, of 271 Averill avenue, owns what is known as the Pinnacle pit, located on the south side of the Pinnacle hill, just east of South Clinton street. This pit, before the opening of Cobb's hill pit, was the main source of supply and is said to have furnished as high as 135 loads a day during the busy season. A great variety of good sand is to be had here. At the back this excavation is upward of 100 feet high. It is worked on shares by John Schwalbach. Mr Schwalbach has another pit on South Clinton street on the northern side of the range, which is worked on shares by Frank Schwalbach. The total output of Mr Schwalbach's pits for the past year was 7137 loads, 400 of which were used for road repairs in Henrietta. The material is mainly used for sidewalks and street improvement.

On the Ellwanger and Barry tract, off from Rockingham street and a little way from Meigs street, is a pit worked on shares by Melvin A. Clark, of 413 Mt Vernon avenue. The material ranges from coarse molding sand to gravel, the latter being the most abundant. The total output for 1902 was 5193 loads, a large part of which was drawn to the town of Henrietta for roads.

In the continuation of the Pinnacle range west of the Genesee are several pits. One on the Thurston road in the town of Gates is owned by Mrs L. Cornelia Smith. It affords a good quality of brick sand. Part of the output is used by Whitmore, Rauber & Vicinus in their asphalt works located at the Western Widewaters. One fourth of a mile northwest in the town of Gates, at the junction of the Hinchey and Chili roads, and ¼ of a mile west of the Buffalo, Rochester & Pittsburg Railroad, is Haag Bros.' pit, worked by Jacob Haag and son. The output for the last year was about 700 yards. The Lincoln Park pit is located on the Kellogg land tract on the Field road, between the main line and a branch of the Buffalo, Rochester & Pittsburg Railroad. It is owned by Mr Thomas A. Smyth and is run under the business name of Lincoln Park Sand Co., office 411 Beckley building. The output of this bank is brick and plaster sand, of which 1811 cubic yards were sold during the past year. Sand is being drawn from a newly opened pit just west of the above, across the branch of the Buffalo, Rochester & Pittsburg Railroad. The Pfaudler Vacuum Fermentation Co. owns and works it for its own purposes. About 2000 loads were used in the construction of its extensive plant during the past year. This completes the list of pits in the Pinnacle range supplying Rochester.

The Ridge road pits, with one exception, are all east of the Genesee. This exception is the pit owned by J. A. Rainesford, and located in the town of Greece on the north side of the Ridge road, just west of the Lincoln Park branch of the Buffalo, Rochester & Pittsburg Railroad. It furnishes a good quality of brick sand. Mr Rainesford sold 300 cubic yards last year. The first pit east of the Genesee is owned by Mrs George Huntingdon and Mrs F. E. Elder, of Rochester, and is known as the Gilbert pit. It is located just south of the Ridge road and east of Hudson street. The output was 3500 yards. David Heffer has a pit just west of Portland avenue and on the same side of the Ridge.[1] The material of this pit is largely a clean gravel, portions of it being of a size suitable for roofing gravel. For this purpose it is sold in hundred pound bags at 8 cents a hundredweight. There are some veins of good brick sand. In the upper portion is a regular beach sand mixed with flat waterworn stones. It is more or less limonitic. These pits are all on the landward side, and the southern portions take in the finer sands of the lagoon area. This completes the number of Ridge road pits supplying Rochester.

The sandpits in Brighton village between the Ridge road and the Pinnacle range are worked for foundry sand. The sand is very fine and somewhat limonitic. Three pits affording a limited supply of material have been opened on the Blossom road just west of Arbutus avenue. The sand runs in thickness at these pits from nothing to 2 or 3 feet, being merely a light mantle deposited in a sheet of glacial water. The owners are William H. Jones, Mahlon Phillips and Henry DeFloe.

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[1] The output from this pit for the last year was 1000 yards. At the eastern end the upper portion of the bank is a sand dune. Otto Moeschler has a pit on the east side of Portland avenue and on the same side of the Ridge.

Lauer & Hagaman bring sand to the city, by way of the Erie canal, from Bushnell's Basin, a distance of 12 miles to the east. Last year 3500 yards were used by them in making concrete foundations for streets.

Within the county are many other gravel and sand pits but most of them are of comparatively little importance, being merely worked for the local supply, and most of them for road metal. There are however a few quite extensively developed. One of these is the gravel-pit of the Buffalo, Rochester & Pittsburg Railroad, at Scottsville. There are some veins of sand which, when used for masonry purposes, has to be screened. The bulk of the material is used for ballast on the railroad, and most of the remainder for bridge construction. The amount used during the past year was 40,201 yards of gravel and 2200 yards of sand. A large sandpit 1 mile west of Despatch village, on the main line of the New York Central Railroad, is used by this road for engine sand. No record of exact amounts was kept.

Throughout the county the regulation price for sand and gravel is 20 cents a yard, though in winter, at some of the pits about Rochester, owing to the difficulty of keeping them open, the price is 30 cents.

The pits of less importance are included in the following directory to the sand and gravel pits of Monroe county.

Sand and gravel pits of Monroe county

1 **Charles Brush estate.** Sand; Hamlin; postoffice Morton.
2 **Schwartz, F.** Gravel; Hamlin; postoffice East Hamlin.
3 **Burret, Charles.** Gravel and sand; Clarkson; postoffice Clarkson.
4 **Crary, *Mrs* Mary C.** Mixture for roads; Clarkson; postoffice Clarkson.
5 **Smith, George L.** Sand and gravel; Sweden; postoffice Brockport.
6 **Terry, Frank.** Sand and gravel on Henry Root place; Sweden; postoffice Brockport.
7 **Schroeder, John.** Gravel and sand; Brighton; postoffice Brighton.
8 **Corporation pit of Brockport.** Sand and gravel; Sweden.
9 **Hinnan, A.** Both sand and gravel; Sweden; postoffice Brockport.
10 **Shafer, C. E.** Worked by John Meeskill; sand and gravel; Sweden; postoffice Brockport.
11 **Crippen, Dean.** Gravel; Sweden; postoffice Brockport.
12 **DeFrees, Charles.** Gravel from lake shore; Parma; postoffice Hilton.
13 **Ferguson, Ervy.** Gravel from lake shore; Parma; postoffice Hilton.

14 **Dickenson, Edward**. Gravel from lake shore; Parma; postoffice Hilton.

15 **Hall, Peter**. Gravel; lake shore; Parma; postoffice Hilton.

16 **Haslip, Robert**. Gravel; lake shore; Parma; postoffice Hilton.

17 **Vandorn, Adelbert**. Gravel; Parma; postoffice Hilton.

18 **Cosman, Henry**. Bank farm; gravel; Parma; postoffice Hilton.

19 **Burritt, D. C**. Gravel and sand; Parma; postoffice Hilton.

20 **Williams,** *Dr*. "Vanzie farm"; worked by a tenant; gravel; Parma; postoffice Hilton.

21 **Bacon, William**. Gravel; Parma; postoffice Parma Center.

22 **Peckham, William F**. Mainly gravel and sand; (sells more than anybody else in the south part of the town): Parma; postoffice Parma Corners.

23 **Coe,** *Mrs* **Anna**. Place occupied by Mrs Martha Wellman; gravel and sand; Parma; postoffice Parma Corners.

24 **Rausch, Matthew**. Gravel and sand; Parma; postoffice Parma Corners.

25 **Hazen, George**. Sand and gravel; Parma; on Pease road; postoffice Spencerport.

26 **Meeskill, Edward**. Sand and gravel; Parma; postoffice Spencerport.

27 **DeRoller, Amos**. Gravel; Parma; postoffice Spencerport.

28 **Udell,** *Dr* **P. G**. Fine 40 foot bank sand and gravel; Ogden; ½ mile west of Spencerport; postoffice Spencerport.

29 **Ross, William**. Gravel; Ogden; postoffice Spencerport.

30 **Graves, Byron J**. Gravel; extensive pit; Ogden; postoffice Parma.

31 **New, Henry**. Fine sand drawn to Chili; Ogden; south of Adams Basin on Washington st.; postoffice Ogden.

32 **Rogers, Joseph**. Sand and gravel; Ogden; postoffice Spencerport.

33 **Rann, Horace**. Gravel; Ogden; postoffice Spencerport.

34 **Brower, Elsworth**. Gravel; Ogden; postoffice Spencerport.

35 **Rogers, Joseph**. Good gravel; Ogden; postoffice Spencerport.

36 **French, George**. Sand and gravel; Ogden; east edge of town; postoffice Spencerport.

37 **Bogardus, George**. Gravel; Riga; postoffice Churchville.

38 **Squire, Alexander Petrie**. Gravel; Riga; postoffice Riga.

39 **Minzie, Peter J**. Gravel; Riga; postoffice Riga.

40 **Keenan, John**. Gravel; Riga; 4 miles from Churchville; postoffice Riga.

41 **McVean, Cameron**. Gravel; Wheatland; 1 mile west from Wheatland Center; postoffice Wheatland.

42 **Garbutt, William D**. Extra good gravel; Wheatland; 1 mile north of Wheatland Center; postoffice Wheatland.

43 **Kingsbury, Frank**. Sand and gravel; Wheatland; postoffice Wheatland Center; Albert Mudge, Rochester N. Y.; combined pit; sand supplied to the Diamond Wall Cement Co., Garbutt.

44 **Gatenby, John**. Gravel; Wheatland; postoffice Wheatland Center.

45 **Greenleaf,** *Col.* **Halbert S**. Worked by William Dean; Greece; postoffice Charlotte.

46 **Cashburn, George**. Gravel; Greece; south side of Ridge road; postoffice Barnard.

47 **Harris, Richard**. Gravel; Greece; Ridge road; postoffice Barnard.

48 **Denning, H. C**. Gravel; Greece; postoffice South Greece.

49 **Reinhardt, Valentine**. Gravel; Greece; Big Ridge; postoffice Barnard.

50 **Buckley, Keron**. Gravel; Greece; near Mount Read; ½ mile south on west side of road; postoffice Barnard.

51 **Truesdale, Warren**. Gravel; not worked much; Greece; postoffice Barnard.

52 **McDowell, Benjamin**. Gravel; Gates; postoffice Gates.

53 **McCarn, Samuel C.** Sand and gravel; mostly used for roads; Gates; postoffice Spencerport.

54 **Gutherlet, George**. On Mrs John Miller's farm: sand and gravel; Gates; postoffice Gates.

55 **Amish, August**. Sand; Gates; postoffice Gates.

56 **Rose, Henry**. Sand for macadamized road this year; Gates; Buffalo road north of Coldwater; postoffice Coldwater.

57 **Haag, Jacob**. Sand and gravel; Gates; postoffice Gates.

58 **Lincoln Park Sand Co**. Brick and plastering sand; Gates; 411 Beckley building, Rochester N. Y.

59 **Smith,** *Mrs* **L. C**. Brick sand; Gates; postoffice Lincoln Park.

60 **Blimb, Jacob**. Gravel; Chili; postoffice Chili.

61 **Pit, Gilbert**. Sand and gravel; Irondequoit; address Mrs George Huntington, 1½ Delevan st., Rochester N. Y.

62 **Heffer, David**. Sand; Irondequoit; postoffice Irondequoit.

63 **Moeschler, Otto**. Irondequoit; postoffice Irondequoit.

64 **Clarke, Melvin A**. Sand and gravel; Rochester; 413 Mt Vernon st., Rochester.

65–66 **Schwalbach, Caspar**. Sand and gravel; Brighton; 271 Averill av. Rochester.

67 **Lynn, Thomas**. Sand and gravel; Brighton; address, Atkinson av. Rochester.

68 **Sheehan, J. S**. Sand and gravel; Brighton; postoffice Brighton.

69 **Sheehan, M. D**. Sand; Brighton; postoffice Brighton.

70 **Jones, William H**. Molding sand; Brighton; postoffice Brighton.

71 **Phillips, Mahlon**. Molding sand; Brighton; postoffice Brighton.

72 **De Floe, Henry**. Molding sand; Brighton; postoffice Brighton.

73 **Kaiser, Franz Joseph**. Gravel; Henrietta; postoffice West Henrietta.

74 **Bushman, Ivan**. Gravel; Henrietta; postoffice West Henrietta.

75 **Search, Charles**. Gravel not well assorted; Henrietta; postoffice West Henrietta.

76 **Ginegaw, Charles**. Sand and gravel; Henrietta; postoffice Henrietta.

77 **Shaw, George**. Gravel; Henrietta; postoffice Rush.

78 **Pedley, William**. Gravel; Rush; postoffice West Rush.

79 **Clapp, Edwin P**. Gravel; Rush; postoffice North Rush.

80 ——— Sand and gravel; Rush; postoffice North Rush.

81 **Dell, Gus**. Gravel; Rush; postoffice North Rush.

82 **Fishell, Benjamin**. Gravel; northeast portion of Rush township, up Creek road from Rush.

83 **Moran, Thomas**. Mendon; 1½ miles northwest of Honeoye Falls; Sibleyville; post-office Honeoye Falls.

84 **Mahar, Patrick**. Gravel; Mendon; west of Mendon near Mendon Center postoffice Rochester Junction.

85 **Toby, Reuben.** Gravel; Mendon; postoffice Rochester Junction.

86 **Monk, William.** Gravel; Mendon; 1 mile northeast of Honeoye Falls; postoffice Honeoye Falls.

87 **Maxfield, Herbert A.** Sand and gravel; Mendon; postoffice Rochester Junction.

88 **Hopkins, Robert M.** Pittsford; postoffice West Henrietta.

89 **Douglass, John A.** Road metal; Mendon; near Mendon Pond postoffice; 2 Portland av. Rochester.

90 **Falkner, Daniel.** Pittsford; postoffice Pittsford.

91 **Harter, John V.** Gravel used on roads; Pittsford 3 miles south of Pittsford; postoffice Pittsford.

92 **Toby, M. P.** Coarse gravel; Pittsford; postoffice Pittsford.

93 **Corporation gravel pit.** Coarse gravel; Pittsford, on Mendon road; postoffice Pittsford.

94 **Schweney, John.** Coarse gravel; Pittsford, 1 mile south of Cartersville; postoffice Pittsford.

95 **Lauer & Hagaman.** Plastering sand; Pittsford near Bushnell's Basin; postoffice 458 Clinton av. South, Rochester.

96 **Robins, Henry S.** Plastering sand; Pittsford; 1 mile from Cartersville; postoffice Pittsford.

97 **Austin, Chester.** Plastering sand; Pittsford 1 mile east of Cartersville and just south of Palmyra road; postoffice Pittsford.

98 **Sand bank,** New York Central R. R., Pittsford, used for engine sand.

99 **Cullen,** *Mrs* **Katharine.** Used on R. & E. Rapid Transit railway for ballast and in concrete bridge foundations; Pittsford; postoffice Pittsford.

100 **Hunt, Stephen.** Gravel; Perinton, 2 miles from Egypt; postoffice Egypt.

101 **Long, William P.** Sand and gravel; Perinton; postoffice Egypt.

102 **Aldrich, G.** Gravel; Perinton; used extensively for road purposes; postoffice Egypt.

103 **Hartley, Edward.** Gravel; Perinton, near cemetery, 1¼ miles southeast of Fairport; postoffice Fairport.

104 **Crump, S. J.** Plastering sand; town of Perinton; on Irondequoit creek; just south of Palmyra road; postoffice Pittsford.

105 **Howard,** *Mrs* **Daniel.** Sand and gravel; Perinton; on Erie canal; just west of the corporation line of Fairport; postoffice Fairport.

106 **Harris, Darwin.** Sand and gravel; Perinton; Whitney road; postoffice Fairport.

107 **Knapp, Charles H.** Gravel; Perinton; postoffice Fairport.

108 **Felt, Joseph.** Gravel; Penfield; postoffice Penfield.

109 **Jordon,** *Mrs* **Edwin B.** Sand and gravel; Penfield; postoffice Penfield.

110 **Smith, Ernest.** Fine plastering sand; Penfield; postoffice Penfield.

111 **Hebbs, James.** Gravel; Penfield; postoffice Penfield.

112 **Williams, K. B.** Gravel; Penfield; postoffice Penfield.

113 **Sprague, Halsie.** Gravel; Penfield; postoffice Webster.

114 **Hatch, E. A.** Clayey gravel; Webster; postoffice West Webster.

115 **Heimes, Anthony.** Gravel and sand; Webster; Ridge road; postoffice Webster.

116 **Klem, Peter D.** Sand and gravel; Webster; postoffice Union Hill.

117 **Brower, H.** Gravel; sold an acre this year to the Rochester & Sodus Electric Railway; Webster; postoffice West Webster.
118 **Weeks, O. J.** Sand and gravel; Webster; postoffice West Webster.
119 **Pierce, Samuel.** Gravel; Webster; postoffice Forest Lawn.
120 **Burnette, B. W.** Gravel; Webster; postoffice West Webster.
121 **Peacock, John.** Sand and gravel; Ogden; postoffice Spencerport.
122 **Pledger, John.** Gravel; Ogden; postoffice Spencerport.
123 **Hiscock, George W.** Gravel; Ogden; postoffice Spencerport.
124 **Darling, Everett.** Gravel; Ogden; postoffice Parma.
125 **Rich, James.** Gravel; Ogden; postoffice Adams Basin.
126 **Brower, F. W.** Sand and gravel; Ogden; postoffice Spencerport.
127 **Henchen,** *Mrs* **Virginia.** Sand and gravel; Greece; postoffice Barnard.
128 **Kirkpatrick, W. J.** Gravel; Mendon; postoffice Rochester Junction.
129 **Rainesford, J. A.** Brick sand; Greece; postoffice Barnard.
130 **Budlong,** *Mrs* **Helen S.** Gravel; Wheatland; postoffice Scottsville.
131 **Thompkins, John.** Gravel; Parma; postoffice Hilton.
132 **List, Katherine M.** Gravel; Irondequoit.
133 **Rochester Suburban Railway.** Gravel; Irondequoit; Rochester.
134 **Pardee, E. S.** Gravel; Irondequoit.
135 **Windhauser, John.** Gravel; Irondequoit; Rochester.
136 **Waltzer, Joseph.** Gravel; Irondequoit.
137 **Sweet,** *Mrs* **E.** Gravel; Irondequoit.

Gypsum industry

There are two plaster mines within the county, both located in the southwest corner, in the town of Wheatland on Allen's creek; one at Garbutt and the other 2½ miles westward at Wheatland Center.

The one at Garbutt is that of the Lycoming Calcining Co., superintended by Mr C. A. Sweet. It is located on the south side of the creek opposite the mill and is reached by a trestle. The entrance to this mine is by a tunnel into the side of the hill. The plaster bed worked is what is known locally as the upper bed, and here runs in lenses and ridges from 4 to 6 feet thick. It is overlain by about 40 or 50 feet of waterlime and dirt. Considerable "dirt" is found at points in the gypsum where the calcium sulfate has been dissolved out, leaving a clayey, dirt-colored residue. Owing to the unstable nature of the roof, much timbering is necessary. The work is carried on in several different headings, with two to six men at a heading. From 20 to 40 men are employed, and as high as 100 tons of gypsum are removed in a day. Drilling is done with "New Auger" coal drills, and the blasting with a low grade dynamite. The material is conveyed from the mine to the mill in cars drawn by mules. This company at the present time owns and has under lease 100 acres of land underlain by plaster rock. The company has just opened a new shaft at this level, a few hundred yards south and west of the old opening, which, they expect, will increase their output. A vertical shaft in the mine penetrates at the depth of 7 feet, another bed of plaster 5 feet in thickness. It is planned to work this, and a horizontal shaft has been begun at the creek side. A third and still lower level for gypsum is reported as existing.

The gypsum is used here in the manufacture of the three substances, land plaster, stucco or plaster of paris (the name given to the product when calcined), and wall plaster. Steam power is used in the mill.

The land plaster is made by running the raw plaster rock first through a nipper, then a cracker of coffee mill type and then grinding it between burstones.

For stucco, the material is subjected to the first two stages of the above process, by which it is broken into fragments about the size of a pea, when it is taken to the calciner. The process of calcining is what is known as the Cummer process. The material is conveyed by a bucket elevator to a rotary kiln or drum, a cylinder inclined a few degrees from the horizontal, over a fire, fueled with soft coal from an automatic American stoker, the material being kept constantly mixed by being carried up to a certain point by shelves lining the interior, when it falls down again. From here the material is conveyed into brick cooling bins. When cooled, it is ground with emery stones and comes out stucco, ready to be put up for shipping. This material is shipped in bulk, also in jute bags.

The dry mortar wall plaster is made by the Diamond Wall Cement Co., who occupy the west end of the building. The mixture is two parts sand and one of stucco, with a small proportion of hair and retarder.

The sand is obtained at Wheatland Center, 2 miles west, on the line between the farms of Frank Kingsbury (Wheatland Center) and Albert Mudge (Rochester). During the last year, 6000 yards were used. The sand is prepared for use by shoveling it into a sand drier at the outside of the building, from which it is conveyed by a bucket elevator to the top of the building and passed through a screen, falling into a storage bin. From the bin it is conducted to hopper scales, where it is mixed with the stucco and other ingredients, coming out the finished product.

During the past fiscal year, it is stated, 3000 tons of land plaster, 15,000 tons of stucco and 15,000 tons of wall plaster were sold from these mills. The Lycoming Calcining Co. is expecting to supply 200 tons of stucco a week to the Sackett Wall Board Co., which has just erected an extensive factory at this place.

At the works of the Consolidated Wheatland Plaster Co., located at Wheatland Center, about 2½ miles northeast of Caledonia and 16 miles from Rochester, the manufacture of land plaster is conducted on a larger scale. The property is admirably located both for mining and grinding the gypsum rock. The concern owns 37 acres of land in fee simple, on which is located a never failing water supply capable of developing 100 to 150 horse power. Beside this, the company owns the bed of Allen's creek, from Wheatland Center for about 1 mile to the east, with all the water rights and privileges to high water mark. It also leases 86 acres of gypsum on the north side of Allen's creek. The water power makes the production very cheap. The company has two large mills, one of which, the lower, is operated entirely by water power supplied by Allen's creek, and the other, known as the "Upper," or "Strobel mill," by water and steam power. The capacity of both mills is about 80 to 100 tons of crushed and ground plaster each day of 24 hours.

At the lower mill the gypsum is crushed with the Good Roads Machinery Co.'s "Champion rock crusher" and ground with a common underrunner, 42 inch Munson mill. At the upper mill the company has water power enough to operate one run of Munson millstones with a large pot crusher. In the busy season steam can be put on if necessary, and two runs of 42 inch underrunner Munson mills operated. This upper mill is equipped with bolts by which gypsum can be bolted as fine as flour. It is either sacked or loaded in bulk on track scales at the side of the mill. The output of plaster for the fiscal year just closed was 15,000 tons. The entire product is shipped by the Buffalo, Rochester & Pittsburg Railroad. The company is provided with storage room, so that the plaster made during the winter can be stored for the spring season.

In the upper mill an insecticide called " Black Death," made with gypsum as a basis, is manufactured for the O-at-ka Chemical Co., which is under the same management as the Wheatland Co. About 250 tons were sold last year.

The mine is reached by a bridge across the creek, on a level with the mill floors and the horizontal tunnel running into the mine. The plaster rock runs in a pure vein 6 or 7 feet in thickness, averaging 6 feet. It is about 6 feet above creek level and is overlain by 40 to 50 feet of waterlime, and underlain by a bed of carbonate of lime. It is reported that under this is another bed of plaster considerably thicker. The roof of this mine is without a seam and is supported by pillars of the gypsum 20 to 30 feet apart. The common Jeffrey Manufacturing Co. hand coal drills are used for drilling. For blasting, a 20% nitro glycerin is used. After the rock is blasted out in the different headings, it is loaded on mule cars. About 2 tons to a car is a load. The rock is allowed to dry under sheds before being ground. Charles H. Root, president and treasurer, states that the company expects to erect a calcining kettle for the manufacture of plaster of paris.

Peat deposits

There are several peat deposits in the county, but all of small extent. Several of these have been worked in the past for fuel, but only two on a commercial scale. At present, with one exception, they are not worked. This exception is a small deposit filling a kettle hole in the north side of the Pinnacle range, ¼ mile east of South Goodman street, Rochester(1). It lies partially on the property of the Ellwanger & Barry Nursery Co. and partially on land owned by Charles Barton. The basin is oval, having a length from east to west of about 300 feet and a breadth of perhaps 100 feet.

In 1897 a pit was dug in this deposit to the depth of 13 feet and a stake then forced down 12 feet farther, without any signs of having reached the bottom.

The peat is of the consistency of cheese and is plastic in the hand. Standing in it, one will sink, sometimes nearly a foot, the peat adhering like clay. When fresh its color is a light brown, becoming dark brown in drying. Large limbs of trees buried in it may be cut through as easily as the rest of the deposit, but when dried usually shrink and crack, becoming probably harder than when growing. Insects in the peat are well preserved, in consequence of the antiseptic properties of the peat water. The plants composing the peat are still recognizable and show some changes in the forms which have contributed to the deposit. The bog is now covered with black and yellow birches. The filling of the depression has at present reached such a level that oxidation and accumulation are just balanced.

Ellwanger & Barry use this material in their nursery in making a compost. Mr Barton sells that from his part of the bed for use in the public parks. Last year he sold 117 yards at 85 cents a yard. It is used in forming a compost for rhododendrons and plants of the heath family.

A large bog in the town of Ogden, 1 mile south of Spencerport on a farm belonging to Dr P. G. Udell(2), was worked in 1864 by John R. Garretsee, and the material shipped away on the Erie canal. Another bog located 1 mile east of Adams Basin(3), on the farm of Freeman Webster, was worked on a small scale for experimental and domestic purposes. Another in the same town is situated 1 mile east of Spencerport on the farm of George W. Hiscock(4).

A bog(5) in the southeast corner of Gates, between the Buffalo, Rochester & Pittsburg Railroad and the branch of the Western New York and Pennsylvania Railroad, was worked for two or three years, beginning about 1870, under the business name of "Babcock Peat Works." A press was erected and the peat made into cylindric cakes.

There are two deposits in the southern part of Parma, a little northeast from Hinkleyville, one on the farm of Milton and

Lucy Palmer(7), the other on the property of Mrs Julia Rensch(6). Another bog(8) on the property of J. B. Collamer, in the northeast corner of the town near the Greece line and on the lake shore, stands as follows: at the outside is an area of muck, within this, an area of peat and then reed-grown water.

A peat deposit(9) on the land of Wayland A. Keyes, in the eastern part of Rush near the town line, was worked some years ago, for private use by Hallock Bros.

In the town of Mendon in the region of the Mendon ponds, are several bogs. One(10), a closed bog, known as Huckleberry swamp, is on the farm of Judson Howard. This is a typical sphagnum swamp, being surrounded by a narrow ring of mud and water, and higher in the center than at the sides. Mendon pond(11) and Mud pond(12) are surrounded by a deposit of muck, within which is an area of peat, seemingly floating on the water, as it will spring and rock under foot. Within this is open water. Round pond has been divided into two ponds by the formation of a bar of peat. This peat or vegetable matter, for very little earthy matter can reach the center of the pond, is gradually encroaching on the open water and will eventually claim the whole pond. Many of the bogs of the vicinity probably originated in this way. One(13) of this nature is located on the property of Morey C. Garland, in the southwest corner of Pittsford.

Just north of Mendon pond, in the town of Pittsford, is what is known as the Beaver meadow(14). An attempt was made some 40 years ago, to use the peat from the portion lying on the farm of Robert Hopkins. According to S. J. Crump, of Pittsford, who has examined this deposit, there are about 2 feet of soil, 3 feet of pure peat, under this a thin layer of a black, carbonaceous, jellylike matter which hardens on drying, then a shell marl which has been penetrated to the depth of 2 feet. Conspicuous in the marl are the shells of the common pond snail, *Limnea stagnalis*.

Peat occurs at one or two points in the troughlike lagoon area on the south side of the Ridge road. The peat from one of these(15) in Greece, ½ mile west of Lake avenue, Rochester, on the land of

Heman Glass, has been used for making a compost. This deposit extended to the south under the property of W. H. Robinson. In the dry season of 1892 or 1893, this portion took fire and smoldered for a week or more, finally burning itself out. At several points the overlying loam sank in, forming shallow pits.

There is a deposit of peat(16) 2½ miles east of Penfield village, on the Commission ditch. About 40 years ago, while the New York Central Railroad Co. was still burning wood in its engines, it was planned to organize a company for the purpose of supplying the railroad with peat from this bed, as a fuel. Samples for testing were taken from various points in the deposit. But the price of coal fell at this time; so the company decided to have its engines equipped for burning coal.

A small, boglike area in Rochester, on the present site of the Rochester Atheneum and Mechanics Institute, showed the following arrangement of material: a layer of clay, a layer of shell marl and a shallow layer of sphagnum peat followed by a layer of filling.

NOTES ON MINERAL DEVELOPMENTS IN THE REGION AROUND ITHACA

BY HEINRICH RIES

The quarry industry in this region has not been specially active during the past year, the quarries at Union Springs and Seneca Falls having done little business, but the limestone quarries at Waterloo are stated to have been in active operation most of the time.

The bed of slip clay located on the property of William Young on the south edge of the city of Seneca Falls has, so far as I am aware, never been mentioned in any previous report. But in previous years some quantity of it has been dug and shipped to stoneware potteries in Ohio, Tennessee, and West Virginia. Mr Young contemplates resuming mining operations in the near future. The large deposit of marl and clay underlying the swamp at Alpine station still remains undeveloped, but it is expected that a cement plant will be located at the locality in the spring of 1903. Mr George Cook, of Newfield N. Y., contemplates building a second brick plant at that locality, which will be known as the Ithaca Red Brick & Tile Co.

The brick works at Horseheads and the brick and terra cotta works at Corning have continued in active operation.

The two most important developments which were made in this region during the past year are the establishment of and operation of the new Portland cement plant and a new salt works, both located on the eastern shore of Cayuga lake. The Portland cement plant is operated by the Cayuga Lake Cement Co., with the general offices at Ithaca, and the works at Portland point, 6 miles north of Ithaca on Cayuga lake. The raw materials used are a silicious Tully limestone and a calcareous Hamilton shale, of which the analyses have been kindly furnished me by Prof. R. C. Carpenter of Cornell University.

	Limestone	Shale
Silica	9.72	53.46
Alumina	4.20	20.28
Ferric oxid	.48	6.72
Lime	47.11	6.66
Magnesia	.66	3.82
Loss on ignition	undet.	8.18

The company began operations in February 1902, and the actual output at the present time is stated to be 600 barrels a day, but additional machinery is being put in, so that by Dec. 1, 1902, its capacity is expected to reach 1000 barrels a day. The method of manufacture consists of gradually reducing the raw materials in large crushers, Griffin mills, or tube mills; the burning is done in rotary kilns, and the clinker is ground in Griffin mills and tube mills.

The Remington salt plant is located on the eastern shore of the lake about ½ mile north of Ithaca. Three wells have been sunk, the record of the first, whose mouth is at an altitude of 400 feet above sea level, being carefully preserved. It is as follows:

	Feet
Portage shales and sandstones	240
Genesee shales	125
Tully limestone	30
Hamilton shales	1079
Marcellus shales	81
Corniferous limestones	95
Oriskany sandstones	15
Lower Helderberg shales	135
Onondaga limestones	295
1st layer of salt penetrated	42
Total	2137

The works are now in active operation.

MINERAL RESOURCES OF ONONDAGA COUNTY, NEW YORK

BY T. C. HOPKINS

Building stone

Onondaga limestone. The gray, crystalline Onondaga limestone, which forms the base of the Corniferous group, is commercially the most important rock in the county and is quarried quite extensively in several different localities. The greater part of the dimension stone quarried from this formation comes from the Onondaga Indian reservation, 4 miles south of the city of Syracuse. The rock is hauled by wagon from the quarries at the reservation to the city of Syracuse, where part of it is used for stone buildings, and trimmings for brick buildings, and part of it is shipped by rail and canal to more distant points.

In 1902 there were three quarries in operation on the reservation. The most northern one was operated by Kelly Bros., the next by Patrick McElroy and the southern one by D. Story. They were all in active operation during the season, quarrying dimension stone almost entirely.

Besides the stone quarried for dimension stone, there are large quantities of the Onondaga limestone quarried for use in the manufacture of soda ash by the Solvay Process Co. At present it is using 1200 tons a day for this purpose. Part of this supply is quarried by the company from its own quarries at Split Rock, 3 miles south of the works and brought to the works by its overhead wire cable and bucket system. Heretofore, the stone, after being blasted from the quarry, has been broken into small dimensions by hand, a slow and laborious process, but the company has now completed the erection of two giant crushers, each having a capacity of 200 tons an hour, equivalent to the services of 200 men. This crushing plant, probably one of the largest in the State, has been constructed at an expense of $75,000 and will greatly facilitate this part of the work of this great company.

However, despite its large quarries and large force of men at work, the Solvay Co. finds it necessary to purchase stone from outside parties to supply its needs. A. E. Alvord at Manlius in the town of DeWitt is at present quarrying and shipping 300 tons of the Onondaga limestone a day to Solvay. The stone is quarried on the hill above the village of Manlius and hauled in carts to the railway at the village, where it is loaded on the railway cars.

Another source of supply for large quantities of stone for the Solvay works is I. E. Britton's quarry, 2 miles south of Syracuse, on the Delaware, Lackawanna & Western Railroad. A considerable part of the stone from this large quarry goes to Solvay, but part of it is shipped to the sugar factory at Binghamton for use in refining the sugar.

At Britton's quarry there is no sharp line of demarcation between the Onondaga limestone and the underlying Oriskany sandstone, so that the lower portion of the limestone is impregnated with sand and hence unfit for either the soda or sugar factory, and this portion of the stone is used this year for macadam in grading the streets.

Besides the large quarries mentioned above, there are several small quarries, where the Onondaga limestone is taken out in limited quantities for purely local use.

The Lower Helderberg limestone. The Lower Helderberg or Manlius limestone is quarried in large quantities in the county and used locally as building stone for foundations, retaining walls etc. and for macadam for roads, for quicklime, and certain layers for waterlime or hydraulic cement. It is quarried for building stone and for broken stone for macadam by I. E. Britton, E. I. Rice, Daniel Murray, Mr Wells and Thomas Coughlin in the Onondaga valley south of Syracuse, by the Solvay Process Co., at Split Rock, and E. B. Alvord, near Jamesville. It is quarried for waterlime by I. E. Britton, Syracuse, A. E. Alvord, Manlius, Robert Dunlop, Jamesville, and John Costello, Manlius. Bangs & Gaynor at Fayetteville and Thomas W. Sheedy 1 mile north of Fayetteville have kilns for burning and mills for grinding waterlime, but they buy the raw stone from small quarries in the vicinity.

The largest producers of the Lower Helderberg limestone in Onondaga county during the year were E. B. Alvord, Jamesville, I. E. Britton, Syracuse, John Costello, Manlius (formerly the James Beahan quarry), and the Solvay Process Co.

Clay and clay products

There are no high grade clays in Onondaga county, but brick and tile clays are used in large quantities and pottery clay in one locality. The Syracuse Pottery Co. obtains pottery clay at Belle Isle, a few miles west of Syracuse on the New York Central Railroad. The works of the Onondaga Pottery Co., which were destroyed by fire a few months ago, have been rebuilt and are expected to be in operation by Jan. 1, 1903. They do not use any local clay.

The brick companies in active operation during the year 1902 were the New York Paving Brick Co., C. & L. Merrick, George W. Pack, and the Onondaga Vitrified Brick Co.

The New York Paving Brick Co. obtains its clay from its pits on the east bank of the Seneca river, east of Baldwinsville, and ½ mile north of Belgium. The clay is partly glacial deposit and partly alluvial deposit. The bottom of the deposit consists of a smooth, plastic, blue, glacial till, overlain by an irregular deposit of sand and gravel, which is overlain in turn by a finely laminated, buff colored clay. Several acres of the clay have been worked over to a depth of 15 to 25 feet. The clay is loaded on barges at the pit and transferred by the river and the canal to the factory at Geddes on the west side of the city of Syracuse. The company manufactures vitrified brick for street paving, some for building and some for the alkali and paper works. The bricks are widely known among the paper manufacturers for their power to resist the action of strong alkalis and are shipped for this purpose to distant parts of this and other countries. The bulk of the output, however, is used for street paving. The company has not been able to fill all its orders, so great has been the demand for the bricks this year, though it has been turning them out at the rate of 60,000 a day, or about 15,000,000 for the season.

George W. Pack's brickyard lies on the northwest side of the city of Syracuse. The clay is a lacustrine deposit and is worked to a depth of 5 or 6 feet. It is adapted to the manufacture of common red brick, for which purpose only it is used. The clay burns to a pale red color. The clay is brought into the machine in carts and is fed into the machine by a belt with carriers attached. The bricks are dried in racks and burnt in the common up-draft kilns. The market is almost wholly local. The yard closed down Nov. 15 with a total product of 1,000,000 for the season.

C. & L. Merrick's brickyard is at Whiskey island, 2 miles northeast of Syracuse, on the cut-off of the New York Central & Hudson River Railroad. Besides the great number of common red brick, they manufacture repressed, hollow, and buff brick and draintile. They have increased the output this year, which amounts to about 3,000,000, by putting an automatic cut-off to the machine. They have also obtained new dies for the tile machine.

The Onondaga Vitrified Brick Co. manufactures red building brick at its plant at Warner's.

Lime and cement

The quicklime industry was almost entirely abandoned in Onondaga county during 1902, largely from the high price of coal due to the strike in the anthracite coal field. The output of waterlime was much smaller than usual, partly for the same reason, the high price of coal, and because of the more extended use of Portland cement, which seems to be displacing the natural cement to some extent.

The Paragon Plaster Co. obtains its waterlime from the different quarries in the county, while its quicklime is made from limestone brought from Chaumont, Jefferson co., and the sand is obtained from Forestport, Oneida co.

R. D. Button, Cottons, Madison co., quarried a few hundred tons of gypsum this year and sold it to the plaster and cement companies. Mrs F. Hodge, Perryville, Madison co., has a small mill for grinding plaster, which is bought from the neighboring quarries.

The Empire Portland Cement Co. of Warner N. Y., whose large mill was destroyed by fire recently, has rebuilt the mill, enlarging its capacity and equipping it with improved rotary kilns. The new building is constructed of steel and is modern in every respect. It will have a capacity of 500 to 600 barrels of cement a day. The works are expected to be in operation by February 1903.

Sand and gravel

Large quantities of sand and gravel are quarried at Syracuse and near vicinity for use in mortar, plaster, cement and other purposes, but the industry is so purely local and carried on by individual operators in such an irregular way that no attempt has been made to get a directory of the dealers. Most of the sand is obtained from the beach deposits of the fossil Lake Iroquois.

Salt

Solar salt is manufactured in large quantities at Syracuse, but the product this year is below the average on account of the excessive rain and little sunshine during the summer months. The salt is all produced from water from the State wells. The output and details of the industry are given in the report of the state commissioner in charge of the wells and hence are omitted here. The Solvay Process Co. continues to get its salt from its wells at Tully. It has recently changed the plan of operating the wells. Formerly the fresh water was put into the wells under sufficient pressure to force it through the salt bed and out at the mouth of the well, whence it flowed by gravity to the works at Solvay. It was noticed after a time that more water was put into the well than was coming out, and there appeared to be also an increase in the percentage of salt in the State wells at Syracuse. The pressure was released on the Tully wells and the water pumped out of the wells into the pipes in which it is conducted to the works.

Gypsum

The gypsum industry has been fairly active during the current year, the output being somewhat above the normal. Part of the output is used for wall plaster and decorations, part goes to the cement manufacturers, and part is ground raw and used for land plaster.

The sand is used in the manufacture of window glass and bottles, and to some extent, in steel mills. For these purposes, it is shipped to Rochester, Ithaca, Lockport, Black Rock, Syracuse, Clyde etc.

The following producers have given their output for the year.

J. L. Bentley, Fish Creek	200–300 tons
E. H. Cook & Bros., Bernhard's Bay	5000 tons
A. L. Gifford, Rome	1000 tons
A. F. Purdy, Bernhard's Bay	2500 tons
William Williams, Durhamville	A few barrels

Iron ore

The Clinton iron ore is at present worked for two distinct purposes, as a source of iron and for the preparation of mineral paint.

The mines now in operation are situated just east of the village of Clinton, where mining has been carried on for about 50 years.

The Franklin Iron Manufacturing Co. has an extensive mining plant capable of producing a large quantity of ore. The entire output is smelted at the company's furnace at Franklin Springs, about 2 miles by rail from the mines.

The plant was put into operation July 12 and up to Sep. 27 had mined 13,800 gross tons of ore.

Adjacent to the foregoing mines is the property of C. A. Borst, who has recently installed a very complete mining plant.

The product of the mines is at present all used in the manufacture of mineral paint.

The output for the year was 2925 gross tons.

Mineral water

A short distance south of Franklin Springs a mineral water industry of some local importance has developed within a few years.

The water comes from wells drilled to depths of 75 to 100 feet, the source being apparently in Clinton rocks.

While the different waters vary considerably in composition, they are as a rule quite saline. In two cases lithium is reported in some quantity.

Producers and output for the year are as follows:

J. B. Coates, Clinton. 12,000 gallons. Clinton lithia water

George H. DeNike, Clinton. 15,000 gallons. Split Rock natural mineral water

Kirkland Mineral Spring Co., Clinton. Output not reported. Kirkland and Glacier waters

F. H. Suppe, Franklin Springs. Output not reported. Franklin natural mineral water

Warner, Franklin Springs. Output not reported. Warner's natural mineral water

ECONOMIC PRODUCTS OF ST LAWRENCE COUNTY

BY W. N. LOGAN

Sandstone

The E. A. Merritt Sandstone Co. of Potsdam has quarries and mills located at Hanaway Falls. E. A. Merritt is the manager of this company. The sandstone is the Potsdam in its typical locality. The value of the output is about $100,000 a year.

The Clarkson Sandstone Co. has quarries 1 mile north of Hanaway Falls. The value of the product is $40,000 a year. The sandstone is used for building purposes and flagging.

Potsdam sandstone is quarried on the L. F. Hale farm 2 miles south of Canton. The product of the quarry is used locally. A quarry of this stone on the Edward Gilson farm 4 miles northeast of DeKalb village in DePeyster supplies a small local demand for building stone.

The Potsdam sandstone is also quarried on the Saxon farm 2½ miles south of Brushton. It is used locally for building purposes. Output 100 cords a year. Also on the Sid. Paddock farm 3 miles east of Malone. The value of the output is $12,000 a year. On the Levi Bashah farm ½ mile north of Malone, 100 cords a year, valued at $5 a cord; on the Green farm ½ mile north of Malone, 50 cords; on the Paddock farm ½ mile west of Malone, 75 cords a year.

Limestone

Chazy limestone is quarried on the Oscar Hale farm 3 miles northeast of the village of Norwood in the town of Norfolk by Charles Warren. The limestone is used for building purposes and for road metal. The value of the output is $15,000 a year.

Another quarry located 1½ miles northeast of the village of Norwood supplies the local demand for building stone.

Other quarries located at West Potsdam and Massena supply a local demand. No estimate of the output could be obtained.

Marble

The marble quarrying industry of St Lawrence county has been very active during the past year. Nearly all of the old quarries have been in operation and a number of new ones have been opened.

The E. E. Stevens quarry located 1½ miles southwest of Canton village produces a gray marble very closely resembling gray granite in appearance. The product of the quarry is valued at $10,000 a year.

The Nickerson quarry situated 2 miles south of Canton on the Nickerson farm has not been operated the past year. The marble receives a light yellow color from the presence of serpentine.

The Chamberlain quarry located 2½ miles from Kent Corners and operated by W. D. Chamberlain of Dayton O. has just resumed operations. The value of the output the last year worked was $15,000. The marble is white in color.

A marble quarry was opened by Horace Ellsworth, of Canton, on the Peter Fallon farm 1¾ miles east of Colton village in the town of Colton. A white marble quarry was opened on the J. C. Leary farm 2 miles east of Colton.

The Gouverneur Marble Co. of Gouverneur operates a quarry located 1 mile southwest of Gouverneur in the town of Gouverneur. The company employs 65 men and values the product of the past year at $90,000. Two thirds of the output are used for monumental purposes and one third for building purposes. Some of the waste from the mills is used for road metal. The marble varies from a light to a deep blue. A chemical analysis gave the following result: silica 1.58%; iron and aluminum oxids .79%; lime 51.45%; magnesia 3.49%; sulfur .83%; carbonic acid 42.56%.

The St Lawrence Marble Co. has quarries located 1½ miles southwest of Gouverneur. The company employs 30 men and had an output valued at $30,000 (for the year 1901). It works two quarries.

The Davidson Bros.' marble quarry is located 1¾ miles southwest of Gouverneur. The mills of the company are at Watertown. Seventeen men are employed at the quarry. The output of the company is 40,000 cubic feet, valued at from $1.25 to $4.50 a cubic foot.

The Northern New York Marble Co. has two quarries, the Northern and the Empire, located 2½ miles southwest of Gouverneur. This company employs 100 men and has an output valued at $80,000. The marble is used mostly for monumental purposes. Some of it however is used for building purposes.

Morrison & Whitney of Gouverneur have opened a quarry of white marble 3½ miles north of Gouverneur on the Babcock farm. Machinery for the quarry and mills is being put in rapidly.

Lime

The crystalline limestones of the Grenville series are burned for lime in many parts of St Lawrence county. They produce a lime of superior strength, but it requires a high temperature to calcine them.

A kiln is operated by Mr Church, of Crary's Mills, about 4 miles southeast of Canton village in the town of Canton. The output is about 600 bushels a year.

Williams & Johnson operate two kilns at the village of Bigelow in the town of DeKalb. They also operate a kiln 2 miles south of the village on the Tom Davis farm. The yearly output is about 1000 bushels.

A kiln on the V. P. Abbott farm 2 miles southwest of Gouverneur in the town of Gouverneur is operated by C. J. Maimer and produces 400 bushels a year.

A kiln on the J. C. Leary farm 2 miles east of Colton village has supplied a local demand, but is not operated at present.

Iron ore

There has been renewed activity in the production of iron ore in this county during the past year. Many of the mines which were compelled to close down about 10 years ago, because dealers refused to buy that grade of ore, have resumed operations. When the mines closed, ore containing less than 50% of iron could not be sold. At the present time there is a market for ore running as low as 48%.

The Rossie Iron Ore Co., represented by Mr B. Nicholls, 59 Wall street, New York, has two mines located at Caledonia in Gouverneur. Both are in operation, and a third has just been opened. The company employs 65 men and has a daily output of 100 tons. The ore is hematite and contains about 50% of Fe.

The ore occurs in beds which are constricted in places, forming lens-shaped masses. The beds are tilted, and the ore is always richest in the trough of the lenticular mass. The age of the rocks I have not determined, though I think they are later than Grenville.

The Carney Ore Mining Co. of New York operates three shafts ¾ of a mile east of Caledonia. The mines are managed by Johnson Bros., of Gouverneur. The output is 80 tons a day. The ore grades from 48% to 50% Fe.

A deposit of micaceous hematite was discovered in the public road 3 miles east of Canton village. It has been opened and the ore used for road metal.

Hematite was found also on the George Cole farm, 1½ miles northwest of High Falls. Also on the Grant Hastings farm, ½ mile west of the same village.

A deposit of red hematite found on the Halley farm 2 miles from High Falls was leased by M. W. Spalding, of Rensselaer Falls. These ores all occur in rocks of the Grenville series. An iron ore bed was opened during the past season on the Vanderhoff farm, 2 miles south of Crary's Mills in the town of Pierrepont, by S. Vanderhoff. The ore contains 55% of Fe. A shaft has been sunk to a depth of 20 feet.

Iron ore was discovered at Owl head 6 miles south of Malone. The deposit has not been exploited.

The Chateaugay Iron Mining Co. is said to be operating mines on Upper Chateaugay lake.

Lead

Rossie and Macomb have in times past produced lead, but the mines have not been worked in recent years. The lead ore occurs in small veins in rocks (limestones and schists) of the Grenville series. During the past summer lead ore was discovered near the DePeyster-Macomb line, 4 miles east of Macomb village and 7 miles north of Gouverneur. The discovery revived interest in lead mining. Preparations are being made by the Gouverneur Garnet and Lead Mining Co. to exploit this vein.

Talc

The talc industry of St Lawrence county has been prosperous during the past year. All of the old mines have been working, and a number of new ones have been opened. The Ontario Talc Co. of Gouverneur has one mine located ¼ of a mile north of Fullerville in Fowler, and two 1 mile north of Fullerville. The daily output is 20 tons. It is used in the manufacture of paper, paint and toilet preparations. Sixty tons a week are used by the Bellows (Vt.) Paint Co. The company produces four grades of bur and cylinder talc.

The International Talc Co. of Gouverneur owns three mines at Talcville in Edwards. The output is 35,000 tons a year. The product is used in the manufacture of paper, paint, rubber goods and toilet preparations. There are five grades, both bur and cylinder.

The United States Talc Co. of Gouverneur operates one mine at Talcville. Its output is 10,000 tons a year. The product is used principally in the manufacture of paper.

The Union Talc Co. of Gouverneur operates three mines in the vicinity of York in the town of Fowler. Its output is about 30,000 tons a year. Ninety per cent is used in the manufacture of paper. The company produces several grades, both bur and cylinder.

The C. T. Holbrook Co. opened a mine 3½ miles west of DeKalb Junction in DeKalb, on the Helageas farm. About 500 tons of talc have been taken out.

A deposit of talc was located on the Close and Root farms 2 miles east of Colton. It has been leased by A. Fuller, of Colton.

Apatite

This mineral occurs associated with the crystalline limestone of the Grenville series. Quantities of crystals are collected each year by museum collectors from the marble quarries of Gouverneur and from other localities in Macomb. It has not yet been found in sufficient quantities to be of commercial value as a fertilizer.

Diopsid

Well formed crystals of green diopsid were collected from the farm of George Foster, 2 miles east of Bigelow in DeKalb, during the past year. The crystals occur in pockets and fissures in the crystalline limestone of the Grenville series. A deposit existing under similar conditions occurs on the Calvin Mitchell farm, 1¾ miles from Bigelow. These two deposits have been visited by collectors and the material is sold for cabinet specimens.

Garnet

The Gouverneur Garnet & Lead Mining Co. opened a garnet mine 3 miles north of Gouverneur during the past summer. The garnet is to be used in the manufacture of sandpaper. It is the variety known as almandite and occurs in a quartz vein in gneiss. A garnet-bearing rock was found also ½ mile east of the village of Colton.

Graphite

Numerous deposits of graphite have been discovered in St Lawrence county during the past year. On the L. C. Smith farm, 3 miles southwest of the village of Canton, a shaft has been sunk to a depth of 25 feet. The graphite occurs in veins and pockets in a gneiss of the Grenville series. The graphite is of the foliated variety and free from impurities. It has not yet been found in paying quantities. This mine is controlled by W. Chamberlain & Co. of Canton.

Another graphite mine was opened by C. T. Holbrook, 1 ½ miles south of High Falls on the John Lalone farm. The graphite occurs in a gneiss of the Grenville series. The mine is not being worked at present.

Graphite was discovered on the William Perry farm 4 miles southwest of the village of Canton. The deposit has been leased by M. W. Spalding, of Rensselaer Falls.

A deposit of graphite was found 1½ miles southeast of Pope's Mills in Macomb, on the Olds farm. About 100 tons of graphite-bearing rock has been taken out. The deposit is worked by Chamberlain, Jenks & Roberts of Canton.

Mica

Mica has not yet been found in quantities of commercial value in St Lawrence county. It has been located at the following points, and small quantities have been taken out. On the William Kelley farm, ½ mile south of High Falls in the town of Canton (biotite). One the J. Murray farm, ½ mile south of High Falls in the town of Canton (biotite). On the Butler farm 4 miles south of Colton in the town of Colton. On the Brown farm 2 miles east of Colton.

Iron pyrites

The Stella Mining Co. has mines located 1 mile northeast of the village of Hermon in the town of Hermon. These mines have an output of 60 tons a day. The mineral is shipped to a chemical company in Cleveland O.

The High Falls Pyrite Co. has mines located at High Falls, town of Canton. The output of these mines is 20 tons a day. The product is sold to chemical works. During the past season a mine was opened on the Alexander Farr farm 2½ miles northeast of the village of Bigelow in DeKalb. The mine was operated by G. Fleming, and six or eight carloads have been taken out.

A deposit of pyrites occurs on the L. Hockens farm 7 miles west of Rensselaer Falls in the town of De Peyster; also on the George Styles farm, 1½ miles east of Bigelow in DeKalb; and on the Steve Hendricks farm 1 mile south of Bigelow.

These deposits all occur in rocks of the Grenville series.

Tourmalin

Small deposits of this mineral have been discovered during the past season on the S. Newcomb farm 6 miles west of Rensselaer Falls in De Peyster and on the Hamlin farm 3 miles east of Colton. It is of value only for cabinet specimens.

NOTES ON RECENT MINERAL DEVELOPMENTS AT MINEVILLE

BY HEINRICH RIES

The introduction of a new and successful method of magnetic separation for treating the magnetite ores at Mineville, Essex co., has led to renewed activity in the iron mining industry at that locality.

The special object of thus treating the ores is to obtain a product low in phosphorus, which in the crude ore often runs from 1½% to 2%, and thus make it available for Bessemer work.

In the summer of 1901 Witherbee, Sherman & Co. installed a new separating plant for treating the ore from the Joker and Bonanza shafts on the Old Bed.

In this plant the ore, after a preliminary crushing, is dried to remove all moisture and then passed through Wendstrom magnetic separators. The concentrates from these are ready for shipment, but the tails are recrushed to 20 mesh and passed through a Witherill separator with two magnets. The first magnet removes the magnetite, which is added to the concentrates mentioned above, while the second magnet takes out the hornblende, thus leaving a mixture of apatite with some quartz to pass off at the end of the belt. The last mentioned product is sold to manufacturers of fertilizer.

The present separating plant has four Wendstrom separators, and three Witherill machines, giving a daily capacity of about 400 tons of concentrates, which, when the machines are not overcrowded, usually run from 64% to 65% iron and .5% to .7% phosphorus.

Since the present separating plant has been so successful, the company is erecting a second one to the north of the first, which is to have a daily capacity of 500 tons.

In the new separator the ore is crushed to the proper size in jaw crushers and rolls, dried in a vertical dryer and then passed through the Witherill machines, no Wendstrom separators being employed in this case. It is probable that the new works will be in operation by November 1902.

The ore from the Harmony or A shaft on the new bed runs from .1% to .3% of phosphorus and hence can be shipped in its crude form.

In March 1902, a new shaft, known as the B shaft, was begun at a point about 500 feet south of the A shaft. About 250 feet of glacial drift were penetrated before bed rock was struck. This occurred at the end of August 1902.

Considerable prospecting with diamond drills has been done during the 12 months ending September 1902, and some additional beds of good ore have been found.

The Port Henry Iron Ore Co. has continued shipments from its mine, no. 21. This goes in part to the furnace at Port Henry, which went into blast again in February 1902 and is now being operated by the Northern Iron Co., with an output of 100 to 125 tons a day. The product is chiefly Bessemer pig and in part foundry iron.

The blast furnace at Crown Point still remains inactive.

ADMINISTRATION

The work of the State Museum for the fiscal year ending Sep. 30, 1902, has been productive of varied and valuable results.

Since the opening of the remodeled building Oct. 7, 1901, the attendance has been greatly increased and, in the 12 months from that date, has surpassed any previous record since September 1893, when the turnstile was first put in, the total number of visitors aggregating over 75,000. This may be safely taken as an expression of the fact that, if the museum collections were in a proper building with sufficient room for their exhibition, the number of people benefited would be very great. Under the present circumstances, there being little opportunity for the amplification of the exhibition collections, a large part of the energy of the museum staff is directed to work of research and publication. The aggregate of this publication work is evidenced in the reports and bulletins issued, for the fiscal year the bulletins distributed numbering 12 and aggregating 1595 pages.

PALEONTOLOGY

During the past year the state paleontologist and his staff have been largely occupied with special problems arising from recent field operations. These have required work both in field and office and may be briefly stated. The discovery of a quite remarkable and heretofore unknown development of the Guelph fauna in New York has led to its careful exploitation as an important addition to the ancient fauna of the State. A memoir on this fauna and its distribution in the State is now printing.

Interesting additions to the Portage fauna and to evidence bearing on its origin and migrations have been made by operations in Chautauqua county, and an account of this fauna, bringing together the results of several years investigations, is likewise in press as a Museum memoir. In connection with this work examination has been made of sections in Erie county, Pennsylvania and at Kettle Point and vicinity, Ontario.

The region directly south of Syracuse, covered by the Tully topographic quadrangle, has been mapped stratigraphically in detail, and the map is ready for publication. The area covered by Becraft mountain near Hudson, celebrated in New York geology for the completeness of its stratigraphic section and the subject of a number of important papers, has been mapped in detail, on a base scaled 1 mile to ½ inch. This work with the report thereon will soon be ready for publication.

Correlation study of the "Hudson river shale" formation has been continued in Rensselaer county under specially favorable conditions afforded by the Melrose water tunnel, which makes an underground rock section about 1 mile in length. The Coralline, or Cobleskill, limestone has been carefully restudied from its outcrops in Otsego county, eastward into Ulster county.

In the office, time has been given to the completion of the *Catalogue of Type Specimens,* which is now printed to about 600 pages, half its entire length, and, in connection therewith, the ticketing and labeling of the type specimens have been carried forward.

Investigations have progressed on the relations of the Potsdam sandstone and its fauna to the overlying formations, by Gilbert van Ingen; on crustaceans of the Salina group, by C. J. Sarle; on the pyrite fauna of the Tully limestone, by Dr F. B. Loomis; on the paleontology of the Salamanca quadrangle, by Charles Butts; and on the Guelph and Naples faunas, the graptolites of the Beekmantown shales, the fauna of the Gaspé sandstone and Grand Grève limestone and the fauna of the Elmira quadrangle, by the paleontologist and his assistant.

Full details of the work of this division are given in the separate report of the state paleontologist.

ZOOLOGY

The assistant in zoology returned from field work Oct. 1, and the first part of the year was spent in cataloguing and identifying the material collected during the summer and in cataloguing the material collected by Dr Bean. Part of the exhibition collection needed attention and was gone over and a number of additions were made to it. These amounted to 24 in the vertebrate series and 54 in the invertebrate. Besides these, 67 descriptive labels were prepared and placed with the specimens.

These occupied the time of the assistant till Mar. 1, when he took his vacation. This was spent in an examination of a number of European natural history museums, on which a short report is appended. After his return May 1, the assistant spent considerable time in collecting in the vicinity of Albany. Short trips were also made to several other places, including Averill Park, Altamont, Howes Cave, in order to investigate cave fauna; Peekskill, Catskill, Aquetuck, in order to investigate the finding of a supposed Quaternary horse, which a careful examination has shown to be indistinguishable from the modern horse, Equus caballus; Sheffield Mass., in search of rattlesnakes; and Cold Spring Harbor. The entire month of August was spent in the Adirondacks, the places visited being White Lake, Oneida co., Wilmurt, Herkimer co., and Keeseville and Upper Jay, Essex co. Considerable valuable information concerning the distribution of various forms was obtained. September was spent on Long Island continuing the investigation of the edible crab, and a report is appended on the commercial relations of that form.

The only publication of the department of zoology during the year was the catalogue of the reptiles and batrachians of New York prepared by the assistant, Dr Paulmier, and Mr Eckel. This was intended only as a preliminary catalogue, but has been very well received and has been the means of interesting a number of people in different parts of the State in these forms and has resulted in a number of additions to the collections. It is hoped that in this way sufficient specimens and information concerning their distribution may be obtained to permit of the publication of a more complete catalogue.

No changes of any importance have been made in the arrangement of the specimens on the fourth floor, but the very fine collection of domestic fowl formerly the property of the New York State Agricultural Society, on the first floor of the rear wing, has been placed in the custody of the Museum, and a number of specimens have been placed on polished bases.

A number of the vivariums which were mentioned in the last report were kept on exhibition during the winter and attracted considerable attention. A number of new forms have been collected during the summer and are now in the halls.

Prof. James L. Kellogg, who prepared for the Museum a bulletin on the clam and scallop industries of New York, has continued his work on this subject and has made a supplementary report, which is now in press.

CRAB FISHERIES OF LONG ISLAND

BY FREDERICK C. PAULMIER

During the summers of 1901 and 1902 the writer spent some time in investigating the crab fisheries of the Long Island coast, and a preliminary report was published in the report for 1901.

During 1902 the time which could be allotted to this study was but short, and the present report is merely on the state of the fisheries and on the methods of taking crabs employed on Long Island.

The past season was not a very successful one. This was due to the scarcity of crabs, and only about one third of the usual number of hard crabs were shipped to market. Soft crabs were so scarce that not enough was taken to supply the local demand. The reason assigned for this by the fishermen was the coolness of the summer, other conditions being apparently the same. There is nothing to warrant the fear that the scarcity is due to overfishing; for similar off years have occurred before and been followed by a more abundant supply the next year. It was noticed that, while the number of crabs was smaller than usual, they appeared to average larger in size.

Crab fisheries

Crabs are, of course, taken all over the island by boys and by the summer boarders, by whom it is regarded as one of the amusements of the summer.

The method used by these is to entice the crab within reach by means of a fish head or other bait and then catch it in a long-handled crab net. This method results in the capture of only a small number of crabs, but yields plenty of amusement.

For the market, however, the fisheries are confined mostly to the eastern end of Moriches bay, Center Moriches and Brookhaven being the principal places for shipping.

The following is the method of procedure. A manila rope several hundred feet long is taken, and on this, at intervals of from two to three feet, lines about 18 inches long are fastened, and to the ends of these the bait is tied. This consists of pieces of eel's flesh, which is sometimes fresh but more frequently salt. The catching and salting of this are done in the previous winter. The rope is now coiled in a tub and taken out to the shallow water where the crabs occur. One end is fastened to a pole set in the bottom and the rope is then paid out along the bottom, and the other end fastened to another pole. The line is then gone over the following day by the fisherman in a row boat, pulling himself along by it, and the crabs which are found clinging to the bait are drawn up and secured with a crab net. They are either put directly into barrels or else into the bottom of the boat to be barreled after the return to the shore. The handling of the crabs is done by means of a pair of iron or wooden forceps about 18 inches long. The fishing is usually done early in the morning, and the lines are rebaited, if necessary, in the afternoon.

The barrels used in the shipping are empty lime barrels, which are furnished to the fishermen at the station by the Long Island Express Co. for 9 cents each.

A barrel will hold 200 to 250 crabs according to its size and weighs about 110 pounds.

In some places the Long Island Express Co. maintains a free collection, and the crabs are then collected from the fishermen and taken to the station. In other places the fishermen have to send them to the station. They are shipped to New York on an express train, leaving late in the afternoon or evening, and the express charge is 40 cents a barrel.

The season lasts from July 1 to Sep. 15, though crabs may be taken both before and after those dates. The number of men engaged in the business varies considerably, many fishermen taking it up only when other occupations fail for the time. Attending to the wants of the summer population, sailing, etc. seem to be more lucrative than crabbing. The last season also was such an unfavorable one for crabs that but few carried on the business.

Center Moriches. In 1901 there were 12 men engaged in catching and shipping hard crabs. The shipments here during the season averaged about 50 barrels a day, running at times up to 80. In 1902 about the same number of men were catching them, but only about one third as many crabs were taken, and the shipments averaged only about 20 barrels a day. A free collection of the barrels is maintained at this place.

Brookhaven. In 1901, 10 men were catching hard crabs, and the average was about 50 barrels a day. In 1902 only five were doing it, and the shipments were only about 30 barrels to Aug. 1. At the time the writer visited the place, in the latter part of August, the shipments had fallen to about five barrels a day. A free collection also was in operation here.

Eastport. Not visited in 1901, but in 1902 there were about 11 men engaged in catching crabs. The shipments were only about 20 barrels a day and there was no free collection.

Speonk. Here, the only other place mentioned by the officials of the express company as a place for shipping crabs, no one was found regularly engaged, but a few men caught crabs when they had nothing else to do. Four or five barrels were occasionally shipped.

The shedding of crabs for the New York market is confined on Long Island to Freeport. It is carried on to a certain extent for local purposes at several other places, as at Great River, where four men were engaged in it. These men did it only as a side business, and their product amounted to only three or four dozen a day each.

At Center Moriches, one of the centers for the hard crab shipping, one of the fishermen spends his entire time in shedding crabs; and his method may be taken as a good example of those in use. His being located in the center of the crab fishery is of considerable advantage; for he does not have to go in search of those about to shed, but purchases them from the hard crab men for one cent apiece. These crabs are technically known as "comers" and are recognized by the appearance of a membrane between the joints of the large claws, which then look as if scratched by a pin. A "comer" may also be recognized by breaking off the ends of one of the walking legs, when the new skin will be found underneath, and still later by the appearance of the crack around the edge of the carapace. At this stage they are known as "crackers."

The " comers " are put by themselves in a crab car, which is a float about 10′x4′ with a bottom of boards and with sides about a foot high, of laths placed perpendicularly. These are moored along a platform and float, so that there is about 6 inches of water in them. The crabs are thus easily watched and can be reached with a net.

In the process of shedding the carapace splits all along under the edge, and the top is raised up, disclosing the soft new skin underneath. In this stage they are known as " busters " or " peelers " and are carefully removed to another car, so that they will not be injured by the more active " comers." The crab in this stage is covered with a thin membrane, which prevents the water from getting on the new shell. If it becomes broken, the crab dies, in the parlance of the fishermen, from " drowning."

The active process of shedding takes place by muscular action, the crab gradually drawing its body out through the wide opening of the dorsal part of the old shell and pulling the legs out through the openings at their bases. Once out of its shell, the crab lies helpless on the bottom of the car and must at once be taken out, or it will soon commence to harden and become what is called a " paper shell." The soft shell crabs are carefully taken out of the water as soon as they have shed and are packed with their anterior end upward with damp eelgrass, in shallow boxes, for shipment to market. Packed in this way, they will not harden for some time. For shedding purposes, the female crabs are preferred, as they appear to stand the process better and " set up " in a better manner after shedding.

SNAKES OF ROCKLAND COUNTY, NEW YORK

BY W. SEWARD WALLACE

The region on the west side of the Hudson river, between West Point and New York city, is said to be one of the richest areas in species of flowering plants in the eastern United States. It is also rich in other forms of life, the Reptilia, in particular, being abundantly represented.

The following notes were taken in part during the summers of 1895-96, on the low chain of hills that extend from Sparkill, northward, along the river to Haverstraw, and thence westward and southward to the vicinity of Sterling lake.

Rockland county, the smallest in the State, is three-sided, its boundaries having the form of a triangle, the apex a few miles west of Ramapo, the base resting on the Hudson river. This geographic area nearly coincides with a geologic basin comprised between the Highland range and the trap rock elevations known as the Palisades (Closter, Tallman, South and other mountains; Verdrietege Hook and the High Tor). These high hills extend in a hugh semicircle along the Hudson river, and from near Haverstraw northward to "near the Highlands,"[1] and thence southwestward toward the Highland range, which continues the formation southward. Inclosed within the various hills lies a basin of fertile land, the exposed rock being the Triassic sandstone. Thus on the hills we find a region quite different from that of the low plain in the interior, and corresponding differences in the fauna.

Certain species are of somewhat rare occurrence in the county, and it is possible that they are only strays. It seems very possible that single individuals or even numbers of a species may wander north or south of their habitat during a single season, and be found there, without necessarily extending the natural habitat of the species. Thus the northern limit of the pine snake, in the vicinity of New York, was heretofore the southern portion

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[1] See Mather's Report on the First Geological District, Geology of New York, 1843, where an excellent account is given of the whole formation.

of New Jersey;[1] yet a single specimen of this snake was found on a high hill near Piermont N. Y., nearly 500 feet above tide water. So, while recording the species in the Ophidia of the county, it is probable that this specimen was a stray and far northward of where it is normally found. DeKay, however, thought that the species would "probably be found in this State."

There are several points within this area which I have not yet visited, but the present list is quite complete and has my personal identification of nearly every snake mentioned.

Technical descriptions have been omitted, as such may be found in any good herpetology. The following are the best for this purpose.

1 **Brown, A. Erwin.** A Review of the Genera and Species of American Snakes, north of Mexico. Acad. Nat. Sci. of Philadelphia. Proc. January 1901 (issued Ap. 2).

2 **Cope, E. D.** Crocodilia, Lizards and Snakes of North America. U. S. National Museum. Report 1898; Serpentes. p. 153-1270.

3 **Eckel, E. C. & Paulmier, F. C.** Catalogue of New York Reptiles and Batrachians. N. Y. State Museum. Bul. 51. Albany 1902.

I THE COLUBRINE SPECIES

Not poisonous

GROUND SNAKES

Carphophis amoenus (Say)

Worm snake

This snake, while generally common in the eastern states, seems rare around Nyack, but one specimen having been taken in 1899 at Blauveltville N. Y.

The beautiful rich color of the back is not easily seen in the localities where the little ground snake hides, and the lighter red of the underside can not be seen till the snake is turned over. As the gastrosteges are generally appressed to the ground, the snake is almost invisible in a plowed field, or elsewhere where the ground is exposed.

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[1] "Pine woods, New Jersey to Ohio and southward," Jordan.

RING SNAKES

Diadophis punctatus (Linn.)

Ring-necked snake

This snake is quite frequently found, but it seems to be scarcer each year. Indeed, all the snakes in the vicinity of Haverstraw, New City and other towns are decreasing on account of the merciless slaughter carried on by boys and men. It is more common in New Jersey and Connecticut.

The ring-necked snake extends very far northward; the writer found it in Digby county, Nova Scotia, in 1898; southward it extends to the South Atlantic states. A single specimen was taken at Cold Spring Harbor L. I. in August 1899.

BLOWING ADDERS

Heterodon platyrhinus (Lat.)

Blowing adder or spreading adder

This serpent is perhaps more dreadful in its appearance than any other snake of the eastern states, owing to its habit of coiling up, flattening its head and hissing like a poisonous snake. It is, however, quite harmless.

The blowing adder is not at all common in Rockland county.

It is found commonly in Connecticut, as at Hartford.

GREEN SNAKES

Cyclophis aestivus (Linn.)

Rough green snake

In Rockland county only two species of snakes are regular tree-climbers, the pilot snake and this little green snake, though DeKay's snake sometimes climbs in bushes over water in the spring.

The green snake is called the summer snake, and it is, where it occurs at all, extremely abundant. It is fond of lying in low grass, coiled up in a tight knot, and is often found in New Jersey in meadows bordering streams and lakes.

This snake is, to those who can overcome their repugnance to snakes in general, a very attractive little creature and makes an extremely docile and interesting pet. The eyes are large, bright and intelligent looking. It seldom reaches 15 inches in length, is very slender and of a beautiful, bright emerald green color.

GRASS SNAKES

Liopeltis vernalis (DeKay)

Grass snake

Another of the green snakes is also quite common in Rockland. This is the little "grass snake." It is very similar to the bush-climber, but is much smaller, more stout and of a more energetic disposition. The eyes are even larger that in *C. aestivus*, the general color is of a deeper tint, and the head is longer, on a more slender neck. The species is not easily tamed, like the green snake.

This little snake loves grassy fields and is often seen in apple orchards and around barns. It does no climbing, like the preceding species. It does not seem to abound in this county, and is not common in New Jersey, near by. Both species eat flies and other insects and are a real boon to the farmer, who, nevertheless, ruthlessly murders them at sight. In Nova Scotia, on about lat. 44° 30′, this snake is common along the borders of the numerous lakes.

BLACK SNAKES

Zamenis constrictor (Linn.)

True black snake

This well known snake is one of the largest in the county, often reaching 7 and (if reports are true) 8 feet in length. It is very fond of water and swampy tracts, but is also common in grassy fields and cornfields, along with the next species (*Coluber obsoletus*).

The black snakes often live in holes in the ground, beneath bushes or stone walls. The so called "blue racer" is a variety of this species, which Cope refers to Michigan; the present species has however well earned the same name around Nyack, both by its clear blue color and its extraordinary speed. The average "blue racer's" speed is marvelous, considering that it has nothing but the ventral scales to take hold of the ground with.

Walking along the path by the eastern branch of the Hackensack river one day, the writer came suddenly on a nest of black snakes, all of large size, coiled up in a heap. There seemed to be a dozen. Three of the largest showed fight at once, rearing their heads and vibrating their tails angrily; but the others immediately slid into the water and disappeared. I had no stick at the time; there were only small willow bushes near, and no rocks. I leaned over, and shook the nearest bush violently, and the three snakes immediately slid into the water and beat a hasty retreat across the stream, leaving in the muddy bank an impression similar to ripple-marks on a beach.

PILOT SNAKES

Coluber obsoletus (Say)

Pilot snake

This is also a "black" snake and is often confused with the true black snake. It is however a larger species and is not so bold or venturesome. But it is a very swift and beautiful creature, generally more robust than the last.

The pilot snake often climbs trees "by following the depressions in the rough bark," as Jordan says. This snake is occasionally seen in trees, or on fallen logs, over the Hackensack river and smaller streams in Rockland county.

The pilot is the only member of the beautiful genus Coluber found in the county, with the possible exception of the fox snake, *C. vulpinus,* which undoubtedly occurs in New Jersey[1] a few miles to the southward. *C. vulpinus* is not included in the list however, as no specimens could be identified with that species.

PINE SNAKES

Pityophis melanoleucus (Daudin)

Common bull snake

But one specimen of this brilliant patterned snake was seen in Rockland county and this specimen was, moreover, dead, and half eaten up by ants, though the skin was whole. It was found on Tallman's mountain, near Nyack. These snakes are common in the more southern states of Delaware and Maryland, where they grow very large. One specimen obtained from New Jersey measured over 6 feet.

It has been already mentioned in the introductory remarks, that the occurrence of the pine snake in Rockland county is pos-

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[1] N. J. Geol. Sur. 1889. Zoology, p. 646.

sibly explained by the migration of a single specimen, or of a pair of specimens, beyond the northern limit of their habitat, southern New Jersey. A series of such migrations, extending through a period of time, would, of course, tend to establish the southern parts of Rockland county as the northern limit of distribution of the pine snake. It would however seem best to wait till further evidence can be secured before placing the pine snake permanently in the state fauna.

These remarks apply also to the bush snake, *Cyclophis aestivus,* for though occasionally seen in Rockland county, this snake's habitat heretofore only reached southern New Jersey.

KING SNAKES

Ophibolus

The snakes of this genus are all well known for their bright markings, their bravery and their swiftness. They are all large and heavy, and each member of the genus is nicknamed. Thus the "king snake" (the western form) is an "enemy of the rattlesnake."

I have been repeatedly informed by residents of Nyack that the king snake is troublesome to the farmers in the county, but they must have reference to the milk snake, or the corn snake, as king snakes do not occur as far north as New York. The corn snake, however, has never been identified in Rockland county, though it undoubtedly belongs in the state fauna.

Ophibolus doliatus triangulus (Boie)

Milk snake

A prominent member of the king snake tribe is the milk snake, var. *triangulus* (Boie), which is common in the villages and farm country of Rockland county. This variety, according to Cope, Stejneger and other authors, is the most northern and also the most widely separated from the type (*Osceola doliata* of Cope).

The milk snake is often killed in barns by the farmers of the state. The writer has never seen it take milk or steal eggs, as it has been accused of doing by trustworthy writers.

WATER SNAKES

Natrix fasciata sipedon (Linn.)

Water snake

This snake is (falsely) called "moccasin." The "moccasin" of authors is a member of the Crotalidae and is a very dangerous snake; but the snake under consideration is harmless. It is often seen along the banks of the Hackensack and other streams in the country, but it is not so common as the "black snake." It lies stretched out on fallen trees or on the flat leaves of water lilies that are strong enough to hold it, and it swims very readily with a rapid, sinuous motion.

A very large one that was seen on the Hackensack swam for some distance in front of a pursuing canoe, and then dove like a duck; nor did he reappear anywhere while we were in the vicinity. Another dropped into the stream from a limb fully 10 feet or more above the surface of the river.

Storeria dekayi (Holb.)

DeKay's snake

Two of this species were taken above the town of Blauvelt on the Hackensack in May 1901.

The larger was an adult male and had recently shed his skin. He was coiled tightly around a small clump of alder twigs and did not hear or see me till my hand was within a few inches, when it was too late to escape capture.

The smaller was an immature specimen, only 50 mm long. He was, nevertheless, swimming upstream, against a powerful current, and making good headway when captured.

It seemed strange to find these generally land-loving, little snakes not only sleeping in a bush which grew in water, but actually swimming about.

DeKay's snake is not common anywhere in the county, or at least is not frequently seen, which is owing to its diminutive size and secretive habits.

Storeria occipitomaculata (Storer)

Red-bellied ground snake, brown snake

Common in the farming country, but seldom seen in the rocky hills. This species loves flat, dry areas and plowed fields, where there is dust. It is very frequently found on the roads, killed by boys and mashed almost beyond identification.

It is found also in New Jersey, and a specimen has been taken at Cold Spring Harbor L. I.

GARTER SNAKES

Eutaenia saurita (Linn.)

Ribbon snake

The prettiest garter snake, if it may be so called, is this snake. Cope includes it in the group and places it, phylogenetically, at the point farthest off from the type, *E. sirtalis.* This one is domestic in its habits and is frequently found around kitchen gardens, where it snaps up insects.

One fact is noticeable, that, while *E. sirtalis* is the most variable species in the county, *saurita* seems always the same in pattern and in brightness of colors.

Eutaenia sirtalis (Linn.)

Common striped snake

The snake that is oftenest seen lying dead on the country road, or thrown over an orchard wall, is this unfortunate garter. There is no reason for killing it; it is undoubtedly of value to the farmers, and is perfectly harmless.

Going along a road, some 3 miles from the village of Nyack one day in the spring of 1896, the writer was a witness of a most interesting courtship. A large female garter snake was coming down the road toward me, evidently making for a stone wall near by. Suddenly from a bush emerged another garter. He gave chase to the first, caught up with, and headed her off. Then for 10 minutes the two circled about, going up and down the road, passing me several times. At last they glided gracefully over a low road and disappeared in the adjoining field.

The common garter snake is a most variable species, and several so called varieties have been accredited to the eastern states, but the writer has never seen more than two varieties of *Eutaenia sirtalis* in the county of Rockland, one with bright spots, *E. ordinata,* spotted, and one with bright lines, *E. sirtalis,* striped. It is even possible, in the opinion of the writer, that these are not varieties, but subvarieties. The young and old of this snake also differ in a most remarkable way. Cope thought that the *sirtalis* was the ancestral form of the genus. It is the least specialized of all.

2 THE CROTALINE SPECIES

Poisonous

"PIT VIPERS"

Ancistrodon contortrix (Linn.)

Copperhead

Of all snakes the copperhead is the most interesting to the writer. It is very common in Rockland county, and in a number of localities it occurs frequently enough to be dangerous. With one or two exceptions, copperheads are always found living on elevated rocky places, which are occasionally at a considerable distance from water.

An exceedingly vicious specimen was found on the very summit of the Hook mountain, which is about 800 feet above the nearest water (Rockland lake, 2 miles away). There were no ponds or pools whatever on the mountain, but possibly reptiles find water underneath the rocks in places or collect it from dewy leaves. The region is arid enough for the prickly pear, which flourishes on the rocky hilltops of the range.

The local name of this snake is the "copper"; the southern is the "cottonmouth," a name also given to the moccasin. In the villages of the county this dangerous reptile is well weeded out; but it is still unpleasantly numerous on farms, in woodlands and along the Hackensack river. At a place back of Haverstraw, some years ago in the springtime, a farm-hand discovered a great nest of copperheads and rattlesnakes in an old cellar and killed a great many of them with a whip. Six were found one dry morning in the summer of 1897, with the aid of a friend, on Snake hill, over Nyack.

The old and young of the species differ in color; the old are dull brownish in color, with a heavy thick body and a rather broad head like a rattlesnake's. But the young are slender, vividly colored, and the head is not conspicuously broad.

The nests are generally holes under large stones or in banks, or occasionally in disused springs, basins or cellars.

The tail of the copperhead, being armed with a stiff, horny point (a primitive rattle), makes, when the snake vibrates it in the dry leaves or grass, a noise like that produced by a cicada, when the latter is pinned to the ground or a tree by a digger wasp and beats its wings about.

The copperhead lives principally on toads and the terrestrial and arboreal frogs and lizards, but the writer never actually caught it feeding.

Dr R. E. Kunze (quoted by Stejneger in his paper on poisonous snakes) thinks that the copperhead does not strike from a coil, but from a curved, twisted attitude it often assumes. This can be confirmed so far as the annoyance of a stick or cane produces a natural strike, for it seldom coils up when thrown on the defensive, but contracts suddenly into a close, zigzag position, very much like any other snake; and, when in this attitude, it can cast itself at any object very effectively.

Crotalus horridus (Linn.)

Rattlesnake

In the report of the geologist[1] it is stated that no rattlesnakes have been seen in the northern counties of New Jersey for 50 years. This must be an error, probably due to the lack of correct local information; for rattlers are still met with in both states (New Jersey and New York), and specially in Rockland county, along the line of the West Shore Railroad, and the New Jersey & New York Railroad. For this I can personally vouch.

These dangerous snakes are specially numerous in the level, cultivated area lying to the west of the Hackensack river, in Haverstraw, Monsey, Suffern and other towns. The case of a farm-hand finding a nest of venomous snakes in an old cellar near Haverstraw has already been mentioned.

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[1] N. J. Geol. Sur. 1890-92. Zoology, 2:648.

Rattlesnakes occasionally stray westward over the higher hill country, and the writer has twice seen rattlers on Eagles' Nest hill, South mountain, over Nyack. On one occasion I was walking on the hill and sat down on a rock to sketch. Suddenly I heard what I took to be an early locust or cicada (it was in July); but the sound was less musical and seemed unfamiliar. On investigation a small snake was discovered thrashing about and occasionally coiling up. My attempt to catch the snake failed, and it quickly disappeared beneath the very rock which I had been using as a seat. There can be no doubt as to the identification, as no other snake has a rattle, or could make such a noise as that on a bare rocky surface.

I had further and more direct proof later when, one morning, I came across another rattler, larger than the first, lying on a boulder by the Balance Rock road. He tried to get across the road, but was headed off. Then he alternately coiled and sprang his rattle and chased about me, in a circle, till he finally escaped, as the other had, beneath a round, granite rock that stood by the roadside.

Mr Edwin C. Eckel, in his "Snakes of New York State," [*Am. Nat.* 35:155] says:

Crotalus horridus still occurs in Orange and Rockland counties, but is very rare and possibly extinct east of the Hudson. Cope mentions a specimen collected in 1878 from Katonah, Westchester co.; and I have been informed that one was killed in 1887 near White Plains.[1]

With this somewhat rare snake I come to the end of the known species of Ophidia occurring in Rockland county, N. Y. There are in all 16 species and varieties, divided among 14 genera. I regret that I have not a collection of snakes to back up my list; but my notes and observations, together with the fact, mentioned before, of having handled specimens of nearly every species, I have thought sufficient for the purposes of the present paper.

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[1] Mr W. H. Davis reports the capture of one at Garrison-on-Hudson in the summer of 1902. *Ed.*

REPORT ON A VISIT TO SOME EUROPEAN NATURAL HISTORY MUSEUMS

BY F. C. PAULMIER

During the spring of 1902 the writer spent his vacation time in Europe in visiting some of the larger natural history museums.

At the request of the chairman of the State Museum committee and of the director of the Museum, the following report was prepared. It is not intended as representing a study of museums, but merely points out some of the exhibits and methods of display which it would be worth while to copy in the State Museum, and it is also confined more particularly to observations on methods of exhibiting the invertebrates in which the writer is most interested. It is to be regretted that lack of time prevented him from visiting some of the smaller local museums. The limited period of his vacation, however, prevented him from doing so, and only the larger museums in Vienna, Prague, Dresden, Berlin, Munich, Stuttgart, Paris and London were visited. The writer wishes to express his thanks for the courtesies extended to him by the directors and other officers of these museums. They extended to him every facility he desired, and to them much of the success of the trip is due.

The landing was made at Naples, and there considerable time was spent in examining the famous aquarium at the Stazione Zoologica.

Vienna. After a trip through the larger cities of Italy, the museum at Vienna was visited. Here, among many interesting exhibits in the magnificent new building, the thing that impressed the writer most was the very effective use of backgrounds of various shades in showing off the specimens to the best advantage. Thus, for instance, the majority of the birds are displayed in rooms with maroon walls, and the backs of the cases are of the same color; dried echinoderms are shown on an olive ground, as are the alcoholic invertebrates, which are cemented to black or white glass in square jars.

Disarticulated skeletons are mounted on black. The general effect is very good; but the halls must be exceptionally well lighted, as these colors do not reflect the light as well as the lighter shades.

Here, as in other museums on the continent, the use of iron for the frames of cases is quite common.

Prague. The type collections in this museum are particularly fine. Dry specimens are placed on light brown porcelain bases with light green labels. The type collection of insects is in flat cases (covered with black cardboard, to be raised by the visitor), and the upright cases between these are filled with models, nests, examples of mimicry, etc. An interesting exhibit was that of scorpions, showing dry and disarticulated specimens and their allies together with the fossil forms.

Particularly interesting or valuable specimens among the mammals and birds are placed in glass boxes in the cases.

Dresden. The Royal Museum in Dresden is the one which, in the views of the present writer, comes closest to the type which the New York State Museum should be. Here the entrance hall and adjoining rooms contain a collection of the local forms of Saxony, and the remainder of the museum is filled with a type collection.

This has the advantage of showing, within a limited space, the forms which are seen most commonly by the observer and enables him to identify them with ease. From this he can pass on to an examination of the more unfamiliar forms.

Many of the details of the exhibits are worthy of special mention and copy. Among these may be mentioned the fish painted with water colors, a method which the writer regards as being the only satisfactory one of exhibiting that difficult group. The process has been described by Dr V. Brun, of Hamburg, where it has been carried out to a greater extent than at Dresden, but this was the first place in which the writer had seen specimens. The process consists of hardening the fish in as natural a shape as possible and painting the specimen with water colors. It is then mounted in alcohol in a horizontal position against a white glass plate, which is placed in a square jar.

In the local collection the bottom of the jar is covered with gravel, and water plants, also painted, are placed in the alcohol, thus giving a very natural appearance to the specimens. The same idea is carried out with the reptiles and batrachians and is a most satisfactory method of showing them.

Birds eggs are placed in tin trays on blackened hard wood sawdust, which prevents their rolling when the drawers in which they are kept are opened. The distribution of birds is shown by the use of small maps, on which the summer range is shown in one color, the winter range by another and the intermediate region, where the bird is always found, by a third. Differently colored labels are used to indicate the continental areas from which specimens come. Very effective use is made of colored backgrounds, a case of scarlet parrots displayed against a background of rich brown being particularly striking, as were the birds of paradise against a blue ground.

Explanatory labels have not found favor in this museum, the authorities believing that the way to interest the public is to exhibit the specimen in as attractive manner as possible and not attempt to teach the observer more than he can learn from an examination of the specimen itself.

This museum is open to the public only two hours each day, from 11 to 1. The remainder of the time it is kept completely dark to prevent the fading of the specimens from exposure to light.

Berlin. The walls and background in the museum are of a light straw color, which does not give as good an effect as the more pronounced tones of the Vienna and Dresden museums. A most interesting display is that of the transparent hydroids, which are fastened to glass and placed in jars in window cases, so that every detail can be seen. The Coelenterata are illustrated by many colored sketches and diagrams. Many groups of invertebrates and lower vertebrates are shown in square jars in their natural surroundings and very effectively. Considerable attention is paid to comparative anatomy, and many dissections, sketches and diagrams are exhibited.

The museums in Munich, Stuttgart and Paris were also visited; but, as the buildings and methods of installation are not novel, notes on them may be omitted in favor of the natural history division of the British Museum, at South Kensington, London.

London. In the immense collections here so many methods of installation have been tried, and so much information may be obtained concerning good and bad methods, that it is, without doubt, the most important place to be visited by one wishing to study museums.

Among many interesting and valuable things, the following may be noted. Iron cases have not found favor here as they have in some of the continental museums. Great stress is laid on very full explanatory labels and photographs, and sketches are commonly used.

One of the things that impressed the writer strongly was the cases illustrating some of the general facts of zoology, such as mimicry, protective coloration, warning colors etc., shown principally by the insects, and with very full descriptive labels; cases showing melanism and albinism and one of pigeons showing the various breeds produced by artificial selection. Exhibits such as these have a very great educational value, and it is hoped that some of them may be copied in the State Museum.

Well labeled collections illustrating comparative anatomy are shown and include, among other specimens, skulls showing the various varieties of teeth, the succession of teeth etc. These could be copied with success in the State Museum, though of course without carrying the work to such an extent.

The insects are shown in flat cases, which are covered with a frame (to be raised by the visitor) on which are printed diagrams and descriptions of the forms in the case beneath. The collection of hymenopterous nests is good, and many of the galls are represented by wax models. The variations in different species of any part, such as the coxa, are shown by specimens with that part colored red. Forms of antennae are shown by specimens and diagrams. A unique exhibit is the distribution of the genus Carabus, a beetle, shown by specimens pinned on a map.

Arachnids are dried and placed in flat cases on dark green or olive velvet or plush, which, however, has a tendency to fade. Dried Crustacea are placed on sand or sandpaper, while some of the alcoholic specimens are also placed on or partly in sand, so as more closely to simulate their surroundings.

The set of museum handbooks are models of their kind and in some cases are really textbooks of the department they treat of. They are sold at a very low price.

As a result of his trip, the writer would regard the following points as the most important and capable of being copied with advantage in the State Museum.

First and most important, the writer believes to be the use of descriptive labels, sketches and diagrams. Second, the installation of specimens, as far as possible, in groups representing them in their natural surroundings. In the limited amount of space at present at the disposal of the museum, this is out of the question with the larger forms, but many of the lower and smaller forms may thus be shown to advantage. Third, in order to add to the attractiveness of the exhibits, the use of colored backgrounds is recommended for such cases as those of corals and skeletons. Many other suggestions might be made; but these three the writer regards as most important, and it is hoped that, as far as time will permit, they may be introduced into the Museum.

ENTOMOLOGY

The state entomologist reports that very important results were obtained in 1902 though the season was comparatively poor for the development of many insects, and relatively few destructive species were brought to notice.

Investigations. The studies on insects injurious to forest and shade trees have absorbed much time, and the results of several years' work are embodied in an extensive, well illustrated memoir, in which the forms affecting shade trees receive special attention. This work not only contains many original observations on species of importance in New York State, but gives a summary of our previous knowledge and will consequently prove of great value to subsequent students of this group. A critical, biologic study of certain wood borers belonging to the genus Saperda, undertaken in cooperation with Mr H. L. Joutel, has been completed, and the admirably illustrated account will appear as a separate bulletin. The grapevine root worm, a most serious pest in vineyards in the Chautauqua grape belt, has been closely studied, and the results of the investigation are presented in a bulletin on this insect.

The study of aquatic insects, begun at Saranac Inn in 1900 and prosecuted at Ithaca in 1901, was continued during the past season by Dr James G. Needham and his associates. The second report on this work treats largely of the damsel flies, Odonata-Zygoptera; the insect food of brook trout; certain aquatic beetles, Donacia; the Chronomidae, a group of much importance as food for fishes; and the neuropterous family Sialidae; and is now in the printer's hands. Dr Needham is at present engaged in the study of other material, and his next report will be concerned largely with the stone flies, Perlidae, and Chironomidae.

Experiments with remedies for the San José scale have been pursued during the season on a more extensive plan than formerly, and control was secured of another orchard near the original experimental ground and also of one in the lower part of the

Hudson river valley. The results of this work are given in detail in the entomologist's report. A study of our mosquito fauna has been undertaken and will be continued another year.

Collections. Systematic collecting was pursued in the vicinity of Albany, and considerable additions were made to the state collections. Every opportunity was embraced to secure desirable specimens for exhibition purposes, and a number of additions have been made to the general collection exhibited in 1901 at the Pan-American Exposition. A small special collection, illustrating the more important mosquitos and their differences, has also been placed on exhibition, and arrangements have been completed for supplying public schools with small collections of insects at a nominal expense. The general state collection has received considerable attention, and gratifying progress in the systematic arrangement of the Coleoptera and Lepidoptera can be reported.

Publications. The following publications have been issued during the year: Museum bulletin 46, *Scale Insects of Importance and List of the Species in New York State;* Museum bulletin 47, *Aquatic Insects of the Adirondacks;* Museum bulletin 53, *17th Report of the State Entomologist;* and Museum bulletin 57, *Elm Leaf Beetle in New York State.* The latter is an extended and revised edition of Museum bulletin 20 and was issued on account of the great demand for information concerning this serious pest of our elms. Those now in press are mentioned in connection with the investigations on which they are based.

Other lines of work. The report from the corps of voluntary observers and the lists of publications and of contributions, contained in the entomologist's report, are records of other activities of the office.

A detailed report on the work of this division is contained in Museum bulletin 64.

BOTANY

The state botanist reports that his work for the season just past has been specially directed to the investigation of our native species of the genus Crataegus and to a continuation of our efforts to unfold the riches of our mycologic flora. Several species of thorn bushes and trees, new to our State, have been discovered, the exact number of which can not be stated till their careful study and examination have been completed. The region about Albany has been found to be unexpectedly rich in species and will probably afford one or more new to science.

Fair progress has been made in the collection of specimens of mushrooms and other fungi for the herbarium and for the economic exhibition of these interesting plants, many of which are yet to be examined. Mushrooms were not as plentiful as the rainy character of the season might lead one to suspect. An excess of moisture may be unfavorable to their development as well as a deficiency of it. Unless accompanied by a favorable temperature, rain will not make mushrooms plentiful. The prevailing low temperature has doubtless prevented the development of many species that rejoice in very warm weather.

A few species have been subjected to a test of edibility, some of which have been found worthy of addition to our list of edible species.

An attempt was made to collect specimens of all our poisonous and suspected species of mushrooms for the purpose of having them chemically analyzed and of publishing figures of all of them, but, owing to their scarcity, it has not been possible to complete this work.

For the detailed report of the work of this division see bulletin 67.

ARCHEOLOGY

During the past year Rev. William M. Beauchamp has done 150 days' work on archeologic bulletins for the State Museum, having completed one on metallic implements and another on metallic ornaments. Two others require only final touches. One is on the aboriginal use of wood and the other on the Perch Lake and other mounds. Material has been partially collected for other bulletins.

ATTENDANCE AT THE MUSEUM

[1]Oct. 7, 1901–Oct. 7, 1902

Total	75 598
Monthly maximum	11 404
Daily maximum Aug. 12	940
Average, monthly	6 299
Average, daily	241

ACCESSIONS TO THE COLLECTIONS

Economic geology

Specimens collected by Arthur L. Parsons

1 specimen of peat, Montezuma swamp, about 1 mile west of the village of Montezuma

1 of peat, 2½ miles north of Chittenango station

1 of peat (under marl), 2½ miles east of Oniontown (known locally as Ognon)

1 of peat, from small bed in a tamarack swamp, near Montezeuma swamp, on the hills about 2½ miles south of Savannah

1 of peat, 2½ miles north of Canastota

1 of peat, Oak Orchard swamp, north of Elba

1 of peat, Cowaselon creek 2½ miles northwest of Canastota

1 of peat (under marl), Cowaselon creek, 2½ miles northwest of Canastota

1 of marl, Cowaselon creek, 2½ miles northwest of Canastota

1 of marl from Oniontown (known locally as Ognon).

Donation

Carborundum Co., Niagara Falls. 1 bag of powdered carborundum

Mineralogy

Purchase

G. L. English. 1 specimen of witherite, Fallowfield, Northumberland Eng.

5 specimens celestite, Put-in-Bay O.

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[1] After being closed on account of extensive repairs since Sep. 22, 1900, the museum was again opened to the public Oct. 7, 1901.

Donations

F. P. Graves. 1 specimen cerussite on galena, Doe run Mo.; 1 sphalerite, Joplin Mo.

Michigan state commission for the Pan-American Exposition. 1 specimen hematite, Negaunee mine, Negaunee Mich.

W. A. Rogers. 1 specimen fluorite, Mannie Furnace Tenn.

Cuban commission for the Pan-American Exposition. 1 specimen pyrite, Cuba

P. H. Kimbel. 2 specimens beryl, Bedford N. Y.

H. H. Hindshaw. 6 specimens vivianite in early Pleistocene clay, Anne Arundel county, Md.

Donor unknown. 1 specimen arsenopyrite, Brazil

E. C. Eckel. 1 specimen gold, Cripple Creek Col.; 1 malachite, Clifton Ariz.

A. L. Parsons. 3 specimens corundum, Craig mine, Ontario; 8 franklinite, zincite, willemite, Franklin N. J.; 1 willemite, franklinite, Franklin N. J.; 1 asphalt rock, Uvalde county, Tex.; 1 rutile, Australia; 1 columbite, Amelia Court House Va.; 1 magnetite, Mineral City Va.

Mineral Creek Mining & Smelting Co. 2 specimens realgar and orpiment, Mineral Creek, Lewis co., Wash.

Miss Hill. 1 specimen volcanic dust, Mt Pelee, Windward islands

Gilbert van Ingen. 1 specimen pyrite altering to limonite, West Chazy, Clinton co.; 1 calcite, Kenwood, Albany co.; 1 pyrite on slate, Granville, Washington co.

Harold Heiser. 2 specimens gold in quartz, Victor Col.; 1 sylvanite, Victor Col.

A. Corbin jr. 1 specimen garnet in quartz, Gouverneur; 1 garnet, North Creek

Exchanges

WITH THE EGLESTON MINERAL MUSEUM, COLUMBIA UNIVERSITY

1 specimen of allemontite, Pribram, Bohemia: for 1 specimen dyscrasite, Andreasberg, Hartz; 1 tiemannite, Clausthal; 1 alabandite, Tombstone Ariz.; 1 linnaeite, Siegen, Prussia; 1 smaltite (chloanthite), Schneeberg, Saxony; 1 nagyagite, Nagyag, Transylvania; 1 berthierite, Braundsdorf, Saxony;

1 guitermanite, Zuni mine, San Juan co., Col.; 1 pyrostilpnite, Samson mine, Andreasberg, Hartz; 1 enargite, American Belle mine, Ouray co., Col.; 2 sylvite, Stassfurt; 1 iodyrite, Chile; 1 carnallite, Stassfurt; 1 cervantite, Kern co., Col.; 1 massicot, Chenati mountains, Tex.; 1 jacobsite, Jacobsberg, Sweden; 1 hausmannite, Thuringia; 1 minium, Lucky Cuss mine, Tombstone Ariz.; 1 braunite, Cummington Mass.; 1 octahedrite, St Gothard, Switzerland; 1 Zunyite, Zuni mine, Silverton Col.; 1 fosterite, Bolton Mass.; 1 bertrandite on beryl, Mt Antoro, Col.; 1 dumortierite, Clip, Yuma co. Ariz.; 1 gmelinite, Cape Blomidon, Nova Scotia; 1 olivenite, Cornwall Eng.; 1 clinoclasite, Mammoth mine, Tintic dist., Ut.; 1 tyrolite, Mammoth mine, Tintic dist., Ut.; 1 pharmacosiderite, Cornwall Eng.; 1 childrenite, Tavistock, Cornwall Eng.; 1 mixite, American Eagle mine, Tintic dist. Ut.; 2 glauberite, San Bernardino co., Col.; 1 chalcanthite, Clifton Ariz.; 1 jarosite, Tintic dist. Ut.; 1 stolzite, Zinwald, Bohemia

Specimens collected by H. P. Whitlock

1 amphibole (actinolite), Tilly Foster mine, Brewster
2 brucite, Tilly Foster mine, Brewster
1 enstatite and prochlorite, Tilly Foster mine
1 magnetite in serpentine and chondrodite, Tilly Foster mine
2 pyroxene (coccolite) in hornblende and epidote, Tilly Foster mine
4 chondrodite with magnetite, Tilly Foster mine
1 serpentine, Tilly Foster mine
1 serpentine pseudomorph after magnetite, Tilly Foster mine
1 hydrotalcite, chondrodite and magnetite, Tilly Foster mine
2 pseudomorph, serpentine after calcite, Tilly Foster mine
2 molybdenite on serpentine, Tilly Foster mine
2 calcite crystals, Tilly Foster mine
2 calcite, incrusting, Tilly Foster mine
1 siderite, Ancram
12 albite, Ancram
4 talc, loc. 1, Staten Island[1]

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[1] Locality 1 Staten Island is in the town of Tompkinsville.

5 serpentine asbestos, loc. 1, Staten Island
1 anhydrite and talc, loc. 1, Staten Island
2 chromite in serpentine, loc. 1, Staten Island
1 magnesite on serpentine, loc. 1, Staten Island
3 serpentine showing veining, loc. 1, Staten Island
1 amphibole decomposing to serpentine, loc. 1, Staten Island
1 brucite on serpentine, loc. 1, Staten Island
1 serpentine (decomposed), loc. 1, Staten Island
1 serpentine (slickenside), loc. 1, Staten Island
2 serpentine (Garretson's), loc. 2, Staten Island
2 serpentine, loc. 4, (Todt hill) Staten Island
1 quartz, loc. 4, (Todt hill) Staten Island
1 serpentine, loc. 5, (Grant City) Staten Island
2 serpentine, loc. 6, Hoboken N. J.[1]
1 serpentine, loc. 7, (Castle point) Hoboken N. J.
1 hematite, Pike Clarke mine, Somerville
3 amphibole (actinolite), Smith's Mills, St Lawrence co.
6 pyrite in calcite, old Fluorite loc., Macomb
6 fluorite in calcite, old Fluorite loc., Macomb
2 calcite, old Fluorite loc., Macomb
1 tourmalin in granite, Macomb lead mines, Macomb
5 galena, Dodge lead mine, Macomb
4 graphite, Holbrook's graphite mine, North Russell
6 phlogopite, Holbrook's mica mine, North Russell
4 pyroxene and titanite, Holbrook's mica mine, North Russell
1 titanite, Holbrook's mica mine, North Russell
1 apatite in calcite, Holbrook's mica mine, North Russell
1 molybdenite, Holbrook's mica mine, North Russell
1 calcite, Holbrook's mica mine, North Russell
4 labradorite (?), Holbrook's mica mine, North Russell
14 serpentine, New Rochelle
5 sphalerite, Ellenville
1 galena, chalcopyrite and quartz, Ellenville
4 chalcopyrite in quartz, Ellenville

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[1] Locality 6 is 70 yards south of Stevens Institute, Hoboken.

Zoology

MAMMALS

Collections

1 jumping mouse, *Zapus hudsonius,* Rensselaer

E. C. Eckel. 1 New York weasel, *Putorius noveboracensis,* White lake, Oneida co.

Purchases

1 opossum, *Didelphis virginiana,* Cedar Hill, Albany co.; 1 monkey skeleton, *Cebus* sp.

Donations

J. L. Paulmier. 2 opossums, *Didelphis virginiana,* Madison N. J.

Bronk Van Slyke. Teeth and feet of a supposed Quaternary horse, *Equus* sp. Aquetuck

Van Allen Lyman. 1 skull of dog, *Canis familiaris,* Clarksville

BIRDS

Donations

William H. Hogle. 1 Brünnich's murre, *Uria lomvia,* Blooming Grove, Rensselaer co.

E. N. Holly. 1 nest of humming bird, *Trochilus colubris,* Tribes Hill N. Y.

REPTILES

Collections

1 green snake, *Liopeltis vernalis,* Sacandaga Park; 1 milk snake, *Osceola doliata triangula,* Fort Lee N. J.; 1 DeKay's snake, *Storeria dekayi,* Albany; 1 New York city; 1 brown snake, *Storeria occipitomaculata,* Upper Jay, Essex co.; 1 garter snake, *Eutaenia sirtalis,* Upper Jay; 1 Altamont; 1 ribbon snake, *E. saurita,* Fort Lee

2 ring-necked snakes, *Diodophis punctatus,* White lake, Oneida co.

1 blowing adder, *Heterdon platyrhinus,* Karners

Donations

Bronk Van Slyke. 2 black snakes, *Zamenis constrictor,* Aquetuck N. Y.

Van Allen Lyman. 2 green snakes, *Liopeltis vernalis,* Ausable Forks N. Y.; 1 garter snake, *Eutaenia sirtalis,* Ausable Forks N. Y.

R. C. Benedict. 1 green snake, *Liopeltis vernalis,* Litchfield county, Ct

Mr Halsey. 1 garter snake and brood of young, *Eutaenia sirtalis,* Long Island

C. A. Trask. 1 worm snake, *Carphophiops amoenus,* Karners

Harold Roys. 1 rattlesnake, *Crotalus horridus,* Sheffield Mass.

BATRACHIA

Collections

2 *Amblystoma tigrinum,* Wilmurt, Herkimer co.

Amblystoma sp., eggs and larva, Forbes Manor

13 *Plethodon cinereus,* Wilmurt; 2, Altamont; 10, Averill Park, Rensselaer co.; 1, Rensselaer

12 *Plethodon cinereus,* White lake, Oneida co.; 1 *Plethodon glutinosus,* Altamont N. Y.

5 *Spelerpes bilineatus,* Karners, Albany co.; 5, Cold Spring Harbor L. I.

4 *Spelerpes ruber,* Madison N. J.

11 *Desmognathus ochrophaea,* Wilmurt; 1, Altamont

5 *Desmognathus fusca,* Karners; 9, Madison N. J.; 12, Menands; 3, Averill Park; 2, Port Douglas, Essex co.; 4, East Greenbush, Rensselaer co.

2 *Diemictylus viridescens,* Wilmurt; 5, White lake, Oneida co.

1 *Bufo lentiginosus,* toad, Wilmurt; 1, toad and eggs, Clarksville; 1, White lake

1 tree frog, *Hyla pickeringii,* Sheffield Mass.; 1, Averill Park

2 leopard frogs *Rana virescens,* Wilmurt

1 wood frog, *Rana sylvatica,* Wilmurt; 1, White lake, Oneida co.

2 green frogs, *Rana clamata,* Mill creek, Rensselaer co.

5 bull frogs, *Rana catesbiana,* White lake N. Y.

1 northern frog, *Rana septentrionalis,* White lake N. Y.

Donation

Dr S. R. Williams. Eggs and larva, *Spelerpes bilineatus,* Cold Spring Harbor L. I.

INVERTEBRATES

Collections

13 crayfish, *Cambarus* sp., Karners; 6, Albany; 30, Madison N. J.; 3, Altamont; 10, Wilmurt; 7, Port Douglas, Essex co.

10 *Crangonyx* sp., Howes Cave

5 fiddler crabs, *Gelasimus pugnax*, Cold Spring Harbor L. I.

21 *Virbius zostericola,* Bayshore

20 shrimps, *Mysis stenolepis,* Bayshore

21 *Oniscus asellus,* Catskill; 13, Rensselaer

12 *Oniscus* sp., Bayshore

7 *Orchestia agilis,* Bayshore

98 *Gammarus* sp., Bayshore

7 *Gammarus fasciatus,* Cold Spring Harbor N. Y.; 3, Van Cortland park, New York city

1 *Hyalella dentata,* Van Cortland park, New York city

12 *Asellus communis,* Van Cortland park, New York city

7 *Talorchestia megalophthalmia,* Point o'Woods, Fire island

75 water fleas, *Daphnia pulex,* Kenwood, Albany co.

1 mite, *Trombidium* sp., Clarksville

1 fly larva, *Tipula abdominalis*, Howes Cave

Tumblebug, male, female and egg ball, *Canthon laevis,* Aquetuck

1 *Polydesmus* sp., Kenwood; 3, Altamont; 1, Averill Park, 1, Cold Spring Harbor L. I.; 1, Catskill; 1, Rensselaer; 1 Wilmurt

12 *Julus* sp., Port Douglas, Essex co.; 6, Peekskill; 1, Wilmurt

2 *Fontaria coriacea*, Aquetuck; 1, Peekskill

1 *Lithobius forficatus,* Bayshore; 1, Catskill; 1, Wilmurt

2 *Geophilus* sp., Kenwood; 1, Rensselaer; 1, East Greenbush, Rensselaer co.

The following specimens of leeches, Hirudinea, are undetermined: 2, Wilmurt; 3, Long Lake, Oneida co.; 1, Kenwood; 1, Albia; 3, Altamont; 12 on crayfish, Albany; 3 on catfish, Kenwood; 1, Madison N. J.

1 earthworm, *Allobophora foetida,* Kenwood

3 earthworms, *Lumbricus terrestris,* Howes Cave

2 *Nereis limbata,* Bayshore

18 flat worms, *Planaria* sp., Van Cortland park, New York city

1 roundworm, *Filaria* sp., Rensselaer N. Y.

17 *Synapta* sp., Point o'Woods, Fire island N. Y.

The following specimens of "daddy longlegs," Phalangida, are undetermined: 7, Rensselaer; 43, Kenwood; 3, Wilmurt; 1, Bayshore; 3, Peekskill; 1, Cold Spring Harbor; 9, Catskill; 8, Altamont; 7, Karners; 3, Averill Park; 2, Sheffield Mass.

The following specimens of spiders, Areina, are undetermined: 5, Bayshore; 10, Kenwood; 8, Rensselaer; 2, Karners; 6, White lake; 1, Averill Park

Cluster of mussels in marsh grass, *Modiola plicatula,* Bayshore N. Y.

5 sponges, *Reniera* sp., Bayshore

2 sponges, *Microciona prolifera,* Bayshore

Specimens of Spongilla are undetermined from the following localities: Wilmurt; White Lake, Oneida co.; Van Cortland park, New York city

Ethnology

Purchase

Luke I. Fitch, Watervale N. Y.

NEW YORK STATE MATERIAL

15 strings of glass beads containing brass, copper and bone ornaments, Pompey

1 celt, Oneida river

1 celt, Onondaga county

1 celt of striped slate, Onondaga county

1 chipped and polished hornstone celt, Onondaga county; polishing a rare feature in this material

1 broad gouge of ironstone, found throughout New York, but rare, Three River point; picking on back a rare feature

1 worked seashell, Brewerton, Onondaga co.

MATERIAL MOSTLY 17TH CENTURY WORK, FROM POMPEY, ONONDAGA CO.

1 worked seashell

1 silver coin

4 copper coins perforated

1 brass medal

3 lead or pewter medals

1 iron hawk-bell, rare

1 copper hawk-bell and chain
2 pewter hawk-bells, rare
3 copper earrings, very rare
7 brass rings
3 nose-rings (?)
1 shell turtle ornament
1 perforated brass ornament
3 pewter ornaments and buckles
2 rare bone ornaments, Sheldon fort
2 brass bangles
Part of bangle
2 brass articles
1 copper ornament, doubly perforated
6 metallic figures
1 crucifix
1 horse's leg made of pewter
1 iron ape
1 iron figure
1 pewter figure
18 triangular brass arrows
2 conical brass arrows
1 iron spearhead
2 scalping or hunting knives, one perforated
1 copper knife, rare, Indian hill
2 gun wormers
5 brass needles, rare, antique form
Part of a balance arm for scales
1 iron awl
1 small iron saw
1 glass bead
2 bone beads, Sheldon fort
1 stone bead

Ward's Natural Science Establishment. 1 Indian skeleton found in excavating for a cellar on the shore of Lake Ontario, near Long Pond, Monroe co. N. Y.

Donation

H. W. Seton Karr, Wimbledon, England. 5 paleolithic implements from Somaliland, East Africa.

INDEX

Appendix 1

Geology 5

Museum bulletin 56

5 Description of the State Geologic Map of 1901

Published monthly by the

University of the State of New York

BULLETIN 272 NOVEMBER 1902

New York State Museum

FREDERICK J. H. MERRILL Director

Bulletin 56

GEOLOGY 5

DESCRIPTION OF THE

STATE GEOLOGIC MAP OF 1901

BY

FREDERICK J. H. MERRILL Ph.D.

University of the State of New York

New York State Museum

Frederick J. H. Merrill Director

Bulletin 56

GEOLOGY 5

DESCRIPTION OF THE STATE GEOLOGIC MAP OF 1901

PREFACE

The purpose of this bulletin is to give a certain amount of information which could not be expressed on the geologic map of 1901, namely the detailed credit for the material used in its compilation.

With this it has seemed worth while to give some items of general information about the history of geologic work in New York. The matter relating to the early Natural History Survey is in part based on an article by the late Dr James Hall in a publication entitled *Public Service in the State of New York,* which has been copiously quoted because of its convenient form, though the facts given are on record elsewhere.

In compiling a second edition of the geologic map of the State of New York, on the scale of 5 miles to the inch, the writer has found the task exceedingly complex. While the geology of New York has been carefully studied by many competent observers the lack of accurate maps has rendered much of the field work unavailable for graphic reproduction because many accurate observations could not be located. It also appears that in the earlier work the geologists have not understood the most practical methods of locating their observations, the practice seemingly having been to locate outcrops with reference to drainage rather than with reference to roads.

From the earliest times roads have been surveyed and their principal turns and angles have been located with sufficient accuracy to make them available for reference from one map to another. On the other hand, as the streams have rarely been surveyed and their meanderings have been represented in a conventional and conjectural manner, outcrops or boundaries referred to them are usually unavailable for plotting on an accurate base.

In offering the present map and its accompanying bulletin to the public, the author does not expect that he has been able to avoid errors and he earnestly asks the cooperation of all who are interested in the geologic map of New York to aid him in making it as accurate as possible by supplying corrections for a revised edition.

FREDERICK J. H. MERRILL

Albany N. Y. July 1902

The geologic map of New York, edition of 1901, is sold in atlas form for $3. Mounted on rollers $5.

INTRODUCTION

The geologic map of New York is a graphic expression of the general results of the geologic study of the rocks of the state. This study began as early as 1820 and has been carried on continuously, not only under state auspices, but by private and federal enterprise, and many valuable contributions have been made by geologists not in the state service.

A very complete bibliography of articles on New York geology will be found in bulletins of the United States Geological Survey, nos. 127, 130, 135, 146, 149, 156, 162 and 172.

HISTORY OF THE NEW YORK GEOLOGIC SURVEYS

In 1820 and 1821 Prof. Eaton, with the assistance of Drs T. Romeyn and Lewis C. Beck, under the patronage of Hon. Stephen Van Rensselaer, conducted an agricultural and geological survey of Rensselaer and Albany counties. These surveys, of which reports were published, were intended to serve the interests of agriculture, and were spoken of in the *American Journal of Science* as being the most extensive and systematic efforts of the kind made up to that period. In 1822, also under the patronage of Stephen Van Rensselaer, Mr Eaton undertook a geological and agricultural survey of the district adjoining the Erie canal. The report on this work was published in 1824, in a volume of 163 pages, with a geologic profile extending from the Atlantic to Lake Erie, and a "profile of rocks crossing part of Massachusetts" (from Boston harbor to Plainfield), by the Rev. Edward Hitchcock, who also furnished a description of the rocks and minerals crossed by this profile.

Much had already been done, therefore, to prepare the way, and the public mind was fully awake to the interests and importance of a geological survey, when the Albany Institute, in 1834, memorialized the Legislature for some action in that direction. In 1835 a similar petition was presented by the New York Lyceum of Natural History.

These memorials were referred to a committee of the Legislature of 1835, which recommended a resolution by which the secretary of state was "requested to report to the Legislature at its next session, the most expedient method of obtaining a complete geological survey of the state, which shall furnish a scientific and perfect account of its rocks, soils and minerals, and of their localities; a list of all its mineralogical, botanical and zoological productions, and provide for procuring and preserving specimens of the same; together with an estimate of the expenses which may attend the prosecution of the design, and of the cost of publication of an edition of 3000 copies of the report, drawings and a geological map of the results."

In pursuance of the request contained in this resolution, the secretary of state, Hon. John A. Dix, presented a report[1] at the session of the Legislature in 1836, which contained much valuable information with reference to what had already been done toward developing the mineral resources of the state, giving a summary of our knowledge of the subject at that time, and discussing several questions of great interest; for example, the salt and salt-bearing formations, our mineral springs and the probabilities of finding coal within the limits of the state. He also gave a statement of what had been done in other states, and of work in a similar direction elsewhere in progress or in contemplation.

Under their distinctive heads, he discussed the botany and zoology of the state, and gave reasons why each should receive due attention.

The report concluded with the recommendation of a plan for the geological survey by a subdivision of the state into four districts, a plan which, with some modifications, was carried out in the final organization. This plan contemplated the employment of two geologists for each district, which was subsequently modified by the appointment of one geologist with an assistant, for each district. One mineralogist was appointed for the entire state, and also one botanist and one zoologist.

As shown by the accompanying maps, the first district con-

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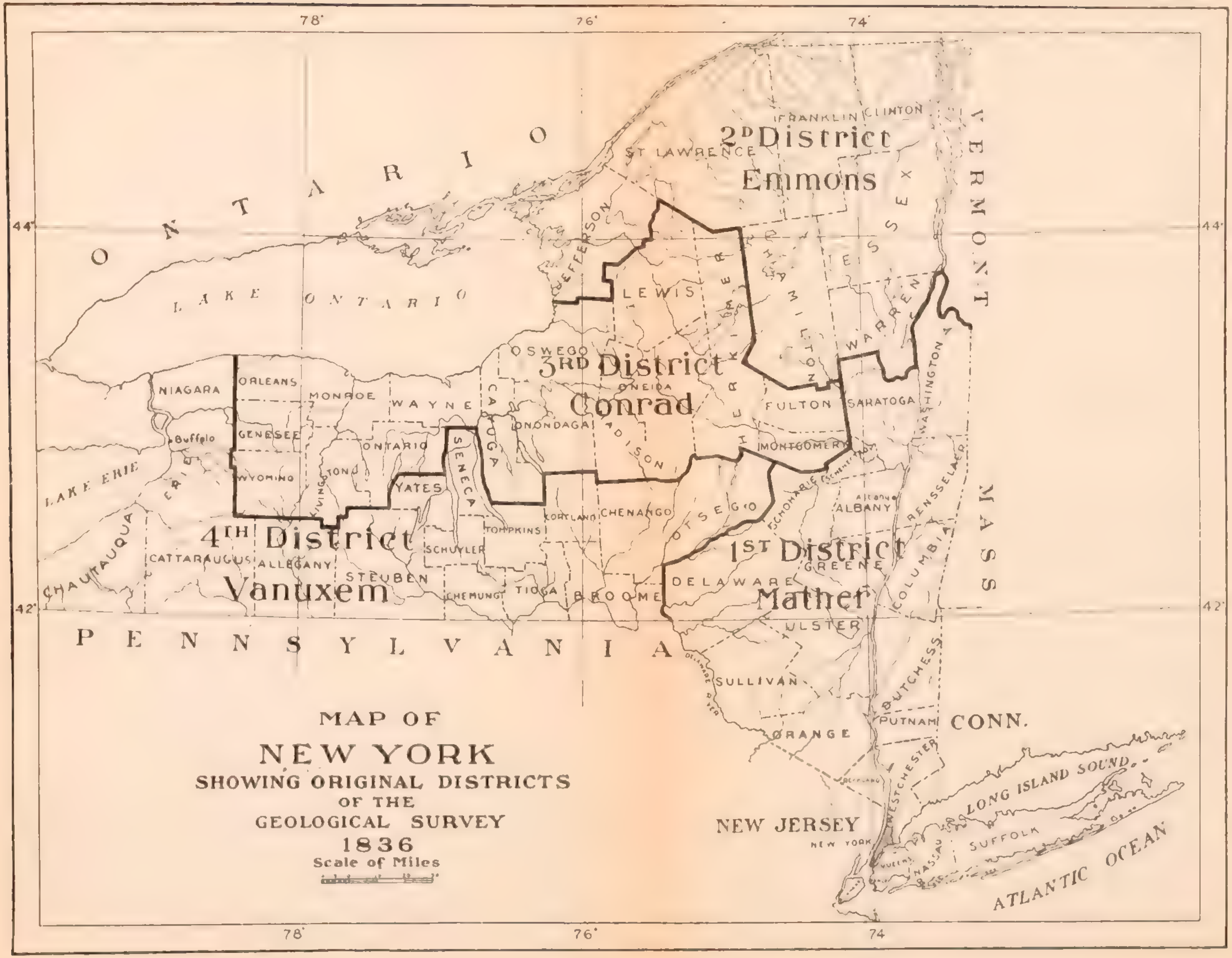
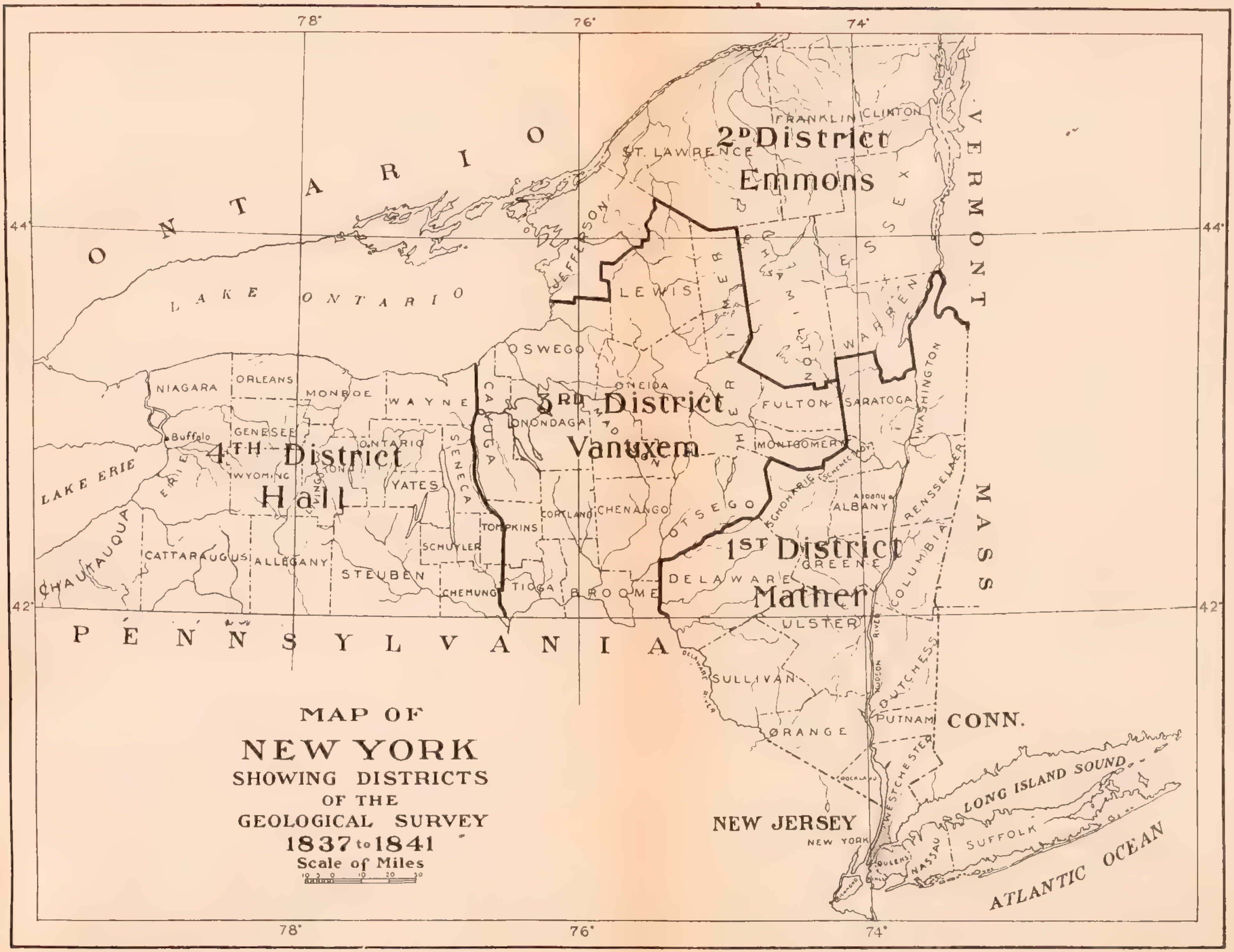
[1] Report of the secretary of state in relation to a geological survey of the state, dated Jan. 6, 1836. Assembly doc. no. 9, 1836.



MAP OF
NEW YORK
SHOWING ORIGINAL DISTRICTS
OF THE
GEOLOGICAL SURVEY
1836
Scale of Miles



MAP OF
NEW YORK
SHOWING DISTRICTS
OF THE
GEOLOGICAL SURVEY
1837 to 1841
Scale of Miles

sisted of the counties of Suffolk, Queens, Kings, Richmond, New York, Westchester, Rockland, Putnam, Dutchess, Orange, Sullivan, Delaware, Ulster, Greene, Columbia, Rensselaer, Albany, Schoharie, Schenectady, Saratoga and Washington, containing an area of 12,263 square miles.

The second district consisted of the counties of Warren, Essex, Franklin, Clinton, Hamilton, Jefferson and St Lawrence, making 10,817 square miles.

The third district comprised the counties of Fulton, Montgomery, Herkimer, Oneida, Lewis, Oswego, Madison, Onondaga, Cayuga, Wayne, Ontario, Monroe, Orleans, Genesee and Livingston, making, as reorganized, 11,468 square miles.

The fourth district consisted of the counties of Otsego, Chenango, Broome, Tioga, Chemung, Cortland, Tompkins, Seneca, Yates, Steuben, Allegany, Cattaraugus, Chautauqua, Erie and Niagara, embracing an area of 11,594 square miles.

The third and fourth districts were afterward reorganized, making all the counties to the west of Cayuga lake, and a line drawn north and south from its two extremities, the fourth district, which contained 11,060 square miles.

During the session of 1836 the Legislature passed "an act to provide for a geological survey of the state," authorizing and directing the governor to "employ a suitable number of competent persons, whose duty it shall be, under his direction, to make an accurate and complete geological survey of this state, which shall be accompanied with proper maps and diagrams, and furnish a full and scientific description of its rocks, soils and minerals, and of its botanical and zoological productions, together with specimens of the same; which maps, diagrams and specimens shall be deposited in the State Library; and similar specimens shall be deposited in such of the literary institutions of this state as the secretary of state shall direct."

This act further provided for an annual appropriation for defraying the expenses, and required the persons employed to make an annual report to the Legislature on or before the first day of February in each year, setting forth the progress made in the survey.

The appointments of the principal geologists were made as follows. Lieut. W. W. Mather, a native of Connecticut, who had lately resigned from the United States army, was assigned to the first district. Prof. Ebenezer Emmons, of Williams College, was assigned to the second district. Mr T. A. Conrad, of Philadelphia, was assigned to the third district, and Mr Lardner Vanuxem, of Bristol Pa., to the fourth district.

The mineralogic department was assigned to Dr Lewis C. Beck, a native of Albany, but at that time a professor in Rutgers College, New Jersey. Dr John Torrey, professor of chemistry and botany in the College of Physicians and Surgeons, New York, was commissioned as state botanist; and Dr James E. De Kay, of Long Island, as state zoologist.

The assistants in geology commissioned by the governor were: Caleb Briggs in the first geologic district, James Hall in the second, George W. Boyd in the third, and James Eights in the fourth district.

The instructions given to these officers were essentially the same as recommended in the report of the secretary of state. Each of the geologists was required to collect, in his own district, eight suites of rock specimens, but no conditions of this kind were imposed on the mineralogist, botanist or zoologist. A special draftsman was appointed for the zoologic department and also for the botanic department. The geologists were each allowed a small sum ($300) annually to pay for the drawings of sections, maps, etc. which might be required for the illustration of their reports.

This, in brief, was the organization of the New York natural history survey at its commencement. At the end of the first year, it became evident to the geologists that the relations of the rock formations, the age and order of superposition, among the then unknown, or very imperfectly understood, stratified deposits, could be determined only on paleontologic evidence. They therefore unanimously recommended to the governor that some competent person be appointed to devote himself to that department. To this position Mr Conrad was assigned, thus leaving a vacancy in the third geologic district, which, after a reorganization of its boundaries, as before explained, was assigned to the charge of Mr Vanuxem, and Mr Hall was appointed to the fourth district.

During the five years of field work which followed the New York geologists accumulated a vast amount of material and of facts regarding the geologic formations within the state, proving conclusively that they could not be parallel with any of the described and well determined formations of Europe. The Silurian system of Murchison, as described and illustrated in the *Edinburgh Review*, in 1838, and as finally published in 1839, though covering a portion of similar ground, was not broad enough to meet the requirements of the geology of New York. Thus failing to find the means of comparison and identification, the term "New York system," was proposed, to embrace the sedimentary formations from the Potsdam sandstone to the base of the Carboniferous system; or, as the formations were developed in New York and southerly into Pennsylvania, the upward extension of this term reached to the base of the Coal Measures. This term "New York system," included the formations ordinarily embraced by the names Cambrian, Silurian and Devonian in England and on the continent of Europe.

In 1842 Mr Conrad resigned his position as paleontologist of the survey without communicating any report to the governor; and the four geologists who had expected to avail themselves of the results of his investigations were left to their own resources. In this state of affairs, each one of the geologists illustrated his own report, as best he could, by figures of characteristic fossils of the rocks and groups which he had studied in his own district. By this means a very considerable number of the more common and characteristic fossils were illustrated in woodcuts, which were printed in the text, thus giving authentic guides for the determination of all the more important members of the series.

The incompleteness of the plan for the contemplated natural history survey of the state was recognized by the governor and Legislature; and it was also claimed that agricultural interests had not been sufficiently considered in the work already published. It was, therefore, decided that the department of paleontology should be reestablished, and that of agriculture be added to the plan of the work. The paleontology was committed to Mr James Hall, who entered on the work in 1844.

The agriculture of the state was reported on by Dr Ebenezer Emmons. The first of the series of five volumes bearing on this subject contained a somewhat detailed discussion of the general geology of the state, with a statement of the author's views regarding the "Taconic" system. A geologic map was prepared to accompany this volume, which was an almost exact reproduction of the geologic map of 1842, with the exception that the area considered by the author to be occupied by the Taconic system was so colored on the map, though not noted in the accompanying legend. This map was not widely distributed.

During the period from 1844 to 1892 little areal work was carried on, the work of Dr Hall being concentrated on paleontology, but between 1890 and 1892, part of the general museum appropriation had been used for geologic work by the writer.

In 1892 an appropriation was secured from the Legislature for the completion and publication of the geologic map of the state and considerable work was done in tracing boundaries. Subsequent to the publication of this map (the Hall map of 1894) small appropriations were annually made for field work and a certain amount of areal mapping was carried on under the direction of Prof. Hall till his death in 1898.

On the death of Prof. Hall the writer was appointed to succeed him as state geologist, while Dr John M. Clarke was appointed state paleontologist and the work of areal mapping has been continued as rapidly as appropriations would permit.

GEOLOGIC PROVINCES OF NEW YORK

The geologic formations of New York, by their lithologic influence on its physiography and topography, separate themselves into several natural divisions, which have invited and held the attention of many geologists who have devoted themselves to the study of one or another area according to their personal interest and experience.

The more prominent of these which have been made subjects of special study are the Adirondack crystallines, southeastern crystallines, metamorphic rocks of the New England border or Taconic range, Silurian and Lower Devonian rocks of the Mohawk valley region and the Upper Devonian rocks.

Adirondack crystallines

With the exception of a few unimportant papers previously published, geologic work on the pre-Cambrian rocks of the Adirondacks dates from 1837, the first year of field work of the Geological Survey of New York. In the division of the work adopted, by far the larger portion of the area in question fell to the share of Emmons, Vanuxem's district touching it in Lewis, Herkimer and Fulton counties only, while Mather had a small portion in Saratoga and Washington counties. Emmons described various classes of rock in his annual reports and in the final report on the second district, which appeared in 1842. These divisions were based on lithologic differences and were not shown on the 1842 map, on which the entire central mass of the Adirondacks is colored in one tint as "Primary." From 1842 till a comparatively recent date, little or no field work of value was carried on in that area, many of the papers published being in relation to the adoption of the names "Huronian" and "Laurentian" of Canadian geologists for subdivisions of the Adirondack series.

In 1895 Prof. J. F. Kemp, at the suggestion of the writer, took up a study of the region of the iron mines near Port Henry. The results of this work appeared in Museum bulletin 14. Subsequently work was continued under the direction of Prof. James Hall from 1896 to 1898, the study of the Adirondack area being divided between Professors Kemp, Cushing and Smyth.

Pre-Cambrian and metamorphic rocks of southeastern New York

Mather, in his final report of 1842, described the rocks of this area under two heads: metamorphic and primary. In the former he included the mica slates, quartzites and crystalline limestones; in the latter the granites, gneisses and igneous rocks. Though in deference to one of his colleagues, he had given space to the Taconic system, he stated that he believed it to consist merely of altered representatives of Champlain (Cambro-Silurian) age, and further says that the "metamorphic" rocks are probably of the same age, but still more highly altered. On the 1842 map, however, only the limestones are separated out and colored distinct from the "Primary gneisses and granites."

Forty years of reactionary ideas elapsed before the work of Dana and the writer verified Mather's statements, the interval being filled in with the publication of schemes of classification and theories of origin, in which the names Laurentian, Huronian, Norian and Montalban figured prominently. The difficulty of establishing these theories without actual field work was apparently not manifest to some of the authors.

The history of modern geologic work in the region dates back less than a quarter century. Dana, in the extension of his work on the Taconic rocks, carefully worked over Dutchess, Putnam, Westchester and New York counties; and correlated the crystalline limestones of the last two with the Cambro-Silurian limestones of Dutchess county. Failing, however, to differentiate the mica schist (Manhattan or Hudson) overlying the limestones (Inwood or Stockbridge) from the gneisses (Fordham) underlying them, his work lacked completeness. This want was supplied by the writer, who recognized the dissimilarity and true stratigraphic positions of the two noncalcareous formations, and correlated the Manhattan schist with the Hudson river slates and shales.[1] Detecting also the presence in these counties of a comparatively thin bed of quartzite (Lowerre) immediately below the limestones, he inferred its equivalence to the Cambrian quartzite of Dutchess county. The series was

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[1] Am. Jour. Sci. Ser. 3. 39:389; N. Y. State Mus. 50th An. Rep't. 1:21-31.

thus found to be complete and the positions of its members well established. Subsequently the positions and boundaries of these members have been located in detail throughout the southeastern counties by the writer and his assistants, Messrs Blake, Ries, Newland, Hill and Eckel.

The rocks of the Taconic range and adjoining areas

Most of the so called "Taconic" rocks fell, on the first geological survey of the state, within the district assigned to Mather, who appears to have recognized their true character and relationship. Emmons, however, insisted that they formed a separate and distinct system underlying the Silurian, and his views were accepted, under protest, by Mather in his final report. Owing to the later advocacy of Emmons's views by Hunt and Marcou, neither of whom performed any field work in the region, the "Taconic question" left a marked impression on the literature of New York and New England geology. The subsequent work of Dana and Walcott was, however, decisive, and since then the only problem has been the exact correlation, so far as exactness is possible, of these Taconic rocks with the unmetamorphosed strata of the Cambrian and Silurian formations.

So far as the area covered by Dale in his work on the slate belt falls within the limits of the 1901 map, his boundaries and correlations have been followed. Maps from several of his other papers have been used for smaller areas, while some areas on the eastern border are taken from the maps of Pumpelly and Emerson. Dwight's manuscript maps contributed for the occasion have been followed for most of Dutchess county, north of the Highlands.

With the exception of small areas near Lake Champlain, credited to Brainerd and Seely, the remaining part of the Paleozoic mapped east of the Hudson is from the work of Dana and Walcott. Dana's mapping covers a relatively small area in northeastern Dutchess and southeastern Columbia county and in the adjoining portions of Massachusetts and Connecticut; while Walcott's boundaries have been followed for most of Rensselaer and Washington counties and nearly all that part of Vermont which appears on the map of 1901.

Silurian and Lower Devonian

The most interesting problems connected with these formations are those of the proper systematic position of the Lower Helderberg and the mutual relations of the Medina sandstone, Oneida conglomerate and Oswego sandstone. The first subject has been discussed by Clarke, Williams, Stevenson and others; while the second remains to be investigated. The mapping of the Cambrian and Silurian formations in the Lake Champlain region is based on the work of Brainerd and Seely, Cushing, Kemp, van Ingen, Walcott and White, all save van Ingen's contribution having appeared in various papers.

The mapping of the pre-Hamilton rocks in the western and northern towns of Orange county is based on the work of Ries; that of the Schunemunk-Bearfort mountain area on Darton's, retraced on the Schunemunk and Ramapo atlas sheets by Eckel. With the exception of the small areas about Kingston and Hudson credited to Davis, Darton's work for the Hall map of 1894 served as the basis for the pre-Hamilton mapping of Ulster, Greene and Albany counties and for the westward extension of the Helderberg rocks across the state. His mapping of the Niagara limestone was also used, supplemented by later work by Sarle, who is to be credited with the Medina-Clinton and Clinton-Niagara boundaries from Oneida lake to Lockport, and with the Potsdam-Trenton, Trenton-Hudson and Hudson-Medina boundaries from near Boonville and Rome to Lake Ontario. Westward of Lockport a manuscript map by Gilbert and the recently published map by Grabau, of the vicinity of the Niagara river, were used. The mapping in Erie county south of Buffalo is based on the work of Bishop, with corrections by Clarke. The boundaries in Onondaga county are mainly as mapped by Luther; while small areas near Skaneateles, and in Oneida county near Oneida, Clinton and Utica were revised by Eckel.

In addition to the work on the areas specified above, Clarke and Luther made many manuscript corrections to the boundaries shown on the map of 1894 in the central and western part of the state, the Hall map of 1894 being used where no information of later date was obtainable.

In the Mohawk valley the mapping of the Paleozoic is based largely on Darton's work under the direction of the late James Hall. The boundary between the Cambrian and the Silurian, north of the Adirondacks, is to be credited to Cushing. White's mapping, revised in some places by Eckel, was used for the Lower Silurian formations in most of Oneida county and in parts of Herkimer and Lewis.

The Upper Devonian and the Carboniferous

The mapping of the formations above the Onondaga on the present edition of the geologic map is based, east of the Chenango valley, on the work of Prosser, except in Albany county, where Darton's boundaries have been used. West of the Chenango valley it is based mainly on recent published and unpublished work of Dr John M. Clarke, aided by Luther in some areas, the portion not thus recently revised being copied from the Hall map of 1894. The position of the Tully limestone, first mapped by S. G. Williams, has been revised by Luther throughout most of its length and by Eckel in that portion appearing on the Ovid atlas sheet.

The Carboniferous outliers in the southwestern part of the state are as mapped, in manuscript, by Clarke after Randall, but are not considered by Dr Clarke to be very reliably determined.

Triassic to Pleistocene

The Triassic sandstone and diabase of Rockland county are as mapped by Kümmel. The pre-Pleistocene boundaries on Staten Island are based on the mapping of Hollick; the Pleistocene of Staten Island and Long Island are from the mapping of Woodworth and Woodman. Their respective areas were separated by the meridian of 73° 30′, Woodworth mapping all west and Woodman all east of that line. The continuation of the moraine across New Jersey and Pennsylvania is credited to Salisbury and Lewis.

LIST OF MAPS SHOWING GEOLOGY OF NEW YORK STATE

DATE	AUTHOR	AREA	SCALE TO INCH	MEDIUM OF PUBLICATION
1830..	Amos Eaton	N. Y	30 m.	Geological Textbook
1842..	Geol. Survey N. Y	N. Y	12 m.	To accompany the geologic reports
1843..	James Hall	N. Y. & central western states	30 m.	Report on the 4th Geologic District of New York
1844..	Ebenezer Emmons	N. Y	12 m.	To accompany the Report on the Agriculture of New York
1845..	Sir Charles Lyell	Canada & U. S	125 m.	Travels in North America
1863..	Sir William Logan & James Hall.	Canada & northeastern U. S.	125 m.	Report on the Geological Survey of Canada
1865..		N. Y	20 m.	On the margin of J. H. French's map of N. Y. state
1867..	Sir William Logan & James Hall.	Canada & northeastern U. S.	25 m.	Accompanying Report on the Geological Survey of Canada
1871..	Charles H. Hitchcock	N. Y	25 m.	Asher & Adams's atlas of New York
1881..	Charles H. Hitchcock	U. S.	20 m.	Published for the author by Julius Bien & Co.
1882..	James Hall	N. Y.	38 m.	Public Service of the State of New York
1884..	W J McGee	U. S.	112 m.	U. S. Geological Survey. 5th report
1886..	Charles H. Hitchcock	U. S.	112 m.	American Institute of Mining Engineers. Transactions. v. 15
1886..	Charles H. Hitchcock	N. Y.	25 m.	10th Census Report, v. 15
1888..	Charles A. Ashburner	Southwestern N. Y.	25 m.	American Institute of Mining Engineers. Transactions. v. 16
1893..	W J McGee	U. S.	112 m.	U. S. Geological Survey. 14th report
1894..	Frederick J. H. Merrill	N. Y.	14 m.	N. Y. State Museum. Bul. 15; also New York at World's Columbian Exposition, 1893
1894..	James Hall	N. Y.	5 m.	
1897..	Frederick J. H. Merrill	N. Y.	25 m.	N. Y. State Museum. Bul. 17
1898..	Frederick J. H. Merrill	Relief map showing geologic systems of N. Y.	25 m.	N. Y. State Museum. Bul. 19
1901..	Frederick J. H. Merrill	N. Y.	5 m.	

EARLIER GEOLOGIC MAPS AND THEIR GEOGRAPHIC BASES

The maps of 1842 and 1844

The condition of the geographic maps of New York in 1842 can best be shown by quoting the words of Prof. Hall.[1]

Upon the organization of the Geological Survey of the State of New York, one of the first objects sought was a map for laying down the limits of the geological formations. At that time there were no accurate maps except of small parts of country, and the best resource was found in Burr's atlas of the state and county maps of the State of New York. There seems to have been no approximately correct geographic map of the state available for the use of the geologists in recording their observations. At the close of the survey a small map was engraved expressly for the use of the geologists in laying down the limits of the geological formations. This map from the eastern limits of the state adjoining Massachusetts, Connecticut and Vermont to its western extremity was about 28 inches, and its extreme limit from north to south along the eastern counties of the state or from the Canada line to Sandy Hook was 2 inches less than its extent from east to west, or 26 inches. The locations of towns, villages and postoffices were doubtless taken from the best maps extant, but these afforded very unsafe guides for locating the outcrops of the geological formations.

Emmons's map of 1844 was colored on the same base as the map of 1842.

In 1867 a geologic map of Canada and the northern and eastern United States was published by Sir William Logan, director of the Canadian Geological Survey. This map is on a scale of 25 miles to the inch, and is of interest in the present connection because of the fact that the geology of the United States was compiled for it by Prof. Hall. The geologic mapping of New York there shown is, therefore, the first authoritative revision of the 1842 geologic map of New York.

Of this map it is said that only three copies were sent to the United States. These were presented to Prof. James Hall, Prof. James D. Dana and the United States Coast Survey. A reproduction on the scale of 125 miles to the inch is contained in the atlas accompanying the report of progress of the Canadian Geological Survey for 1863.

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[1] N. Y. State Geol. 12th An. Rep't. 1893. p. 27.

In 1882 Dr Hall prepared a small black and white geologic map of the state on the scale of 38 miles to the inch to accompany a publication entitled *Public Service of the State of New York.*

In 1894 an "Economic and Geologic Map of the State of New York" was prepared by F. J. H. Merrill to illustrate the report of the board of managers of the exhibit of the State of New York at the World's Columbian exposition. The scale was 14 miles to the inch, and the detail was necessarily much generalized, but in some areas the geologic boundaries were based on more recent data than those shown on the large map prepared under the direction of Prof. Hall.

A later edition of this map was published in bulletin 15 of the New York State Museum, and a reprint of this edition is contained in the report on barge canal by the state engineer, 1901.

The geographic base of 1894

The base of 1894 was prepared for Prof. Hall in Washington under the direction of Mr W J McGee, from such cartographic material as was available at that date. The manuscript draft of the base was prepared by Messrs Klemroth and Torbert on the same scale as that of the publication. The engraving was done on copper by expert engravers of the United States Coast and Geodetic Survey, temporarily unemployed.

While this map is very beautifully engraved, it is not wholly accurate in its geography, owing to the incompleteness of the surveys of the state and the lack of good compilations of such surveys as had been carefully made.

An edition of 1000 copies was printed.

The geographic base of 1901

The lack of accurate geographic information concerning New York state at the time of the compilation of the base of the Hall map rendered it necessarily inaccurate and, though beautifully engraved on copper, the errors were so numerous, which could be corrected through the availability of later surveys at the time of preparing the new edition, that the cost of correcting the copper plates would have been nearly as great as the expense of the original engraving. It was, therefore, decided to use for the new edition the less expensive method of photo-lithographic reproduction and leave to a future period, when the topographic survey of the state might be completed, the engraving of a new copper plate base of which the accuracy might be unquestioned.

The compilation of the manuscript geographic base was made by draftsmen under the supervision of Mr C. C. Vermeule, on the scale of 2½ miles to the inch, using all atlas sheets that had been surveyed at that time. In areas for which atlas sheets had not yet appeared the most accurate county maps were followed. The lithographic work was done by Julius Bien & Co., and after the proofs of the base were submitted they were again revised with the help of all later topographic sheets that appeared up to the time of going to press. The compilation of the geology was made with great care, preparation for it being the compilation during the previous year of a manuscript map of the state on a scale of 12 miles to the inch, in order to bring together all the latest material and to form a definite idea of its adjustment. Detailed credit for the material used is given in the text of this bulletin and in the important work of adjustment the writer has been greatly aided by his assistant Mr E. C. Eckel. The drafting of the geologic boundaries on the new base was mainly done by Mr A. M. Evans to whose manual skill and geographic instinct much of the value of the map as an accurate reproduction is due.

It should be understood by those who use the map that a certain percentage of the boundaries shown on it are necessarily conjectural. Some, because they have not yet been carefully surveyed on topographic sheets; some because the extent of Quaternary deposits is so great as to render these boundaries, in a large measure, indeterminate. One of the more prominent examples of the latter class is the boundary between the Niagara and Salina formations, west of the Genesee river. It can not be promised that this boundary will ever be defined with any degree of certainty unless a very extensive system of borings be made.

COLOR SCHEME

The colors and patterns used for the expression of the geologic formations are as nearly as possible those adopted by the United States Geological Survey in its geologic maps. The adjustment of these conventions to so large a map has proved quite difficult, yet it is sufficiently close to be clearly intelligible to those familiar with the system in question.

ACKNOWLEDGMENTS FOR MATERIAL USED

The space necessary for a detailed acknowledgment of material used in the present edition of the geologic map of New York is so great that it was found impracticable to engrave it all on the map itself. In the following pages, therefore, a detailed acknowledgment is made for all material used.

LIST OF CONTRIBUTING GEOLOGISTS WITH COUNTIES IN WHICH THEIR CONTRIBUTIONS LIE

New York

Bishop, I. P. Erie.

Clarke, J. M. Albany, Allegany, Broome, Cattaraugus, Cayuga, Chautauqua, Chemung, Chenango, Columbia, Cortland, Genesee, Herkimer, Livingston, Madison, Monroe, Oneida, Onondaga, Ontario, Otsego, Schuyler, Seneca, Steuben, Tioga, Tompkins, Wyoming and Yates.

Cumings, E. R. Schenectady.

Cushing, H. P. Clinton, Franklin, Herkimer and St Lawrence.

Dale, T. N. Rensselaer and Washington.

Dana, J. D. Columbia and Rensselaer.

Darton, N. H. Albany, Greene, Ulster, Orange, Saratoga, Herkimer, Fulton, Hamilton and Montgomery.

Davis, W. M. Columbia and Ulster.

Dwight, W. B. Dutchess and Columbia.

Eckel, E. C. Westchester, Putnam, Dutchess, Rockland, Orange, Oneida, Seneca and Yates.

Finlay, G. I. Essex.

Ford, S. W. Columbia.

Gilbert, G. K. Niagara.

Grabau, A. W. Niagara and Erie.

Hall, James. Schoharie, Sullivan, Tioga, Tompkins, Ulster, Wayne, Delaware, Monroe, Livingston, Broome, Cayuga, Chenango, Cortland, Erie, Greene, Genesee, Herkimer, Madison, Oneida, Orleans and Otsego.

Hill, B. F. Hamilton, Putnam, Washington, Dutchess, Fulton, Warren and Montgomery.

Hollick, A. Richmond.

Kemp, J. F. Essex, Fulton, Hamilton, Saratoga, Warren, Washington, Montgomery and Rockland.

Kümmel, H. B. Rockland.

Lincoln, D. F. Seneca.

Luther, D. D. Allegany, Broome, Cattaraugus, Cayuga, Chautauqua, Chemung, Cortland, Erie, Genesee, Livingston, Madison, Onondaga, Ontario, Seneca, Steuben, Tompkins, Wyoming and Yates.

Merrill, F. J. H. Queens, New York, Westchester, Putnam, Dutchess, Ontario and Rockland.

Newland, D. H. Dutchess, Putnam, Hamilton, Warren and Washington.

Parsons, A. L. Livingston.

Prosser, C. S. Schenectady, Otsego, Delaware, Schoharie, Greene, Orange, Sullivan, Albany, Ulster, Madison and Chenango.

Ries, H. Westchester, Orange and Putnam.

Sarle, C. J. Niagara, Orleans, Monroe, Wayne, Cayuga, Oneida, Oswego, Lewis, Jefferson and Madison.

Smyth, C. H. jr. Hamilton, Herkimer, Jefferson, Lewis, St Lawrence and Oneida.

van Ingen, G. Clinton and Essex.

Walcott, C. D. Rensselaer, Washington and Columbia.

White, T. G. Essex, Herkimer, Oneida and Lewis.

Woodman, J. E. Nassau and Suffolk.

Woodworth, J. B. Richmond, Kings, Queens and Nassau.

LIST OF GEOLOGIC MAPS USED IN PREPARATION

Clarke, J. M. New York State Geologist. 4th Annual Report. 1885. p. 9.

1 Geologic map of Ontario county.

——— New York State Geologist. 15th Annual Report. 1898.

2 Geologic map of Seneca, Schuyler, Yates and parts of Tompkins and Ontario counties. p. 60.

3 Geologic map of part of Chenango and Cortland counties. p. 42.

——— New York State Museum. Memoir 3. 1900. p. 12.

4 Geologic map of Becraft mountain.

Cushing, H. P. New York State Geologist. 15th Annual Report. 1898.

5 Geologic map of town of Champlain, Clinton co. p. 572.

6 Geologic map of Chazy town, Clinton co. p. 567.

7 Geologic map of town of Plattsburg, Clinton co. p. 556.

8 Geologic map of town of Beekmantown, Clinton co. p. 561.

9 Geologic map of town of Altona, Clinton co. p. 563.

10 Geologic map of towns of Plattsburg and Schuyler Falls, Clinton co. p. 553.

11 Geologic map of town of Peru, Clinton co. p. 550.

12 Geologic map of town of Ausable, Clinton co. p. 546.

13 Geologic map of town of Black Brook, Clinton co. p. 542.

14 Geologic map of town of Saranac, Clinton co. p. 539.

15 Geologic map of town of Dannemora, Clinton co. p. 536.

16 Map of Clinton co., showing boundary between Cambrian and pre-Cambrian formations. pl. 1, p. 503.

17 Map of Ellenburg, Clinton co. p. 553.

——— New York State Geologist. 16th Annual Report. 1899.

18 Map of Potsdam-pre-Cambrian boundaries in Clinton, Franklin and St Lawrence counties. p. 4.

19 Map of a portion of towns of Potsdam and Pierrepont, St Lawrence co. p. 25.

——— New York State Geologist. 18th Annual Report. 1900.

20 Geologic map of Franklin county.

Dale, T. N. United States Geological Survey. 13th Annual Report. 1893. pt 2, pl. 97.

21 Geologic map of the region between the Taconic range and the Hudson valley.

——— United States Geological Survey. 19th Annual Report. 1899. pt 3, pl. 13.

22 Geologic map of the slate belt of eastern New York and western Vermont.

Dana, J. D. American Journal of Science. Ser. 3, no. 120. Dec. 1880. 20:450, pl. 8.

23 Map showing limestone areas of Dutchess, Westchester and Putnam counties, New York and a part of western Connecticut.

——— American Journal of Science. Ser. 3, no. 171. Mar. 1885. 29:222, pl. 2.

24 Geologic map of Taconic region; pt 1, southern portion.

——— American Journal of Science. Ser. 3, no. 197. May 1887. 33:432, pl. 11.

25 Geologic map of middle and northern Berkshire.

Darton, N. H. New York State Geologist. 14th Annual Report. 1895.

26 Preliminary geologic map of portions of Herkimer, Fulton, Montgomery, Saratoga and adjacent counties. p. 33.

27 Sketch map of region north of Mayfield, Fulton co. p. 46.

——— New York State Geologist. 15th Annual Report. 1898. p. 738.

28 Preliminary map of Albany county.

Ford, S. W. American Journal of Science. Ser. 3, no. 169. Jan. 1885. 29:17.

29 Map of Schodack Landing, Rensselaer co.

Grabau, A. W. New York State Museum. Bulletin 45. 1901.

30 Geologic map of the Niagara river.

Hall, James 31 Preliminary geologic map of New York state. 1894.

Kemp, J. F. American Journal of Science. Ser. 3, no. 214. 1888. 36:248.

32 Geologic map of the vicinity of Rosetown, Rockland co.

——— New York State Museum. Bulletin 14. 1895. p. 355.

33 Geologic map of towns of Moriah and Westport, Essex co.

——— New York State Geologist. 15th Annual Report. 1898.

34 Geologic map of the town of Chesterfield, Essex co. p. 580.

35 Geologic map of the town of Wilmington, Essex co. p. 586.

36 Geologic map of the town of St Armand, Essex co. p. 588.

37 Geologic map of the town of North Hudson, Essex co. p. 590.

38 Geologic map of the town of Schroon, Essex co. p. 592.

39 Geologic map of the town of Ticonderoga, Essex co. p. 600.

40 Geologic map of the town of Minerva, Essex co. p. 602.

41 Geologic map of the town of Newcomb, Essex co. p. 604.

42 Geologic map of the town of Jay, Essex co. p. 582.

——— New York State Museum. Bulletin 21. 1898. cov. p. 2.

43 Geologic map of vicinity of Lake Placid.

Kemp and Newland, D. H. New York State Geologist. 17th Annual Report. 1899.

44 Geologic map of the town of Putnam, Washington co. p. 512.

45 Geologic map of the town of Dresden, Washington co. p. 514.

46 Geologic map of the town of Whitehall, Washington co. p. 520.

47 Geologic map of Whitehall village and region to the west. p. 522.

48 Geologic map of the town of Fort Ann, Washington co. p. 530.

49 Geologic map of the town of Bolton, Warren co. p. 534.

50 Geologic map of the town of Chester, Warren co. p. 536.

51 Geologic map of the town of Hague, Warren co. p. 538.

Kemp, Newland and Hill, B. F. New York State Geologist. 18th Annual Report. 1900.

52 Geologic map of the towns of Benson, Hope, Wells, Lake Pleasant and Indian Lake, Hamilton co. p. 141.

53 Geologic map of the vicinity of Wells village, Hamilton co. p. 144.

54 Geologic map of the town of Johnsburg, Warren co. p. 158.

55 Geologic map of the town of Fort Ann, Washington co. p. 162.

Kemp and Hill. New York State Geologist. 19th Annual Report. 1901.

56 Geologic map of the town of Caldwell, Warren co. p. 22.

57 Geologic map of the town of Queensbury, Warren co. p. 26.

58 Geologic map of the northern part of Saratoga county. p. 28.

59 Geologic map of the northern part of Fulton county. p. 29.

60 Outline map of the "Noses," Montgomery co. p. 32.

Kümmel, H. B. New York State Geologist. 18th Annual Report. 1900.

61 Geologic map of Triassic rocks of Rockland county.

Lincoln, D. F. New York State Geologist. 14th Annual Report. 1895.

62 Geologic map of Seneca county.

Map omitted from v. 2 of 48th museum report, where it should also have appeared.

Luther, D. D. New York State Geologist. 15th Annual Report. 1898.

63 Geologic map of the town of Naples, Ontario co. p. 236.

64 Geologic map of Onondaga county. p. 302.

Merrill, F. J. H. New York State Museum. Bulletin 15. 1895. p. 595.

65 Geologic map of a part of southeastern New York.

Prosser, Charles S. New York State Geologist. 15th Annual Report. 1898. p. 87.

66 Geologic map of parts of Chenango, Madison, Otsego, Schoharie and Albany counties.

——— New York State Geologist. 17th Annual Report. 1899. p. 66.

67 Geologic map showing the distribution of the Middle and Upper Devonian rocks in central-eastern New York.

Prosser, C. S.; Cumings, E. R.; Fisher, W. L. New York State Museum. Bulletin 34. 1900. cov. p. 2.

68 Amsterdam N. Y. quadrangle.

Ries, Heinrich. American Geologist. 1896. 18:240.

69 Augen gneiss area near Bedford N. Y.

——— New York State Geologist. 15th Annual Report. 1898.

70 Orange county. p. 395.

71 Town of Warwick, Orange co. p. 408.

72 Towns of Monroe, Woodbury, Highlands, Cornwall and a part of the town of Blooming Grove, Orange co. p. 414.

73 Area around Bull hill, Orange co. p. 423.

74 Geologic map and sections of regions west of Cornwall, Orange co. p. 427.

75 Geologic map of the town of Chester, Orange co. p. 428.

76 Geologic map of the town of Deer Park, Orange co. p. 470.

77 Geologic map of the town of Hamptonburgh, Orange co. p. 472.

78 Geologic map of the towns of Newburgh and New Windsor, Orange co. p. 476.

Smyth, C. H. jr. New York State Geologist. 19th Annual Report. 1901. p. 85.

79 Geologic map of portions of St Lawrence and Jefferson counties.

Walcott, C. D. American Journal of Science. Ser. 3, no. 208. 1888. 35:346, pl. 3.

80 Map of the Taconic region.

White, T. G. New York Academy of Sciences. Transactions. 1894. 13:6.

81 Geologic map of towns of Essex and Willsboro, Essex co.

——— New York State Museum. 51st Annual Report. 1899.

82 Geologic map of the pre-Cambrian border in Oneida and Lewis counties. p. r54.

83 Geologic map of the vicinity of Frankfort Hill. p. r54.

LIST OF AUTHORITIES FOR THE COUNTIES OF NEW YORK

Albany. Below top of Hamilton, Darton (28); corrected as to Oriskany in towns of Knox and New Scotland by Clarke; above base of Hamilton, Prosser (67).

Allegany. Portage-Chemung boundary by Clarke and Luther. Areas of Catskill in Hall (31) omitted.

Broome. Hall (31) corrected by Clarke and Luther in towns of Triangle and Lisle.

Cattaraugus. Clarke and Luther. Carboniferous compiled by Clarke after Randall.

Cayuga. Hall (31) corrected in towns of Aurelius and Springport and city of Auburn by Clarke; Tully and Genesee-Portage boundaries by Clarke and Luther; Clinton by Sarle.

Chautauqua. Clarke and Luther.

Chemung. Clarke and Luther.

Chenango. Hall (31); west of Chenango river; Clarke (3) and manuscript; east of Chenango river, Prosser (66).

Clinton. Cushing (5–18 incl.); with corrections and additions by Cushing.

Columbia. Eastern part, Dana (24, 25); northwest part, Walcott (80); region about Hudson, Clarke (4); Cambrian boundary at Hudson river, Ford (29); remainder of county by Dwight.

Cortland. Clarke (3), Hall (31) corrected by Clarke and Luther.

Delaware. Hall (31), Prosser (66) upper and lower boundaries of Ithaca, Oneonta-Chemung boundary west of Meredith.

Dutchess. Town of Pawling by Merrill except pre-Cambrian boundary from Whaley Pond to northern limit of this formation by Hill; town of Amenia from Wassaic northward by Merrill;

pre-Cambrian and Cambrian of Dover mountain by Eckel; town of Fishkill by Newland and Eckel; East Fishkill and Beekman by Hill; other boundaries by Dwight.

Erie. Hall (31) corrected by Clarke and Luther and I. P. Bishop; Salina-Onondaga boundary near Buffalo, Grabau (30).

Essex. Kemp (33–43) and manuscript; town of Minerva, Finlay; Willsboro Point by White (81) corrected by Kemp; Crown Point Paleozoic corrected by van Ingen.

Franklin. Cushing (18, 20) corrected by Cushing.

Fulton. Darton (26, 27); Kemp and Hill (59).

Genesee. Onondaga and below Hall (31), corrected by Clarke in towns of Alabama, Pembroke and Leroy; above base of Hamilton by Clarke and Luther.

Greene. Hall (31), Oneonta-Chemung and Chemung-Catskill; upper and lower boundaries of Ithaca, Prosser (67).

Hamilton. Northwestern part by Smyth, eastern part, Kemp (52, 53).

Herkimer. Hall (31), corrected in town of Litchfield by Clarke; Little Falls crystalline area by Cushing, White (83); Darton (26).

Jefferson. Pre-Cambrian boundaries, Smyth (79); Paleozoic boundaries above base of Potsdam by Sarle.

Kings. Woodworth.

Lewis. Pre-Cambrian, White (83) and Smyth; others by Sarle.

Livingston. Hall (31), corrected in towns of Caledonia and Lima by Clarke; top of Hamilton to base of Chemung, Clarke and Luther; corrected in town of Mount Morris by A. L. Parsons.

Madison. Hall (31) corrected as to Lower Helderberg by Clarke; Prosser (66); Tully by Luther; Clinton-Niagara and Niagara-Salina by Sarle.

Monroe. Hall (31) corrected in towns of Brighton, Mendon, Rush and Wheatland by Clarke; Medina-Clinton and Clinton-Niagara boundaries by Sarle.

Montgomery. Darton (26); "Noses" area, Kemp and Hill (60).

Nassau. West of 70° 30′ by Woodworth; east of that meridian by Woodman.

New York. Merrill (65).

Niagara. Region near Niagara river, Grabau (30); Clinton other boundaries by Gilbert and Sarle.

Oneida. Hall (31), corrected in towns of Augusta, Marshall and Paris by Clarke, in Kirkland by Smyth, and in Paris, Kirkland and Vernon by Eckel; below top of Niagara by Sarle and White (82, 83).

Onondaga. Luther (64), corrected as to Helderberg and Salina by Clarke; Tully resurveyed by Luther.

Ontario. Clarke (1, 2), corrected by Clarke; Tully by Luther. Boundaries in towns of Seneca, Phelps and city of Geneva by Merrill after well records.

Orange. Schunemunk area of Paleozoic rocks by .Darton; east and south of that area by Eckel; west and north of the Schunemunk area, Ries (70–78); Deer Park, Prosser (67).

Orleans. Hall (31), adjusted to topography.

Oswego. Sarle.

Otsego. Hall (31) below Hamilton; above base of Hamilton, Prosser (67); corrected in towns of Laurens and New Lisbon by Clarke.

Putnam. Southern parts of Phillipstown and Putnam Valley, Merrill (65); Patterson, East Kent and southern Southeast by Merrill; limestones between Anthony's Nose and Cold Spring and in valleys of Sprout brook and Canopus creek by Newland; remainder of the county from reconnaissance by Hill.

Queens. Crystalline rocks, Merrill (65); Pleistocene by Woodworth.

Rensselaer. Rensselaer grit plateau and vicinity, Dale (21); portions of the southeast part, Dana (25); remainder, Walcott (80).

Richmond. Pre-Pleistocene by Hollick; Pleistocene by Woodworth.

Rockland. Triassic, Kümmel (61); pre-Cambrian and Paleozoic boundaries in town of Stony Point, Merrill; towns of Ramapo and Haverstraw by Eckel; eruptives near Rosetown, Kemp (32).

St Lawrence. Smyth (79) and Cushing (18); corrected by Cushing.

Saratoga. Darton (26); Kemp (58).

Schenectady. Darton (26); except Amsterdam quadrangle by Cumings and Prosser (68).

Schoharie. Hall (31); top of Hamilton and Ithaca-Oneonta boundaries by Prosser (66 and 67).

Schuyler. Clarke (2). Relation of Ithaca and Naples beds of the Portage group diagrammatically shown as necessitated by map patterns.

Seneca. Lincoln (62), corrected by Clarke and Luther; Tully limestone within Ovid quadrangle by Eckel; relation of Ithaca and Naples beds of Portage, Clarke (2), diagrammatically shown as necessitated by patterns of map.

Steuben. Clarke and Luther.

Suffolk. Woodman.

Sullivan. Hall (31); top of Hamilton and above, Prosser (67).

Tioga. Hall (31).

Tompkins. Hall (31); Clarke (2); and Tully and Genesee, Luther.

Ulster. Hall (31); top of the Hamilton and above, Prosser (67).

Warren. Kemp, Newland and Hill (49–51, 54, 56, 57), corrected by Kemp.

Washington. Kemp and Hill (44–48, 55); Dale (22); Walcott (81).

Wayne. Niagara-Salina boundary by Hall (31); others by Sarle.

Westchester. Merrill (65); except in town of Bedford, Ries (69); and in towns of Cortlandt, Yorktown, Somers, North Salem, Lewisboro, Poundridge, Bedford, North Castle, Newcastle and Harrison by Eckel.

Wyoming. Clarke and Luther.

Yates. Genesee-Portage and Portage-Chemung, Clarke (2) corrected by Clarke and Luther; Tully limestone by Luther except near Dresden by Eckel.

LIST OF AUTHORITIES FOR CONNECTICUT, MASSACHUSETTS, VERMONT, NEW JERSEY AND PENNSYLVANIA

Connecticut. Dana (23, 24 and 25) modified by unpublished results of reconnaissance by Eckel in towns of Greenwich, Stamford, New Canaan and Darien and H. C. Magnus in towns of Salisbury and Sharon.

Massachusetts. Dana (24, 25) except in the area covered by Dale (21 and the geologic map of Monument mt, U. S. Geol. Sur., 14th An. Rep't), Emerson (U. S. Geol. Sur. Bul. 259 and U. S. Geol. Sur. Monograph 23, pl. 1), Pumpelly, Dale, Wolff and Hobbs.

Vermont. Walcott (80); Dale (22); and Brainerd and Seely.

New Jersey. J. C. Smock (New Jersey geologic map of 1890); except Green Pond mt region, by Darton (Geol. Soc. Am. Bul. 5: 367) as engraved on the Hall map (31); area about Franklin by Wolff and Brooks (U. S. Geol. Sur. 19th An. Rep't); moraine by Salisbury (N. J. state geologist. Rep't 1895).

Pennsylvania. I. C. White (G 6), H. C. Lewis (Q), Frederick Prime jr (D 3) and B. S. Lyman (2d Geol. Sur. Summary Rep't, v. 3)

MANUSCRIPT MAPS

A number of manuscript maps and manuscript corrections embodying the results of unpublished field work, were used in the compilation of the geology of the present map.

A manuscript map of the boundaries above the base of the Portage from Cayuga lake westward was supplied by Dr John M. Clarke, state paleontologist, embodying the results of field work by himself and his assistant, Mr D. D. Luther up to 1898.

Dr Clarke also contributed, as noted above, numerous manuscript corrections of existing maps.

Mr C. J. Sarle, who had been engaged under Prof. James Hall in field work on the Upper Silurian formations of the central and western parts of the state, contributed manuscript maps showing the results of this work.

Mr N. H. Darton, whose mapping of the rocks of the Helderberg escarpment had been used on the Hall map, contributed his original manuscript drafts.

For the Adirondack area Professors Cushing, Kemp and Smyth mapped in manuscript their respective areas of work, much of which had been left uncovered by their published maps. Several of the maps used in manuscript have since been published.

Manuscript maps by G. K. Gilbert, covering parts of the Upper Silurian area of Niagara county and a revision by I. P. Bishop of parts of his map of Erie county were also used.

Prof. W. B. Dwight contributed in manuscript the results of his field work in Dutchess county.

In southeastern New York, field work by the writer and his assistants furnished a large amount of unpublished material.

Long Island was mapped in manuscript by Prof. J. B. Woodworth and his assistant, J. E. Woodman, as the result of field work for the State Museum. Part of the area thus covered has since been described with accompanying maps in Museum bulletin 48.

NOMENCLATURE OF NEW YORK GEOLOGY

In selecting names to be applied to the formations shown on the map the attempt has been made to render it as serviceable as possible to the teacher and student by keeping its nomenclature as close as possible to the mass of older textbooks now in use.

In so doing the editor has not followed in every case the latest expression in terminology or classification, and has not undertaken to decide the merits of any question at issue.

Perhaps the most prominent question of geologic classification in New York now under discussion is that of the systematic position of the Helderberg limestone; namely whether it should be regarded as Silurian or Devonian. Dr John M. Clarke, state paleontologist, after exhaustive study, has expressed the opinion that in this formation fossils of Devonian aspect appear and that it should, consequently, be included in the Devonian system. Prof. H. S. Williams, attacking the question from another point of view, in his studies of the Paleozoic formations of Maine,[1]

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[1] U. S. Geol. Sur. Bul. 165, p. 56.

finds the Square Lake limestone which he correlates by its fossils with the Helderberg formation of New York and above it the Chapman sandstone in which he finds forms representative of the Silurian Tilestone fauna of Great Britain. From this he argues that, inasmuch as these Silurian fossils occur in a formation more recent than the Helderberg limestone, the latter should be regarded as Silurian.

So far as the writer understands from the literature to which he has access, the authors referred to, do not dispute each other's identifications of fossils. The question then seems to hang on the definition of a system; Dr Clarke holding that the system begins where its faunas first appear, while Prof. Williams holds that a system continues as far as its faunas linger, the definition of a system having, apparently, not been previously fixed. The question would, therefore, seem to remain open till the majority of geologists take the one side or the other.

On inquiring the opinion of the director of the United States Geological Survey, he expressed the view that the matter was still unsettled and so it is left by the present writer, the Helderberg being for the purposes of the present map classified in the Silurian system according to the arrangement adopted by Prof. Hall in the geologic map of 1894.

The classification of Oneonta, Ithaca and Portage formations as given on the map is based on a paper by Dr John M. Clarke in the 15th annual report of the state geologist, in which these formations, though regarded as essentially of equal age, lying between Hamilton and Chemung, are treated as separate groups. In the classification printed by Dr Clarke in Memoir 3 of the New York State Museum, he proposes to give the name of Portage group to the aggregate of the three formations and use the term Naples for the formation designated in the previous paper as the Portage group.

The following table shows the progress made in the terminology and classification of the rocks of New York since the beginning of geologic study within its area.

COMPARATIVE TABLE OF GEOLOGIC NOMENCLATURE USED IN NEW YORK STATE PUBLICATIONS

Eaton 1824	Conrad 1836	Emmons 1837	Vanuxem 1837	Hall 1837
Pyritiferous rock or third graywacke with shell limerock Corniferous limerock [illegible] [illegible] [illegible] [illegible] Granular quartz	Shales of superior series [illegible] [illegible] Shales with gypsum beds [illegible] strata [illegible] Transition [illegible] [illegible] [illegible] [illegible] [illegible]	[illegible] sandrock [illegible]	[illegible] [illegible] Upper [illegible] Water[illegible] series [illegible] Protean group [illegible] sandstone Millstone grit Green shale [illegible] [illegible] [illegible] [illegible]	Gypseous [illegible] slate [illegible] [illegible] Shales of Genesee and Niagara [illegible] [illegible]

Mather 1837	Horton 1838	Emmons 1838	Vanuxem 1838	Hall 1838
Limestones of [illegible] [illegible] limestone	Graywacke Millstone grit Transition argillite Sparry limerock	Transition or Trenton limestone Potsdam sandstone	[illegible] limestone Seneca limestone Gray sparry or crinoidal limestone Oriskany sandstone Water lime Saliferous group of Onondaga Protean group Gray sandstone of Oswego Red sandstone of Oswego	Old red sandstone Chemung group [illegible] Upper black shale Tully limestone Moscow shale Encrinal limestone [illegible] shale [illegible] shale Blue shale Dark slaty shale Marcellus [illegible] Seneca limestone Gray crinoidal or Onondaga limestone Oriskany sandstone Waterlime series Onondaga saliferous group Lockport limestone Rochester shale Green shale and iron ore

Conrad 1838	Mather 1839	Emmons 1839	Vanuxem 1839	Hall 1839
Transition Strata Old red sandstone group: Old red sandstone Olive sandstone Dark colored shales Black slate Medial Silurian: Helderberg sandstone Gray Brachiopod sandstone Helderberg limestones Second Pentamerus limestone Gypseous shales Rochester shale Pentamerus limestone Green slate Niagara sandstone Lower Silurian: Salmon river sandstone Gray crinoidal limestone Trenton limestone Mohawk limestone and slate Gray limestone with sparry veins Gray calcareous sandstone Potsdam sandstone	Catskill mountain series: Catskill mountain group Helderberg limestone Group: Corniferous limestone [illegible] grit Sparry limestone Shale Pentamerus limestone [illegible] limestone Water limestone Pyritous slates Red rocks of Shawangunk Shawangunk grit Hudson slate group	Trenton limestone [illegible] limestone Mohawk limestone Calciferous sandrock Fucoidal mass Potsdam sandstone	Montrose sandstone Chemung group Ithaca group Sherburne flagstone Black shale Tully limestone Moscow shale Hamilton group Skaneateles shale Marcellus shale Seneca limestone Corniferous limerock Onondaga limestone [illegible] layers [illegible] Oriskany sandstone Scutella limestone Delthyris shaly limestone Pentamerus limestone Manlius water lime [illegible] Onondaga salt group Protean group Oneida conglomerate Medina sandstone Sandstone of Salmon river Pulaski shale Frankfort slate Black shale Trenton limestone Birdseye limestone Mohawk limestone Calciferous sandstone Potsdam sandstone	Old red sandstone Chemung group Portage group Gardeau flagstone Ithaca group Cashaqua shale Upper black shale Tully limestone Moscow shale [illegible] [illegible] [illegible] [illegible] [illegible] Marcellus shale Seneca limestone Onondaga limestone Oriskany sandstone [illegible] Onondaga salt group [illegible] red shale Lockport limestone [illegible] shale Green shale Pentamerus limestone Iron ore Green shale Medina sandstone Red marl and shale

Conrad 1839	Mather 1840	Emmons 1840	Hall 1840	Conrad 1840
Black slate Gray, blue and black limestones Grit [illegible] Oriskany sandstone Silurian System: Blue [illegible] crystalline limestone and gray shaly limestone Water lime series Gypseous shales Lockport limestone [illegible] Niagara sandstone Salmon river sandstone and shales Trenton limestone	Catskill Mountain Series: Red and gray grits and mottled shales Chemung group Ithaca group Sherburne flags Hamilton group Marcellus shale Helderberg Series: Seneca limestone Corniferous limestone [illegible] [illegible] [illegible] Scutella limestone Delthyris shales [illegible] [illegible] Onondaga salt group Hudson Slate Series: Frankfort slate Mohawk [illegible] Trenton limestone Mohawk limestone [illegible] group Potsdam sandstone	[illegible] Mohawk limestone Potsdam sandstone	Old red sandstone \ conglomerate Chemung group Portage group Gardeau group Cashaqua shale Upper black shale Tully limestone [illegible] Marcellus shale "Corniferous" limestone Oriskany sandstone [illegible] limestone Onondaga salt group	Old red sandstone Upper Series: [illegible] group Cazenovia group Tully limestone [illegible] group Black slate Corniferous limestone Silurian System, Middle Series: Limestone and shale Pentamerus oblongus limestone, iron ore and green [illegible] Lower Series: [illegible]

Emmons 1841	[illegible] 1841	Mather 184[illegible]	Vanuxem 1842	Hall 184[illegible]
Old red sandstone Chemung shales Ithaca shales Genesee slate Tully limestone Hamilton shale Marcellus shale [illegible] Helderberg [illegible]: Encrinal limestone Delthyris shaly limestone [illegible] Ontario [illegible]: Green shales and Oolitic [illegible] Champlain [illegible]: Lorraine shales [illegible]	Taconic System: Taconic slate [illegible] Granular quartz	New York System: Catskill group Ithaca and Chemung group Erie Division: Hamilton group Marcellus shale Corniferous limestone Helderberg Division: Delthyris shaly limestone Ontario Division: Pyritous strata and red shale Hudson river group	Catskill group Chemung group Ithaca group Portage group Genesee slate Helderberg Division: Catskill shaly limestone Ontario Division: Clinton group	[illegible] Helderberg Series: Upper Pentamerus limestone Encrinal limestone Clinton group

Conrad 1837, Vanuxem 1837, Emmons 1836, Mather 1836, Mather 1838, Vanuxem 1840 use no names

* Cambrian system

† Old red system

‡ The nomenclature used on the geologic maps of 1894 and 1901 relates only to those divisions and formations which could be shown on the map

|| The Chazy limestone has been regarded by geologists as lying below the Birdseye, but these two formations do not appear to occur together at any locality

Small capitals indicate earliest occurrence of [illegible]

COMPARATIVE TABLE OF GEOLOGIC NOMENCLATURE USED IN NEW YORK STATE PUBLICATIONS

	Emmons 1838
	[illegible] or Trenton limestone
	[illegible] sandstone

	Vanuxem 1838
	[illegible] limestone
	Seneca [illegible]
	[illegible]
	Onondaga [illegible]
	Waterlime
	Saliferous group of Onondaga
	[illegible] group
	Gray sandstone of Oswego
	[illegible]

	Hall 1838
	[illegible] sandstone
	[illegible]
	[illegible]
	Upper [illegible]
	[illegible] limestone
	Moscow shale
	[illegible]
	[illegible]
	[illegible]
	[illegible]
	[illegible]
	[illegible]
	Seneca limestone
	[illegible] limestone
	[illegible]
	Waterlime series
	Onondaga saliferous group
	[illegible]
	[illegible]
	[illegible] shales and iron ore

	Conrad 1838
Old red sandstone group	Old red sandstone
	[illegible] sandstone
	Dark [illegible] shales
	Black shale
Transition Strata / Medial Silurian	[illegible] sandstone
	Gray [illegible] sandstone
	[illegible] limestone
	[illegible]
	Gypseous shales
	[illegible]
	[illegible] Green slate
	Niagara sandstone
Lower Silurian	Salmon river sandstone
	[illegible] limestone [illegible] Mohawk limestone and slate [illegible] limestone with sparry veins
	Gray calciferous sandstone
	Potsdam sandstone

	Mather 1839
Catskill mountain series	Catskill mountain group
Helderberg limestone group	Corniferous limestone
	[illegible] grit
	Sparry limestone
	Shale
	[illegible] limestone
	Pentacrinite limestone
	Water limestone
	Pyritous slates
	[illegible] of Shawangunk
	SHAWANGUNK GRIT
	Hudson slate group

	Emmons 1839
	Trenton limestone
	[illegible] limestone
	Mohawk limestone
	Calciferous sandrock
	[illegible] Potsdam sandstone

	Vanuxem 1839
	[illegible] sandstone
	[illegible] group
	Ithaca [illegible] [illegible]
	[illegible] shale
	[illegible]
	[illegible] shale
	Hamilton [illegible]
	[illegible]
	Marcellus shales
	Seneca limestone
	[illegible]
	Onondaga limestone
	[illegible]
	[illegible]
	Oriskany sandstone
	[illegible] limestone
	[illegible]
	[illegible]
	MANLIUS WATER LIME GROUP
	Onondaga salt group
	Protean group
	ONEIDA CONGLOMERATE
	MEDINA SANDSTONE
	Sandstone of Salmon river
	[illegible] shale
	Frankfort slate
	[illegible] shale
	Trenton limestone
	Birdseye limestone
	Mohawk limestone
	Calciferous sandstone
	Potsdam sandstone

	Hall 1839
	[illegible] sandstone
	[illegible]
	[illegible] [illegible] [illegible] [illegible] shale
	[illegible] shale
	[illegible] limestone
	[illegible] [illegible] [illegible] shale
	[illegible] shale
	[illegible] shale
	[illegible]
	Marcellus shale
	[illegible]
	[illegible] limestone
	[illegible] sandstone
	Hydraulic limestone
	Onondaga saliferous group, red shale
	Lockport limestone
	[illegible]
	Green shale Pentamerus limestone Iron ore Green shale
	Medina sandstone
	Red marl and shale

	Conrad 1839
	Black slate
	Gray, blue and [illegible] limestones
	[illegible]
	[illegible]
	Oriskany sandstone
Silurian system	[illegible] and gray [illegible] sandstone
	Water lime series
	Gypseous shales
	Lockport limestone
	Rochester shale
	Niagara sandstone
	Salmon river sandstone and shale
	Trenton limestone

	Mather 1840
Catskill Mountain Series	[illegible]
	[illegible] group
	Ithaca group
	Sherburne flags
	Hamilton group
	Marcellus shale
Helderberg Series	Seneca limestone
	Corniferous limestone
	Onondaga limestone
	[illegible]
	[illegible]
	Oriskany sandstone
	Scutella limestone
	Delthyris shaly [illegible]
	Pentamerus limestone
	Water limestone
	Onondaga salt group
Hudson Slate Series	Frankfort slate
	[illegible] slate
	Trenton limestone
	Mohawk limestone
	Calciferous group
	Potsdam sandstone

	Emmons 1840
	HUDSON RIVER SLATE
	Mohawk limestone
	Potsdam sandstone

	Hall 1840
	Old red sandstone / conglomerate
	[illegible] [illegible] Gardeau group Cashaqua shale
	[illegible] shale
	Tully limestone
	Moscow shale Encrinal limestone [illegible] shale Shales Marcellus shales
	Corniferous [illegible] Onondaga limestone
	Oriskany sandstone
	Hydraulic [illegible]
	Onondaga saliferous group

	Conrad 1840
Upper Series	Old [illegible]
	[illegible] Cazenovia group
	Tully limestone
	Sherburne group Shales near Apulia
	Black [illegible]
	Corniferous [illegible]
Silurian System / Middle Series / New York System	Onondaga limestone
	Grit slate
	Fucoidal sandstone
	Oriskany sandstone
	Limestone and shale
	Pentamerus galeatus limestone
	Hydraulic limestone
	Gypseous shales
	[illegible]
	Pentamerus oblongus limestone, iron ore and green [illegible]
	Red sandstone
Lower Series	Shales of Salmon river
	Trenton limestone
	Breccia and sparry limestone
	Calciferous sandstone
	Potsdam sandstone

	Emmons 1841
Erie Group	Old red [illegible]
	[illegible]
	Ithaca shales
	[illegible] [illegible]
	Hamilton shale
	Marcellus shale
	Helderberg limestone
Helderberg Series	Schoharie grit
	Cauda galli grit
	Oriskany sandstone
	Encrinal limestone
	Delthyris shaly limestone
	Pentamerus limestone
	Manlius waterlime
	Onondaga salt and plaster rock
Ontario Group	NIAGARA LIMESTONE
	Green shales and Oolitic ore
	Medina sandstone
	Conglomerate and gray sandstone
Champlain Group	LORRAINE SHALES
	UTICA SLATE
	Trenton limestone
	Marble of Isle La Motte
	Birdseye limestone
	§ CHAZY LIMESTONE
	Calciferous sandrock
	Potsdam sandstone

	Emmons 1841
Taconic System	Taconic slate
	Magnesian slate
	STOCKBRIDGE LIMESTONE
	Granular quartz

	Mather 1842
Erie Division	[illegible]
	Ithaca and Chemung group
	Hamilton group
	Marcellus shale
	[illegible]
New York System / Helderberg Division	Onondaga limestone
	Schoharie grits
	Cauda galli grit
	Oriskany sandstone
	Delthyris shaly limestone
	Pentamerus limestone
	Water limestone
	Onondaga salt group
Ontario Division	Pyritous strata and red shale
	Shawangunk grit
Champlain Division	Hudson river group
	Utica slate
	Trenton limestone
	Black river limestone
	Calciferous group
	Potsdam sandstone

	Vanuxem 1842
Erie Division	Catskill group
	[illegible]
	Corniferous limestone
New York System / Helderberg Division	Onondaga limestone
	Schoharie grit
	Cauda galli grit
	Oriskany sandstone
	Catskill shaly limestone
	Pentamerus limestone
	Waterlime group
	Onondaga salt group
Ontario Division	Niagara group
	Clinton group
	Oneida conglomerate Medina sandstone GRAY SANDSTONE OF OSWEGO
Champlain Division	Hudson river group
	Utica slate
	Trenton limestone
	Black river limestone
	Calciferous sandrock
	Potsdam sandstone

	Hall 1843
Erie Division	[illegible]
New York System / Helderberg Series	Onondaga limest[illegible]
	Schoharie grit
	Cauda galli [illegible]
	Oriskany sand[illegible]
	Encrinal limest[illegible]
	Delthyris shaly [illegible]
Ontario Div	[illegible]
Champlain Division	Trenton limestone
	Black river lime[illegible]
	Calciferous [illegible]
	Potsdam sand[illegible]

	Hall 1894 Map
	Portage group
	Oneonta sandstone
	Hamilton formation
	[illegible] sandstone
	Helderberg limestone
Silurian	Niagara formation
	Clinton formation
	Medina and Oneida [illegible]
	Hudson river and Utica
	Trenton limestone
	[illegible]
Cambrian	Potsdam sandstone
	Georgia formation (in [illegible])

	Clarke & Schuchert 1899	
		Chemung beds
	Senecan	
		Onondaga limestone
		Schoharie grit Esopus grit
	Oriskanian	Oriskany beds
		Kingston beds
	Helderbergian	New Scotland Coeymans limestone
	Cayugan	Salina beds
Ontario or Siluric	Niagaran	Guelph dolomite Lockport limestone Rochester shale
		Clinton beds
Champlainic	Cincinnatian	
	Mohawkian	Black river
	Canadian	
Cambric or Taconic	Potsdamian	Potsdam sandstone and limestone
	Acadian	

	Merrill map 1901
	Chemung
	Oneonta
	Tully limestone
Devonian	Hamilton
	Onondaga
	Oriskany
	Niagara
Silurian	Clinton
	Medina and Oneida
	sandstone of Oswego
	Hudson river
Cambrian	Potsdam
	Georgia slates and Georgia [illegible]

[illegible] Mather 1838, Vanuxem 1842 [illegible] [illegible] system [illegible] system. The nomenclature used on the geologic maps of 1894 and 1901 relates only to those divisions and formations which could be shown on the map. § The Chazy limestone has been regarded by geologists as [illegible] these two formations do not appear to occur together at any locality. Small capitals indicate earliest occurrence of terms used in present systems of nomenclature. Term Salina first used by Dana, Manual [illegible]

INDEX

(*Pages 39–49 were bulletin cover pages*)

Appendix 2

Economic Geology 11

Museum bulletin 61

11 Quarries of Bluestone and other Sandstone, in New York

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New York State Museum

FREDERICK J. H. MERRILL Director

Bulletin 61

ECONOMIC GEOLOGY 11

QUARRIES OF
BLUESTONE AND OTHER SANDSTONES
IN THE
UPPER DEVONIAN OF NEW YORK STATE

BY

HAROLD T. DICKINSON

University of the State of New York

New York State Museum

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ECONOMIC GEOLOGY 11

QUARRIES OF
BLUESTONE AND OTHER SANDSTONES
IN THE
UPPER DEVONIAN OF NEW YORK STATE

PREFACE

The first official study of the building stones of New York was made by Dr James Hall, state geologist, in preparation for a report to the commissioners of the new state capitol in 1868. His examination of the building stones available for this great building led to the formation of a collection of large cubes dressed on different sides to show various modes of treatment, which is now the nucleus of a large collection in the Geological hall.

In 1886 Prof. John C. Smock took up the study of the building stones of New York and in bulletins 3 and 10 of the New York state museum, contributed copiously to our accurate knowledge of the resources of New York state in this sort of building material.

With the lapse of time it becomes necessary to enlarge our descriptions and records and it is now proposed to bring up to date our knowledge of the subject of building stones.

This has, however, grown to such an extent that it seems hopeless to treat it all in one volume or publication. It is intended, therefore, to issue, as time and means will permit, separate bulletins discussing various types of this important material. The first contribution is the following one on that valuable and important variety of sandstone known as bluestone and on rocks of allied character.

FREDERICK J. H. MERRILL

July 1902

INTRODUCTION

The area in New York in which are quarried the sandstones of the Upper Devonian, as shown by the accompanying map, is bounded on the east by a line roughly parallel to the Hudson river and from 5 to 30 miles west of it, beginning in Albany county and running south to West Hurley in Ulster county, where it turns to the southwest, following Rondout creek. The northern boundary of these formations is approximately in an east and west line 15 to 20 miles south of the Mohawk valley and stretching westward to the shore of Lake Erie, which is the western limit. The whole of the central and southern part of New York state is occupied by these sedimentary rocks, the formations extending south into Pennsylvania. The sandstone is quarried at different localities throughout the whole territory, the most productive region being the southeastern part, where numerous quarries have been opened in the eastern face of the Catskill mountains, in the low lying terraces between the mountains and the Hudson river and in the hills on both sides of the Delaware river. This district is favorably situated for the transportation of the stone to the eastern markets and is the chief producer of the commercial "bluestone" so extensively used for flagstone, street crossings and house trimmings in the larger cities of the east.

The beds occur from the Hamilton group to and including the Catskill and are horizontal or dip at gentle angles. The greatest difference in elevation between the workable beds is shown in Ulster county, where a few of the mountain quarries are 2500 feet above the quarries nearest the Hudson river. The rocks are shales and sandstones. But there is so great a range in composition and texture that there are many varieties under each of these heads and an almost infinite gradation from one to another, and no sharp line can be drawn. The quarry stone is, as a rule, even bedded and compact and can be split in planes parallel to the bedding. In texture the stone varies from the exceedingly fine grained material which takes a very even finish, to a sandstone which is almost conglomeritic in its nature. The color is highly variable, being blue, gray, greenish, pink and red in different localities.

Four geologic groups are represented in this territory, viz, Hamilton, Portage, Chemung and Catskill, but the distinctions between these groups are in part paleontologic and may be disregarded in a discussion of the economic geology of the area.

The main belt of country producing the even bedded and compact sandstone suitable for flagging and house trimmings known commercially as "bluestone" begins on the western side of the Hudson river in the southwestern part of Albany county and stretches southward through Greene, Ulster, Sullivan, Delaware and as far west as Broome county.

Besides this main belt there are scattered localities in the central part of the state, producing bluestone, at Oneonta, Rock Rift, Oxford, King's Ferry, Trumansburg and Portageville.

The district including Greene, Ulster, Delaware, Sullivan and Broome counties is the most productive, the products reaching the markets by the way of the Hudson river, and Erie and Ontario and Western railroads. The quarries in this district are all small and as a rule short lived.

The term bluestone was originally applied to the blue colored sandstone quarried in Ulster county, 4 to 7 miles west of the Hudson river. Today in commerce, the name bluestone is applied to a large part of the flagstone produced in the state, regardless of color. It is therefore, today rather a misnomer, for this material is sometimes green and occasionally reddish.

Probably 75% of the Ulster county stone is marketed in the condition known as "quarry dressed," the balance being treated in the mills along the Hudson river.

In Broome, Delaware and Sullivan counties a very small percentage of the product passes through mills in the district. Some "rock" however is shipped in the rough to other mills.

A large part of the stone at Oxford, Portageville and Rock Rift is subjected to mill treatment.

There are three classes of the product of the quarries, 1) flagstone, 2) "edge" stone and 3) "rock." The first class includes the stone used for sidewalks and requires little dressing. A stone 1½ inches thick and over, with a smooth surface and edges at right angles, fulfils all requirements. Bluestone is particularly suitable for use as flagging, retaining after long wear its rough surface. "The stone is so compact as to absorb but little moisture, and thus, when used as flagging, ice and rain remain upon it but a short time." "Its hardness resists wear, never forming the slipping surfaces of clay slate."

The second class includes such stone as curb, window and door sills, lintels and other house trimmings. This stone all requires dressing; curb requires "axing" on the face and edge. This class of stone requires one or more perfect edges for market.

The third class includes the stone sold in the rough to the dealers for mill treatment. All this is thick stone, varying from 4 inches to 5 and 6 feet. It is sawed or planed in the mills for platforms, steps and building stone.

The products of the first two classes are often treated in the mill when orders call for such finished work.

The kinds of stone as to shape, size and use are more numerous than the uninitiated would imagine.

As regards the microscopic structure and quality of the stone, the following notes by F. L. Nason[1] are interesting.

Bluestone. Bigelow bluestone co. (now Ulster bluestone co.) Minerals: quartz and feldspar. The quartz is in grains, which appear to be very angular in shape, more like a breccia. The grains are clearer than those of other sandstones examined, and the proportion of quartz grains to the rest of the matter is smaller. The feldspar observed differs very materially from that in the other stone. Grains of triclinic feldspar are observed, which are very fresh. Another feldspar is almost completely decomposed. No carbonate of lime appears to be present, and very little oxid of iron. The long, wavy, crystallike dark spots in the stone appear to be decomposed feld-

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[1] N. Y. state mus. 47th an. rep't 1893. 1894. p.583; N. Y. state geol. 13th an. rep't 1893. 1894. p.389.

spar, more or less stained with iron. The cementing material is probably silica, as dilute hydrochloric acid has no effect, and it is not stained with iron.[1]

Joints and bedding

The beds of stone are divided naturally by vertical joints at right angles, one system running about north and south, while the other has an east and west direction. The north and south joints are known to the quarrymen as "side seams," while the east and west joints are called "heads," "head-offs" or "headers." These joints are persistent throughout the whole area of the two main districts, but in Delaware and Broome counties the east and west joints are likely to be very irregular. The distance between these joints determines the maximum size of the blocks, but not often is a stone the full size of the block taken up. These joints are from 5 feet to 75 feet apart as a rule. The bed is divided also by horizontal seams which are at varying distances apart. These layers are known as "lifts."

In addition to these open seams and between them, occur what are known as "reeds." The reeds are really closed seams which can be seen on looking closely at the edge of a block. The reeds are both an advantage and a disadvantage. They occur, as a rule, in only the fine grained stone. They are advantageous in that they provide means of splitting a thick stone into a number of thinner ones. This splitting is done by means of a "point" and thin wedges. They are a disadvantage in that they are a source of weakness in the stone. The frost will often open up the reeds, specially in curb which is set on edge. Each quarry has its characteristic reeds. A typical "black reed" is the best for splitting stone.

It is often true of these reeds that, after quarrying, when the stone is exposed to the weather two or three weeks before

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[1] The test was as follows. A thin slice of the stone, $\frac{1}{100}$ of an inch thick was immersed in the dilute acid. In the case of a calcareous sandstone, or of a ferruginous sandstone, the grains of silica and feldspar would have been loosened into sand. The slice of rock remained practically unaffected.

frost, they tighten and close up, while, if it is quarried during the winter, the reeds will open. Again, it is true that, with a thick lift, if the stone is split to a thickness of 6 inches, there is no danger of the reeds opening, while, if it is left thicker than this, the danger of the reeds opening from exposure is great. Some reeds will not open at all, even when the block is "pointed" all around, and others will open only partly. As before stated, each quarry has its characteristic reeds, which have to be found by the quarrymen by experience.

The seams in the quarry are a source of trouble and at times loss. A seam will "shift and grow" or "double," that is, on the front edge of a block the thickness of a lift may be 2 inches while on the back the thickness will be 4 inches. Two seams have run together, not gradually, but by a sudden jump, leaving the two faces of the stone parallel. All these considerations affect the commercial value of a quarry.

When a quarry is first opened, the lifts are always thin, not over ¾ inch to 2 inches thick. As each tier of blocks is taken out, the lifts are thicker. Also it is a common occurrence to find that the lifts in the lower part of the bed are heavier than those at the top. All thin lifts are used as flagstone, while the thicker lifts are worked into edge stone or left in the rough and sold as "rock." As a rule, a good "rock" quarry is the most profitable, as the stone requires no dressing of any kind. But, on account of the sizes and weight of the stone, derricks are required.

Between the lifts, a thin bed of shale may occur, 3 to 4 inches thick. Shale is known to the quarrymen as "pencil." A "rough streak" in a quarry bed is a common occurrence. This is a streak of stone, of varying thickness, in which the seams are very irregular. There are varying degrees of "roughness"; part of the streak may be worked into salable stone, with extra labor, or it all may have to be dumped on the rubbish pile.

A bed of stone is said to be "bottomed" when a thick rough streak or pencil is encountered. A rough streak is not always permanent. With each new tier of blocks taken out, the conditions change, and the rough streak may become as workable as the balance of the bed, and again it may increase in size, spoiling the bed entirely.

Nearly every quarry has its own peculiar formation. Quarries within 400 or 500 yards of each other frequently differ greatly as to quality and formation.

Stripping

The overburden, or "top," consists in Ulster county of a layer of soil, clay or hardpan, underneath this alternating beds of shale and rock. This "rock" is a name given to the part of the ledge which can not be worked into salable stone. ("Rock" also is a term applied to the thick "lifts" of stone which are sold to the mills for sawing and other treatment.) Below the shale and the rock is the bed of stone. The thickness of the soil, shale, rock and bed of stone is very variable. But a rough ratio for profitable quarrying is 1 of bed to from 2 to 3 of top, depending on the ease with which the stone is worked, its quality and the character of the bed. Some quarries have all soil top, some all rock, and again some have all shale top. Generally all three are found except in Delaware and Broome counties, where shale occurs rarely.

The stripping is usually carried on in winter, as only a few quarries can be worked when it is very cold, owing to the effect of freezing on the durability of the stone. The ground also is then frozen hard, and the scales of dirt are quite firmly cemented by frost. Dynamite or some other high explosive is used to loosen the rock and dirt. This is found to be better and more economical of time and labor, since the frozen dirt and slate can be handled better than when uncemented. The stripping is handled by shovels and wheelbarrows for the soil and shale, while powder and dynamite are employed in breaking up the rock. There is not much difference in cost of removing the various kinds of "top" except as to thickness. Rock is easily handled with a derrick after blasting. Hardpan requires considerable work even after blasting. Shale and soil require a great deal of work in handling. A one horse dump cart or a small car and wooden or iron rails are often part of the equipment for stripping.

The waste material or rubbish is carted away and dumped opposite the face of the quarry. In the case of the quarries in the mountains, this rubbish is dumped down the mountain side. Very little attention has been paid to the proper disposal of this rubbish, for, in many cases, it has to be handled twice. In many beds which are now being worked in Ulster county the greatest part of the stripping is rubbish from quarries opened 40 years ago and abandoned.

Quarrying

Quarrying is carried on eight or nine months in the year. In many quarries no work at all is done during the winter. After the stripping is done, the different lifts are raised by wedges driven into the open seams, just enough to give the proper strain for the lift to free itself from the under bed. The area of these lifts varies with the size of the block. That of large ones may be 1000 square feet or more. The thickness varies from 1 inch to 8 feet.

If it is not possible to lift the layer from the whole block, a line is marked by cord and chalk where it is necessary to break the stone. This line is traced across with a point by digging out holes ¾ inch to 1 inch deep and from 2 inches to 3 inches apart. The point is held so that its horizontal projection will fall along the chalk line. After the block has been traced across, every sixth or seventh hole is drilled to a depth corresponding to the thickness of the lift. In these deeper holes, plugs and feathers are placed. The plugs are driven down together by striking one after another, so that the strain is equal all along the line. To do this well requires a great deal of skill, which is a result of long and close attention to work. At a certain point of strain the stone will break off along the chalk line, true and even. In Ulster county the stone breaks the best in a north and south line following the side seam, while in Delaware and Broome counties the stone breaks best in an east and west direction. The quarrymen say that the stone "works" best north and south or east and west as the case may be. This same system is used in breaking lifts of large area to smaller sizes.

Generally, very little powder is used in blasting out the bed of the stone. The joints are usually free or open for working. When powder is necessary in the bed the "Knox" system of blasting is used, a short description of which follows. The holes are first drilled to the desired depth in a line then "reamed" out, making the hole elliptic in section, the longer axis being in the line of the holes. A small amount of explosive is put in each hole with little or no tamping. Within a foot or so of the top of the hole a plug is put in and the tamping placed on top of this. The holes are fired simultaneously by electricity. The greater part of the force of the explosion is taken up by the air cushion and, as a result, the block is not shattered or split.

In the larger quarries in Ulster county district, hand and horse power derricks are used, but in no case are there any steam hoists except at the docks. In Delaware and Broome counties there are a few steam derricks, and all the larger quarries are equipped with hand or horse power derricks. A blacksmith shop for sharpening and tempering tools is usually part of the equipment of all the quarries. The tools consist of hammers, points, drills, wedges, plugs and feathers, crowbars and shovels. In a very few instances does the equipment include steam drills or pumps.

When water is troublesome a siphon is used, if a sufficient fall can be had, or a horse or hand power pump is used when a siphon is not available. In the few cases in which the steam pump is used the "pulsometer" seems to be a favorite.

The following from *Stone* is of interest as showing the peculiarities of bluestone quarrying:

> The quarrying of bluestone probably requires as much skill, if not more, than any other kind of stone, a fact often over-

looked and a potent factor in the success of a quarryman. It seems to be a general impression among a great many users and perhaps a few of the producers of this most useful and durable stone, that a man needs only to find a deposit of salable quality of bluestone, no more than usual proportion of top to bed, with the usual shipping facilities, and success is assured. But for any one who has been closely connected with this especially interesting business, it is easy to find the reason why a quarry has not paid. The causes are usually radical, and one of the first flaws after ascertaining that the quarry contains stone in fair quantity will be found by looking into the system of quarrying, and here is frequently a drawback to the prosperity of the quarry.

As a rule, the best quarrymen have worked in the quarries from the time they have been able to do anything, and, as that is usually pretty early in life, many of them have gained such knowledge of the work that they know to a certainty how the stone will work, as soon as they see the bed, without raising a lift. It is only after long work that a quarryman becomes expert.

Dressing

After the stone is lifted from the bed, it is handed over to the stonecutter, who prepares it for market. If it is flagstone, it is cut into commercial sizes 2, 3 or 4 feet wide, and the irregularities are chiseled down. Flag, as a rule, requires little dressing. If the stone is to be cut into curb or other "edge" stone, the block must be split, if too thick, and then broken to the proper width. Curb is usually "axed" 12 inches to 14 inches on the face, and the top edge is pitched at the proper angle. "Rock" and platform require no dressing in the quarry. The dressing of the stone in the quarry is usually of the roughest kind and is done as quickly as possible. For the finer grades of axed and cut stone, the work is done on the docks.

At many of the docks stone mills are in operation. The mill treatment consists of sawing large blocks, planing and rubbing the house trimmings, platforms, steps etc., and boring sewer heads.

There is a great difference in the stone in regard to its action under a saw or planer. Some stone will chip or check under a planer and not give the smooth surface desired, while other stone will wear out the gang saws very fast. The action of a stone in a mill depends largely on its hardness and texture.

A planer consists of a stationary base with a moving carriage, on which the stone is placed and held firmly by set screws. This carriage moves forward and backward under the bits of the planer. These bits are fastened to the immovable part of the frame, and, as the stone passes under them, take off the irregularities of the surface.

A gang saw has a varying number of saws set at different or the same distances apart. These saws are fastened by wedges on a frame above the block of stone and are moved forward and back by an eccentric. As the cuts in the stone deepen, the frame is lowered by a feeding device. Sand and water are fed into the cuts during the sawing.

Rubbing is usually a secondary treatment to planing. The rubbing bed is a circular cast-iron plate, which revolves horizontally. The stone is placed on this and held stationary by projecting arms. The revolving cast-iron plate grinds the stone and smooths off the irregularities of planing. Sand and water are fed from the center into the bed during the process.

Another kind of saw is the "diamond" saw, which has diamonds set along the edge of the saw. The diamonds are held in cast-iron teeth, which are removable from the blade. There are 10 to 12 teeth, containing 2 to 3 "borts," in each saw, spaced equally, according to length of blade. The diamond saws cut 23″ to 24″ an hour, while the ordinary gang saw cuts only 2½″ to 2¾″ an hour.

Most docks have one or more stonecutters employed in special and fine work.

Rent and ownership

The majority of the quarries in the two main districts are worked by two or three men, sometimes in partnership, but often one man operates the quarry, hiring one or two extra men as quarrymen or stonecutters. A good stonecutter can command a wage of $1.75 to $2.25 a day, while a quarryman is paid $1.50 to $2, and in some places only $1 a day. In Delaware and

Broome counties the demand for stonecutters is greater than the supply this year.

The quarrymen seldom own the land on which the quarry is situated, but lease it at a rental proportionate to the amount of stone taken out. In Ulster county the usual rental is 5% of the value of the stone quarried. In Delaware and Broome counties the rental varies from ½c to 1c a foot of the product, according to the location of the quarry. This "per foot" applies to the stone as sold, that is, if the stone is sold per linear foot, the rental is ½c per linear foot; if sold per square foot, the rental is ½c per square foot. This is hard on the flagstone quarries, as the price of flag ranges from 5c to 8c a square foot, but for quarries producing edge stone, the rental is much less, as curb is sold for 16c a foot. The charge of 5% appears to be a much fairer way of renting.

In Ulster county the larger quarries are in many cases owned by the dealers, but in only a few cases are the dealers operating the quarries. They prefer to rent them on a percentage basis. They own the ledges in order to control the output of the stone.

Transportation

The stone is hauled by two, three and four horse teams to the docks or railroad switches. Only at Rock Rift and Portageville do the railroad switches run into the quarries. In Ulster county very little stone is shipped by way of the Ulster and Delaware railroad from Broadhead's Bridge to Kingston. The freight rate is higher than the cost by wagon.

The wagons in use hold from 8 to 10 tons of rock. A great proportion of these wagons are now equipped with wide tires; in fact, some towns have local legislation requiring wide tires on wagons weighing over a certain amount. The main quarry roads are often "bridged" with bluestone. "Bridging" consists of thick stone laid as a track for the wheels of a wagon. This "bridge" is 20 inches wide and 4 inches to 6 inches thick. It does not take long for wagons to wear deep ruts in the bridge.

But, if kept in repair, these bridge roads are the best for the heavy quarry wagons. The quarries on the hills and mountains have a separate road leading to each from the main roads. As a rule, these are in fearful condition, being cut to pieces by the chained wheels. The grade of these roads is very steep. A 25% grade is not an uncommon one. An extra horse is often employed for hauling the stone wagons up to the quarry.

The loading of the stone on the wagons in the quarry is done by a derrick when possible. If there is no derrick in the quarry, the loading is done by hand. If there are a number of quarries near together, the different gangs assist one another in loading.

In coming down loaded, one or both of the rear wheels are chained or a shoe is used. In addition to this, the front wheels are equipped with foot brakes. The driving of these wagons down such steep grades is attended with much danger, and many fatal accidents occur. The drivers become very skilful in the work, but at times are careless. Carelessness in chaining wheels is often the cause of the most serious accidents. After the wagons reach the main roads, few steep grades are met. The unloading of the stone at the docks or switches is done usually with hand, horse or steam power derricks. The different sizes are piled at separate points on the docks and shipped as ordered.

The cost of transportation to the docks or shipping points is borne by the quarrymen. The cost is based on the value of the load, the distance between the quarry and the dock and the condition and grade of road. The cost runs as high as 50% of the value of the load and as low as from 8 to 10%. The latter cost is for quarries favorably situated in respect to the docks. Usually a team will make three and four trips a day between the dock and quarry, at this price. Quarries are often spoken of as “ three trip ” or “ four trip ” quarries, as the case may be. Only the larger quarries have their own teams, and the hauling is often conducted as a separate business from the quarrying of the stone.

Market

The stone from the quarries is sold to the wholesale dealers, who make a business of collecting the stone and shipping it to the place of consumption. The stone is paid for by the load, or each week or month. Usually the cartage is deducted and paid directly to the teamster. Rent also is deducted from the value of each load, if the dealer owns the quarry ledge.

The stone is sold by the square and linear foot. Flagstone is always sold by the square foot, while curb and crosswalks are sold by the linear foot. What is known as "rock" (the thick large stone) is sold at so much an inch per square foot. That is, a stone 10 inches thick, 10 feet square at 2½c an inch, would sell for $25.

At one time there was a combination of the dealers along the Hudson river to control prices; but this has been broken up now, and the competition between the buyers has resulted in a rise of prices paid to the quarrymen. The largest dealers along the Hudson river have New York or Philadelphia offices, which are selling agencies. Along the Erie and Ontario and Western railroad a few dealers combine and pay an equal share of the expense of a selling agency in one of the large cities. The stone from the Hudson river is sold mostly in New York and New England cities and villages. This stone is loaded on barges, which are towed to the different cities on the seacoast. The stone from Delaware and Broome counties is sold very little in New York city, the high cost of freight and lighterage prohibiting competition with Ulster county stone. This stone is sold in New York and inland towns, such as Binghamton, Elmira, Rochester, Johnstown, Syracuse, Utica. Some of the stone from this district goes to Philadelphia.

The time available for this investigation did not permit the author to visit the quarries of Albany county, consequently the quarry descriptions are not complete for the entire state. For Albany county see Nason, N. Y. state mus. 47th an. rep't, p. 457.

QUARRIES IN GREENE AND ULSTER COUNTIES

The main points where bluestone is quarried in these counties are Quarryville, Fish Creek, Highwoods, Dutch Settlement, Palenville, West Saugerties, Woodstock, Jockey hill, West Hurley, Stony Hollow, Lapala and Mackey hill.

Beginning on the north in Greene county and following a line roughly parallel to the Hudson, the first quarries in this district are 4 miles west of Catskill, those of Lane Bros., Lane & Bloom, Lane & Hood, and Herbert Bloom.

Lane Bros. Bed of stone is 7½ feet thick, with 20 feet of rock and slate stripping. Stone is fine grained, very reedy and of good blue color. The bed is rough and dips south and west. Cross bedding is shown and some "rock" is interbedded with the stone. Lifts are 3″ to 12″ thick. Three to four men are employed nine months in the year. Product is principally curb and other edge stone, and is sold to Smith & Yeager at Catskill.

Herbert Bloom. Quarry is south of Lane Bros. and on same ledge, working only top bed of thin bedded flag 3 feet thick. One man is employed intermittently. The product is flag. and is sold to Smith & Yeager at Catskill.

William Lane & L. Hood. These work on this same ledge occasionally, and sell the product at Catskill to Smith & Yeager.

James Lane & Jacob Bloom. This quarry is situated a quarter of a mile north of Lane Bros., and is probably on the same ledge. Bed of stone is 8 to 9 feet thick, with a top of 15 feet of rock, in which shaly streaks occur. The stone is of fair quality, fine grained and of good blue color. The bed dips slightly to the south and west. Two men are employed during summer months. Product is mostly edge stone, which is sold to Smith & Yeager at Catskill.

To the south of the above are the quarries near Kiskatom and High Falls, where six openings are being worked, as follows.

Bean & Lewis, Kiskatom. Quarry is situated ¾ mile south of Kiskatom. Bed of stone is 5 feet thick with 12 to 15 feet of clay top. Stone is fine grained and full of reeds, and of very dark blue color. No danger of reeds opening when stone is split to

10″ thick. Lifts vary from 10″ to 24″ in thickness. This stone does not work well under planer, being very tough. No "head-offs" are seen in the opening. Product is mostly edge stone, which is hauled 7 miles to Malden and sold to Ulster bluestone co. Cost of cartage is 26% of value of load. Four to five men are employed during the summer months.

Dederick Bros., Kiskatom. This is a small quarry situated east of Bean & Lewis and on the ledge below their quarry. Bed of stone is 2½ feet thick with 7 to 8 feet of clay top. When this quarry was first opened, the bed was much thicker, but, as the quarrymen say, it has "pitched out." Stone is of medium sized grains and good blue color. Reeds are present but are said not to open from the weather. No head-offs are to be seen. Bed dips to the south and west. The ledge has been opened up 300 to 400 feet in a north and south direction. Lifts vary from 2″ to 10″. Product is flag and edge stone, which is sold to Smith & Yeager at West Camp. Three men are employed all the year.

Smith & Yeager, Kiskatom. Quarry is just east of Dederick Bros. and on ledge below. Bed of stone averages 10 feet in thickness with a top of 3 feet of rock, and 12 to 15 feet of clay. The stone is rather fine grained and quite dark blue. Reeds are present, and stone is split 10″ or 12″ to avoid danger of their opening. Lifts are heavy, 5 to 6 feet thick. Water is troublesome here and is handled by a "Bush" pump. The quarry is equipped with two horse power derricks and a steam drill. As no "heads" are present, the drill is used to break off blocks. The holes are drilled very close together in an east and west line. The distance between the edges of adjoining holes is about 1½″. After a row of holes has been drilled the width of the block, a new bit is set in the drill, which breaks out the connecting stone between two holes, giving a fluted appearance to the edge of each block. This is the only place in the Ulster county district where this system is used. The product is of all classes of stone, which is hauled to West Camp. This firm is a small buyer of stone from this district and has docks at Catskill and West

Camp (Smiths Landing). It employs six to eight men in the quarry the year round.

Dederick & Frieze, Kiskatom. Quarry is ¼ mile north of Smith & Yeager and on the same ledge. Bed of stone is 7 feet thick, with 8 to 10 feet of top, 3 feet being rock, the balance clay. Stone is of medium grain and very "reedy." The reeds are very likely to open on exposure. Bed dips to the south and west. Two to three men are employed the year round. Product is mostly edge stone, which is hauled to Malden and sold to the Ulster bluestone co.

Near this quarry are a number of abandoned openings which have not been worked in several years.

James Sterrett, Saxton. Quarry is situated ½ mile west of High Falls. Bed of stone is 13 feet thick, with 35 to 40 feet of alternating beds of rock and shale top. 22 feet above the top of the stone bed a lift of rather coarse grained gray sandstone occurs 2 feet thick, some of which is sold. This stratum occurs 2 miles south of this quarry in the Michigan quarries. Stone is fine grained and a good blue in color. There are no open seams in the bed. The stone is split along the reeds. The quarry is equipped with horse power derrick and siphon. No head-offs appear, but the side seams are very regular. Product is mostly edge stone, which is sold to the Ulster bluestone co. at Malden. Three or four men employed during the summer months.

Harvey Myers, Ashbury, and **Owen Devery**, Quarryville. Both work small quarries occasionally in the vicinity of High Falls.

Farther south at Quarryville is one of the most productive points of the whole Ulster county district.

Abraham Miller & Co., Quarryville. The first quarry south of Sterrett's. Quarry is situated 1 mile north of Quarryville. The bed of stone is 6 feet thick, with top of 20 to 25 feet consisting of rock and black shale. The stone is fine grained, of good blue color and quite reedy. As the lifts vary from 5″ to 6″, there is no danger of the stone "reeding" open. Few heads are present. The strata worked dip to the south and west. The quarry is equipped with hand derrick and siphon. Three men are employed throughout the year. The product is chiefly flagstone, which is sold to the Ulster bluestone co. at Malden.

Con Harvey, Quarryville. This quarry is south of the preceding. The bed of stone is 10 feet thick, with an overburden of 20 to 30 feet, 15 feet of which is rock, the balance clay. The stone is of the best blue color, fine grained and full of reeds, which will not weather open if stone is split to 20″ to 24″ thickness. No heads are found in this quarry, but the side seams are very regular, 3 to 9 feet apart.

The top part of this bed is grayer and harder than the lower lifts, which are soft and blue. All the stone, however, works well in the mill. The product is almost entirely "rock." Four to five men are employed all the year. The equipment consists of a steam pump to handle the rain water, and that issuing from springs in the quarry. Some very large stones have been taken from the quarry, one slab being 9 inches thick and 17 feet by 16 feet in area.

Alfonso Carnright, Quarryville. This quarry is on the same ledge as Harvey's and just south of it. The bed of stone is the same, but the top is 35 feet thick. The gray sandstone noted under Sterrett's quarry shows here in the top. These two quarries are known as the "Michigan" quarries. The ledge is owned by the Ulster bluestone co. of Malden, which buys all the stone. There is only one lift in the bed, but the reeds are so frequent that the stone is easily split.

These quarries were very valuable at one time and have produced a large amount of stone, but now the top is very heavy for the bed, and only skilful quarrying makes it possible to operate them profitably.

The rock is hauled 4 miles to Malden at a cost of 20% of the value of each load. The prices paid vary from 3c to 5c an inch of thickness per square foot. Carnright employs four or five men throughout the year.

South of and below the Michigan ledge is the Quarryville ledge, which has been opened for over a mile in a north and south direction. This was the great ledge of the district at one time, 350 to 400 men being employed at different points. The whole ledge is owned by the Ulster bluestone co. at Malden, to which all the stone is sold. The lifts are very thick, and the chief product is rock and edge stone. The dip of the bed is to the south and west. The water from springs and rains is concentrated at the lower end of the opening, where it is handled by steam pumps installed and operated by the Ulster bluestone co. Each quarryman is charged 5% of the value of the stone quarried, in addition to the rental, for the operation of these pumps.

The bed of stone is fine grained and of good blue color, and reedy. The top lifts are grayer and harder than the bottom lifts. The bed averages 13 to 14 feet thick, 8 feet of which are really good workable stone. The top consists of clay rock and shale of varying thickness, the average being 20 feet. The lifts vary from 6 inches to 6 feet in thickness. The top lifts are worked into edge stone, the lower lifts being sold as rock.

Each firm has either a hand or horse power derrick. Some of the derricks are not owned by the firms, who pay a rental for their use of 5% of the value of the stone produced. 18% of the load value is charged for cartage to Malden.

The different firms working the ledge from north to south and the men employed are given. All are of Quarryville.

Rightmeyer, Bovee & Craft. Three men the year round.

K. Foley. Four men 10 months in the year.

John O'Rourke. Four men nine months in the year.

Hollenbeck & Miller. Four men in summer and two men in winter.

Mack & Kraft. Four men in summer and two men in winter.

C. E. Cook. Three to four men nine months in the year.

Cook & Schoonmaker. Four to five men nine months in the year.

Just east of the main Quarryville ledge and below it another ledge has been opened.

Michael O'Rourke, Quarryville. This is the first ledge west of the Hudson river that has been opened. The bed of stone is 7 feet thick, with 2 feet of rock, 7½ feet of shale and 2 to 3 feet of clay top. Stone is of fairly good blue color, fine grained and reedy. The lifts vary from 2 to 3 feet, and are split to 6″ or 7″ for safety. Three to four men are employed steadily. The ledge is owned by Joseph Maxwell of Saugerties, to whom the stone is sold. The product is chiefly curb and flagstone. The quarry is equipped with a hand pump for disposing of water.

Just above the west of the main ledge at Quarryville two other ledges have been opened.

Van Steenburg & O'Connor, Quarryville, are working the first ledge above. The bed is 6 to 7 feet thick, with 15 to 20 feet of rock top. The quarry is an old one and is badly blocked up with rubbish. The stone is of fair quality and color. The quarry is equipped with hand derrick. Two men are employed part of the year.

Cunningham & Schoonmaker, Quarryville, are working on the next ledge above. The bed, which is a mixture of rock and stone (the larger portion being rock) is 12 feet thick and has a top of 5 feet of rock and clay. The stone is much darker blue than that from the main ledge, and of finer grain. The lifts vary from 2″ to 4″. The product, entirely flag, is sold to T. J. Dunn & Co. at Malden. Two men are employed. The quarry is equipped with hand derrick and siphon.

Between Quarryville and Veteran postoffice there are a few small quarries.

Lawrence Hummel, Quarryville. Quarry is situated ½ mile west of Mt Airy. The bed of stone is 4 to 5 feet thick, with 8 to 10 feet of top of rock and clay. The stone is of medium grain and very dark blue color, and quite reedy. The lifts vary from 6″ to 8″ in thickness. The bed dips more sharply than usual to the west and south. Product is chiefly flag, which is sold to T. J. Dunn & Co. at Malden.

Carty & Rourke, Veteran postoffice. Quarry situated ¾ mile north of Veteran or Unionville. The bed of stone is 7 to 8 feet thick, with 8 to 10 feet of clay and rubbish top. The stone is of a good blue and varies in grain from top to bottom. The top lifts are of coarser grain, and harder than the bottom lifts. A rough streak 1 to 2 feet thick occurs in the center of the bed. The stone is reedy and is split to 10″ to 16″ for safety. No head-offs are to be seen, but the side seams are straight and regular 3 to 9 feet apart. The product is principally edge stone, which is sold to Hudson river bluestone co. at Saugerties. The quarry is equipped with horse power derrick and siphon. Three to four men are employed all the year.

Brink & Jones, Veteran postoffice. A very small and poor quarry on ledge above Carty & Rourke's. The bed is very rough and 3 to 4 feet thick. The stone is fine grained and good blue in color. Two men are employed, not regularly.

Martin Dunn, Veteran postoffice. This is an old quarry on ledge above Carty & Rourke's and is badly blocked up with rubbish. The bed of stone is very rough and 5 to 6 feet thick, with 7 to 8 feet of rock top. It is fine grained and of good blue color. The lifts are 6″ to 8″ thick. The product is sold to James Maxwell at Saugerties. Two men employed, intermittently.

From Veteran postoffice south through Fish Creek and Highwoods is another very productive territory. But the industry has decreased in late years, specially at Fish Creek, where the surrounding hills are covered with old rubbish heaps. At Veteran postoffice there are numerous openings, but only a few quarries are being worked now.

Wyman Spring & Flynn, Veteran postoffice. Quarry situated ½ mile west of Veteran postoffice. The bed of stone is 4 to 5 feet thick, with top of 10 to 12 feet of rock. The bed dips more sharply than usual to the south and west. The stone is fine grained, of good blue color, and some reeds are present. The side seams and heads are quite regular. Streaks of shale appear in the bed. Three men are employed throughout the year. The product is sold to the Ulster bluestone co. at Malden.

Flanagan & Connors, Veteran postoffice. This firm is working on the same ledge as Wyman & Co., and just east of them. The bed is only 2½ feet thick, with the same amount of top. The dip is in the same direction as that in the preceding quarry, though more gentle. The stone is of a lighter shade of blue. Two men are employed throughout the year. The product is sold to James Maxwell at Saugerties.

Along the road from Veteran postoffice, running south through Fish Creek and Highwoods are numerous quarries. Just south of Veteran is the following quarry.

William Hayen, Veteran postoffice. The bed of stone is 10 to 12 feet thick, with 10 to 12 feet of top, which is mostly shale. Bed dips as usual to the south and west, and the bedding planes are irregular. The stone is fine grained, of good blue color and reedy. The rifts vary from 20″ to 24″, which are split into curb. Two men are employed throughout the year. The product is sold to James Maxwell at Saugerties, who owns the ledge.

Eygo Bros. & Cronin, Veteran postoffice. This firm works on same ledge as Hayen. This ledge has been opened about ¼ mile in a north and south direction. Three men employed throughout the year.

John Ferguson, Veteran postoffice. This quarry is just east of Hayen's and on the ledge above. It is being worked toward the east and against the dip. This is unusual, nearly all the quarries being worked from the east toward the west. The bed of stone is 5 to 6 feet thick, with 10 feet of shale top. The stone is fine grained, of good blue color and reedy. The lifts vary from 24″ to 30″. The head-offs are not very prominent and the side seams are somewhat irregular. The product is principally curb, which is sold to James Maxwell at Saugerties, who owns the ledge. Three to four men are employed during the year. This ledge has been extensively worked, but the top is becoming too heavy for the bed.

John Cusick, Veteran postoffice. Quarry is on same ledge as Ferguson, but just north. The top is somewhat thicker, being nearly 60 feet of shale. There is a curious streak in the shale, in which large round boulders are bedded. Two to three men are employed.

Brennan Bros. & Ledwith, Veteran postoffice. This quarry is situated ¾ mile south of Veteran and is in the vicinity of numerous abandoned openings. The bed of stone is 4 to 5 feet thick, with a rock top of 10 to 12 feet. The stone is of medium grain, good color and some reeds are present. The lifts vary from 5″ to 8″ in thickness. The bed dips more sharply than usual to the southwest. The product is principally curb, which is sold to the Ulster bluestone co. Three men are employed throughout the year.

Daniel J. Burke, Veteran postoffice. Quarry situated south of Brennan's. The bed of stone is 4 feet thick, with 5 to 6 feet of rock top. The stone is of fair blue color, fine grained and somewhat harder than is usual in this vicinity. The quarry is said to work "hard." The side seams are very regular and the joints are loose. Lifts vary from 4″ to 20″. The product is edge stone, which is sold to the Hudson river bluestone co. at Saugerties. Four to five men are employed throughout the year. The cost of cartage in this vicinity is based on the number of feet of stone in each load.

T. H. Lockwood, Saugerties. The quarry is situated just north of Fish Creek. The bed of stone is 11 feet thick, with a top of 10 to 15 feet. The stone is of good blue color, fine grained and reedy. The lifts vary from 6″ to 10″, and are split into curb, the principal product. The bed dips south and west. Some blasting is done in the quarry bed, as the heads are absent. The side seams are quite regular and tight. Quarry is equipped with hand derrick. Four to five men are employed during the year. The product is sold to James Maxwell at Saugerties.

Southeast of Fish Creek on Cockburn hill a number of quarries are in operation. One long ledge has been opened on the southern side of the hill, and with two exceptions all the firms are quarrying on this ledge. The ledge has the usual south and west dip, so the drainage is natural toward the lowest and western quarry. The bed of stone averages 7 feet in thickness, is fine grained, of good blue color and quite reedy. Where the ledge has been worked back any great distance, the lifts are heavy, but are easily split along the reeds. Heads are not present as a rule, but the side seams are quite regular.

The ledges are owned by James Maxwell of Saugerties, who buys the output. The top lifts are usually harder than the lower ones.

The following are the operators.

Daniel Darrigan, Saugerties. Bed of stone is 4 to 5 feet thick, with 12 to 15 feet of rock top. Bed dips to the south and west gently. Stone is of medium grain, good blue color, but very reedy. The lifts vary from 4″ to 8″ in thickness. Both systems of vertical joints are present. The product includes all varieties of marketable stone. Five to six men are employed.

Lahert Bros., Highwoods. Bed of stone 6 feet thick, with 9 feet of top, 1 foot of which is rock, the balance being clay containing boulders. Stone is light blue, fine grained and reedy. Lifts are quite heavy, being as thick as 4 feet. Bed dips gently to the southwest. The product is mainly curb. Four men are employed during the year.

Daniel Darrigan, Veteran. Quarry on the same ledge as that of Lahert Bros. One man employed during the year.

Mrs John Darrigan, Highwoods. The bed of stone here is 8 feet thick, with 20 feet of clay and rock top. The stone is a darker shade of blue than that in Laherts' opening. A shale streak also appears in the bed here. The product includes all varieties. Four to five men are employed during the year. The quarry is equipped with a hand derrick.

Richard Lannigan, Highwoods. The bed is the same in thickness and quality of stone as at Darrigan's, but the top is somewhat different, consisting of 3 to 4 feet of clay, 4 feet of shale and 3 feet of rock. The top lifts of this bed are hard, while the lower lifts are softer. No heads are present. The product is chiefly edge stone. Four men are employed throughout the year. A hand derrick is in use.

William Scott, Highwoods. The bed here is not quite so thick, about 7 feet, with 10 or 12 feet of top, mostly shale. The quality of stone is the same. Four men are employed during the year.

James Darrigan, Veteran postoffice. Three men are employed at this quarry, which is close to Scott's, and resembles that quarry in the quality of bed and thickness.

Whittaker & Manterstuck, Veteran postoffice. This is on the same ledge as the preceding, but on the northern side of the hill. The bed is 7 to 8 feet thick, with only a clay top of 3 feet. The quality of stone is the same as in the other quarries. On account of the dip and the direction of working, water is somewhat troublesome. The lifts are 8″ to 10″ thick.

On ledges above the main ledge are numerous abandoned workings, a few of which are being reopened.

John Skchill, Veteran postoffice. The bed of stone is 4 to 5 feet thick, with 10 feet of rock and clay top. A shaly streak is present in the bed. Only one man is employed, eight months in the year.

Lasher Bros., Veteran postoffice. This quarry is on a ledge higher than Skchill's and was abandoned at one time. The bed is 4 feet thick, with 20 feet of rock top. The stone is of good blue color, fine grained and reedy. Heads and side seams are present, and the dip is to the south and west. Two men are employed.

South of Cockburn hill is the Highwoods district. Three different ledges are being worked. On the lowest and most eastern seven firms are quarrying. All the ledges are being worked to the west with the dip. On account of this, water is troublesome in places. The bed of stone averages 12 feet in thickness. The bedding is rather uneven in spots, which causes a great deal of waste. The stone is fine grained, of good blue color and reedy throughout the ledge. The ledge has been worked for a number of years, and the lifts are heavy as a rule. The side seams are quite regular and smooth, but the heads are few and far apart. The top is chiefly shale or pencil. Some shaly streaks appear in the bed. The dip is to the south and west. Blasting is sometimes necessary in getting out the stone.

The following are the operators.

Vedder & Hackett, Highwoods. The bed here is rough and several pencil or shale streaks appear. Four men are employed. The equipment consists of a steam boiler, pulsometer pump and horse power derrick. The product is sold to the Ulster bluestone co. at Glasco.

Richard Rind, Highwoods. Works intermittently, just south of Vedder & Hackett.

Kelly & Hackett, Highwoods. The bed here is 12 feet thick, with 10 feet of shale and clay top. The top 3 feet of bed are hard, while the bottom 9 feet are softer, but do not split so well. The product is mainly curb, which is sold to James Maxwell at Glasco. Four men are employed. The equipment consists of steam boiler, centrifugal pump and steam drill, which has not been used in the quarry as yet.

Thomas Rafferty, Highwoods. The bed is rather rough here. Two men are employed during the year. Edge stone forms the product, which is sold to James Maxwell at Glasco.

Riley Bros., Cockburn. Only 4 feet of the bed are being worked here, owing to rough streaks in lower lifts. The shale top is 15 feet thick. The product is chiefly curb, which is hauled to Glasco and sold to James Maxwell.

William Lannigan, Highwoods. The bed is 14 feet thick, with 12 to 25 feet of shale top. The lifts vary from 14 inches to 4 feet. The product is sold to T. J. Dunn & Co. at Malden. Eight to nine men are employed throughout the year. The quarry is equipped with horse power derrick and pump.

Daniel Rafferty, Cockburn. Works on this same ledge intermittently.

Two quarries are worked on the ledge to the west and the above described ledge. The bed is 11 feet thick, with the shale top 15 to 20 feet thick. Rough streaks occur in the bed occasionally. The stone is fine grained, reedy and of a good blue color, and is easily worked. The lifts vary from 6 inches to 3 feet. The side seams are smooth and regular, 3 to 10 feet apart. Water is troublesome in a wet season. The product from the two quarries is chiefly curbstone and is sold to Thomas J. Dunn & Co. at Malden. The following are the operators.

Lawrence Kenney, Kingston. Employs eight to nine men throughout the year. The equipment of the quarry consists of horse power derrick and pump.

Levi Carle, Cockburn. Two men are employed during the year. A hand derrick is the equipment.

The next ledge to the west is known as "High bank." Only four quarries are in active operation, though this ledge and the one below it have been extensively opened for some distance. The bed of stone averages 6 feet thick, with various thicknesses and kinds of top. The stone is fine grained, of dark blue color, and with numerous reeds. Side seams and heads are both present at varying distances apart. The dip of the bed is the same as that of the other ledges south and west. The bed has rough streaks through it and cross bedding is seen. Stone and rock are interbedded in spots. The lifts vary from 6 inches to 3 feet. The top and bottom lifts are hard, while the middle of the bed is softer. The product includes all the varieties of marketable stone and is sold to James Maxwell at Glasco.

The following are the operators.

Conlon Bros., Cockburn. Six to eight men are employed throughout the year. A siphon handles all the water.

Hackett & McCormick, Highwoods. Four to five men are employed throughout the year.

Hackett Bros., Cockburn. Three men are employed throughout the year.

Jake Connor, Highwoods. One man works intermittently at this southern end of the opening.

Three quarters of a mile west of the "High bank" ledge a number of quarries have been opened. It is not possible to say whether these quarries are on the same ledge, as there is no continuous opening.

Carle & York, Highwoods. This quarry is situated 1½ miles southwest of Highwoods and more men are employed than in any other quarry in Ulster county. The quarry has not been opened on the outcrop of the ledge, which is the usual rule. The opening is in the shape of a rectangular pit in the middle of a level field. The ledge is worked on three sides of the pit, the perimeter of the face being 425 feet. The dip of the bed is gentle and to the west mainly. The water collects in the western end, and is pumped out by a rotary pump driven by steam. The top is hardpan 3 to 4 feet thick and is troublesome to strip. It is blown off as much as possible with powder, the balance being handled by shovels and barrows. The bed varies in thickness, varying from 3 to 8 feet, averaging 6 feet. Stone and rock are interbedded throughout the whole bed. The stone is fine grained and of good blue. The top lifts are harder than the lower ones. It is excellent stone for mill work. Side seams are regular and smooth and are from 1 foot to 8 feet apart. No heads are present. The product is sold to the Ulster bluestone co. at Glasco and to the Hudson river bluestone co. at Saugerties. Fifteen men are employed 10 months in the year. $8000 is the value of the product for the season. Quarry is equipped with horse power derrick.

James Van Aken, Highwoods. Quarry is north of Carle & York's. The bed of stone averages 12 feet in thickness, with 7 feet of clay and 5 feet of shale top. The stone is fine grained, of good blue color, reedy and compact. The lifts vary from 6″ to 14″. The reeds in the stone are said to be very tight. Water is troublesome and is handled by a steam-driven rotary pump. Powder is used in quarrying the stone, as well as the top, owing to the absence of heads. The side seams are regular and smooth and 10 to 25 feet apart. Five men are employed during the year. The product of various kinds is sent to James Maxwell at Glasco and Saugerties.

Nelson Felton, Highwoods. This quarry is ½ mile north of Van Aken's. The bed of stone averages 7 feet, with 8 to 10 feet of shale top. A number of slaty seams appear in the bed, which is rather rough. The stone is fine grained, of good blue color and reedy. The lifts vary from 4″ to 12″. The bed pitches to the south and west gently. The side seams vary from 1 foot to 4 feet apart. No heads are present. The product of edge stone is sold to Hudson river bluestone co. at Saugerties. The equipment of the quarry includes steam-driven rotary pump and horse power derrick. Seven to eight men are employed throughout the year.

Van Bramer Bros., Highwoods. This quarry is northwest of Felton's. Bed is 8 to 9 feet thick, 6 feet of which are workable stone, the balance being rubbish interbedded with the stone.

There is not much variation in the quality of the bed. The top is of hardpan 5 feet thick. The stone is a good blue in color, fine grained and reedy. The lifts vary from 8 inches to 3 feet. The product consists chiefly of edge stone, which is sold to James Maxwell at Glasco. Four men are employed during the year. A hand derrick is the only equipment.

William Doyle, Highwoods. One man works on same ledge as Van Bramer intermittently.

Benjamin Meyers, Highwoods. Quarry situated north of Van Bramer. Bed is 5 to 6 feet thick with 7 to 10 feet of rock top. The stone is fine grained, reedy and dark blue. The bed has the usual dip to the southwest. The lifts vary from 2″ to 12″. No heads are present. The product includes all varieties and is sold to James Maxwell at Glasco. Three to four men are employed during the year. The equipment consists of a siphon and hand derrick.

Carle Bros., Cockburn. Bed of stone varies from 2 to 3½ feet in thickness. The top consists of rock and clay 5 feet thick. The stone is fine grained, reedy and of good blue color. The lifts vary from 2″ to 6″. No heads are present and the side seams are variable. The bed dips to the south and west. The product of flag and curb is sold to the Ulster bluestone co. at Glasco. Three to four men are employed.

Wesley Greene, Highwoods. This quarry was stripped of the upper bed and abandoned for 25 years. A lower bed of 2 feet is now being quarried. The top consists chiefly of rubbish from the old bed 3 to 8 feet thick. The stone is fine grained, of good blue color. The product is curb and flag, which is sold to James Maxwell at Glasco and to Ulster bluestone co. at Saugerties. Two to three men are employed nine months in the year. A hand derrick is in use.

James Depuy, Highwoods. Quarry situated 1 mile southwest of Fish Creek. The bed of stone is 4 feet thick, with rough streaks through it, and is about exhausted. Top consists of shale 2 feet thick. The stone is fine grained, of good blue color, and reedy. The lifts vary from 5″ to 6″. Curb and flag are the principal products, which are sold to Ulster bluestone co. at Saugerties. Three men are employed during the year.

Charles Green, Highwoods. Quarry situated near Highwoods postoffice. The bed of stone is 6 to 8 feet thick and is badly shattered in places. The top varies from 2 to 15 feet of rock and streaks of shale. The bed dips to the southwest. The stone is fine grained, of good blue color, and somewhat reedy. The quarry is being worked toward the east. The lifts vary from 3″ to 12″. The side seams are 2 to 12 feet apart. Product is sold to Ulster bluestone co. at Malden. The equipment consists of horse power derrick and siphon. Four men are employed during the year.

South of the Highwoods district are the quarries near Dutch Settlement. Here, as at other points, the industry has declined of late years. The description of the quarries follows.

John Vederkill, Ruby. Bed of stone 4 feet thick with 6 feet of stripping, of which 5 feet are clay, balance rock. The stone is of fair quality as to color and grain. The lifts are quite heavy. The bed here dips to the north and west. Product is chiefly curb and other edge stone. The product is sold to Ulster bluestone co. Four to five men are employed nine months in the year.

Henry Hart, Ruby. The bed of stone is 2 feet thick with 1 foot of soil top and 2 of rock. The stone is of fair quality regarding color and grain. The lifts are light, flag being the main product. The joints are irregular and tight. Only one man is employed. The stone is sold to James Maxwell at Glasco.

J. A. Longendyke, Ruby. This quarry is near Hart's and on the same ledge. The lifts are somewhat heavier, the product being edge stone. Three men are employed during the year. The product is sold to James Maxwell at Glasco. The quarry is equipped with siphon to drain the water.

Conrad Young, Ruby. The bed of stone is 4 feet with a top rock of 2 feet. The stone is rather fine grained and good blue in color. The bed dips south and west. Some reeds are found in the stone. The product is of all varieties and is sold at

Glasco to James Maxwell. Three men are employed throughout the year.

Charles Steifle, Ruby. Bed of stone is 5 feet thick with 6 feet of rock top. The stone is of good quality. The quarry is the best in the district. The lifts vary from 2″ to 6″. The bed dips to the south and west. Product includes all varieties, and is sold to James Maxwell at Glasco. Four men are employed during the year.

J. Gaddis & Son, Ruby. This quarry is on ledge above Steifle's and is very small. The bed is 3 feet thick, with 5 feet of rock top. The product is sold to James Maxwell at Glasco. Two men are employed.

Jake Stice, Ruby. The bed of stone is 5 feet thick with 10 feet of rock top. The product of flag is of good quality. Lifts are light and easily raised from the bed. The bed of stone rests on pencil. The face of the quarry extends north and south 75 feet. The bed dips to the south and west at a gentle angle. Product is bought by Ulster bluestone co. at Glasco. Three men are employed eight months in the year.

Van Hoevenburg & Nuger, Ruby. The bed of stone is 10 feet thick with 15 feet of rock top. The dip of the bed is to the south and west. The quality of the stone is very fair. All varieties are produced and sold to James Maxwell at Glasco. Three men are employed during the year.

McDonald & Lahey, Ruby. The bed of stone is 4 feet thick with 12 feet of rock top stripping above. The stone is fine grained, of good blue color and somewhat reedy. The bed pitches to the north and west gently. The product including all varieties is sold to James Maxwell at Glasco. Two men are employed.

Hart & Burns, Ruby. The quarry is on the same ledge as McDonald & Lahey's. The bed varies from 5 feet to 7 feet in thickness here, with 5 feet of rock stripping. The water from both quarries collects here and is drained by a pipe. The quality of the stone is the same. The product, chiefly flag, is sold to James Maxwell at Glasco. Three men are employed.

Scheffel & Krell, Ruby. The bed of stone is 8 feet thick, with 15 feet of rock stripping. The stone is of good color and quality. The lifts are quite heavy, producing chiefly edge stone. Water is troublesome and a siphon is in use. The product is sold to James Maxwell at Glasco. Two to four men are employed.

Constance Halbleib, Ruby. The bed of stone is 8 feet thick, with a rock top of 30 feet. The ledge has been worked for 400 yards and was very productive at one time. The stone is of good quality as to color and grain. The lifts are heavy but reedy. The product consists of edge stone, which is sold to Ulster bluestone co. at Glasco. Three men are employed six months in the year.

Sheehan Bros., Ruby. The bed of stone is 8 feet thick, with 25 feet of rock top. The stone is of medium fine grain, good color and reedy. The lifts are quite heavy, ledge stone being produced principally. The product is sold to Ulster bluestone co. at Glasco. Two men are employed throughout the year.

Lannigan Bros., Cockburn postoffice. The bed of stone is 5 feet thick with 10 feet of rock stripping. The stone is fine grained, reedy, and of good blue color. The lifts vary in thickness from 2″ to 6″. All varieties of salable stone are produced, and sold to James Maxwell at Glasco. The quarry is equipped with derrick and horse power pump. Four men are employed during the year.

South from Dutch Settlement are the quarries on Hallihan hill. These are nearly exhausted now, though some are worked intermittently. The only permanent operator is

Chris. McGuire, Katrine. The bed of stone is 4½ feet thick, with 14 to 15 feet of rock top. The stone is of good quality and works fairly well. The product of all varieties is sold to James Maxwell at Glasco. Two to three men are employed intermittently.

Along Sawkill creek a number of quarries have been opened, but only four are in active operation.

Plate 3

To face p. 35

H. T. Dickinson, photo.

View of waste weir of Kingston reservoir no. 1, in Sawkill valley, Ulster co. N. Y. looking west, showing ledges of bluestone

T. McDonald, Sawkill. Quarry is situated 250 feet above the bed of Sawkill creek on the north side. The bed of stone is 6 feet thick, with 10 feet of rock top. The stone is of excellent quality as to color and grain. Some powder is used in blasting out the bed, owing to the tight joints. The product, edge stone and rock, is sold to Hewitt Boice at Kingston, who owns the ledge. Six to seven men are employed.

John McCaffery & Co., Sawkill. This quarry is situated in the bed of the creek on the north side. A flume has been put in for keeping the creek waters out of the quarry, which is being worked below the level of the creek. The bed of stone is 10 feet thick, with 12 feet of rock stripping. The bed is somewhat thicker than 10 feet, but is not worked. The stone is of medium grain, of good blue color and reedy. The vertical jointing is all north and south. All varieties of commercial stone are produced, and sold to Hewitt Boice at Kingston. A horse power derrick is in use. Four to five men are employed throughout the year.

W. McCaffery, Sawkill. The quarry is on ledge overlying McCaffery & Co.'s quarry. The bed of stone is 4 feet thick, with rock top of 6 feet. The stone is of the same quality as usual along the Sawkill. Julius Osterhoudt owns the ledge and buys all the stone quarried. One man and one boy employed during the year.

South of the Sawkill is the Jockey hill district. One ledge has been opened for nearly a mile in length, and a number of firms are quarrying stone from it. Two more ledges above the main one have been opened and are being worked on a small scale. This hill was once very productive, but, as in other places in Ulster county, the industry has declined. Old rubbish heaps are to be seen on every part of the hill.

The main ledge averages 8 feet of stone, which is medium grained, grayish blue and somewhat reedy. The stripping is of rock 5 to 6 feet and clay 4 to 12 feet. The ledge is owned by Julius Osterhoudt and Hewitt Boice, to whom the stone is sold at Wilbur and Kingston. The price of cartage here is based on the number of feet of stone per load. 1c an inch of thickness per square foot of surface is paid for hauling "rock" to market. 6c a linear foot is paid for curbing.

The dip of the ledge is to the north and west. The opening extends north and south, so that the quarries at the northern end receive the water from the other quarries. Owing to different depths of the different workings, water is troublesome in nearly all the quarries. The water is drained by siphons of 2″ cast iron pipes, equipped with a small hand pump at the apex; 10 to 15 feet is the usual fall allowed. These siphons, when the pipe is well jointed, are very efficient, removing a large amount of water in a short time.

The thickness of the lifts varies from the top to the bottom, the top lifts are light, 2″ to 3″, while the lower ones are heavier, 6″ to 10″. Obviously, the top lifts produce flag, and the lower lifts edge stone and rock. Many of the quarries are equipped with a hand derrick for handling the heavy stones. A rough streak appears in some parts of the ledge 2 feet thick and causes some waste. The vertical jointing is north and south, and east and west. Owing to the tightness of these joints, powder is often necessary in the lower lifts.

The following are the operators.

James Howard, Sawkill. Two men employed during the year.

John Murphy, Sawkill. Three men are employed during the year. A siphon is used for drainage.

Thomas Hayes, Sawkill. Five men are employed throughout the year.

Burns Bros., Sawkill. Four men are employed. A hand derrick is in use.

T. McDonald, Sawkill. Ten men are employed throughout the year. The equipment consists of siphon and hand derrick.

B. C. Callahan, Sawkill. Three men are employed.

W. Sheely, Kingston. This quarry used to employ 10 men, but only two are at work now. Water is very troublesome and two siphons are in operation. A hand derrick is also part of the equipment.

Plate 4

To face p. 36

H. T. Dickinson, photo.

Bluestone quarry of T. McDonald in bed of Sawkill creek showing sluiceway for water in creek, looking northwest

Plate 5

To face p. 37

H. T. Dickinson, photo.

Bluestone quarry of Tom Gad on Jockey hill, Ulster co. N. Y. looking northeast, showing bed of stone and pencil (slate) stripping

William Charlton, Sawkill. Two men employed the year round. Quarry equipped with siphon.

W. F. Watson, Sawkill. Two men employed. A siphon is in use.

Sheehan Bros., Sawkill. This quarry is on ledge above the main Jockey hill ledge and is only opened here. The bed of stone is of rather poor quality and only 4 feet thick. The stripping amounts to from 15 to 18 feet of clay and rock. The ledge is owned by Hewitt Boice, who buys the output at Kingston. Two men are employed.

Tom Gad, West Hurley. Quarry is situated on Morey hill just west of Jockey hill. The bed of stone is 10 feet thick with 20 feet of shale stripping. The face of opened ledge is 250 feet long in a north and south direction. The stone is medium grained and of good blue color. Reeds are present. The side seams are regular and smooth. The product is almost entirely edge stone, which is sold to different buyers in Kingston. Eight men are employed in the quarry.

Mrs J. McRieff, West Hurley. Quarry on same ledge as Gad's, but located on opposite side of the hill. The quality and thickness of bed is the same, but the stripping is 30 feet of shale. The product is sold to Hewitt Boice at Kingston. Two men are employed.

Following this line of quarries south from Jockey Hill, it turns westward in a direction parallel to the Rondout creek through the following quarry districts: Stony Hollow and West Hurley, Morgan hill, Lapala, Atwood, Vly, Scarawan and Mackey hill. The quarries will be described in order.

At Stony Hollow and West Hurley the same conditions hold as in many others of the districts in Ulster county, viz. the beds have been worked out as the stripping has become too heavy for profitable operation.

Owen Grant, West Hurley. Quarry is at Stony Hollow. Bed of stone is 10 feet thick, with an equal amount of stripping of rock. The stone is of excellent quality for curb and cross walks. It is not suitable for building purposes, as small round spots in the stone stain badly when exposed to the weather. The lifts vary from 4″ to 8″ in thickness. Side seams and heads are both present. The quarry is equipped with horse power pump and two dump carts. The product is hauled to Wilbur and sold to various dealers at Wilbur. Twelve men are employed.

Doyle & Co., West Hurley. The bed of stone is 10 feet thick with 15 to 18 feet of stripping. The stone is fine grained, blue-colored and reedy. The ledge has been opened 100 feet in a north and south direction. The vertical joints are well developed. The product is sold to various dealers at Wilbur. Six men are employed.

T. J. Conroy, West Hurley. The bed of stone is 10 feet thick, with 25 to 28 feet of rock and shale top; the lifts vary from 4″ to 8″; and the stone is very dark blue and fine grained. The systems of vertical joints are well developed. The length of face is 75 feet. The product is sold to the Hudson river bluestone co. at Wilbur. Three men are employed.

James Devine, West Hurley. Bed of stone 12 feet thick, with 20 feet of rock top. The stone is dark blue and fine grained. Reeds are present. The lifts vary from 4″ to 10″ in thickness. The vertical joints are quite tight, and powder is used in blasting out the heavier lifts. The product is sold to the Hudson river bluestone co. at Wilbur. Four men are employed.

John Purcell, West Hurley. Bed of stone is 10 feet thick, with a 10 foot thickness of rock overburden. The stone is dark blue and rather fine grained. The lifts are heavy and are split along the reeds. The vertical joints are tight and powder is used in getting out bottom lifts. The product, chiefly edge stone, is sold to the Hudson river bluestone co. at Wilbur. Three men are employed the year round.

McConnell & Charleton Co., West Hurley. This is a very small quarry with 4 feet of bed and 5 feet of rock top. Face is 50 feet long in a north and south direction. The stone is of the average quality of this district. The product is sold to the Hudson river bluestone co. at Wilbur. Two men only are employed.

Plate 6

To face p. 38

H. T. Dickinson, photo.

Bluestone quarry of Owen Grant near Stony Hollow, Ulster co. looking north

Lamb Bros., West Hurley. This is another small quarry with only 3 feet of bed, with 7 feet of stripping. The stone is not as good a blue as is usual in the district, and only small sizes of stone are produced. The quarry is equipped with a siphon. The product is sold to Hewitt Boice, Kingston. Two men are employed.

James O'Neill, West Hurley. The quarry is situated ½ mile southwest of West Hurley. The bed of stone is 8 feet thick, with an average thickness of stripping of 10 feet. The lifts vary from 4″ to 20″. The stone is fine grained and of good blue color. The two systems of vertical jointing are present. The bed dips to the south and west. Some blasting is necessary in quarrying some of the heavier lifts. The Knox system is used. The water is drained by a ditch and horse power pump. The length of face in a north and south direction is 350 feet. The output includes all varieties of marketable stone, and is hauled by wagon to Hewitt Boice at Kingston. O'Neill does his own hauling, and at 70c a ton a profit is made. Ten men are employed 10 months in the year. $6000 is the value of the product per year.

Martin Lane, West Hurley. This is an old abandoned quarry opened up this year. The face is 75 feet long, in a north and south direction. The bed of stone is 7 feet thick with 10 feet of shale and rock top. The stone is of fair quality and quite reedy. The lifts vary from 4″ to 20″ and can be split to almost any thickness. The bed dips to the south and west. The output is sold to various dealers at Wilbur, where it is hauled by wagon. A siphon is in use. Three men are employed.

South of West Hurley and Stony Hollow is the Morgan hill and Hurley woods district. The quarries are nearly all abandoned now, only a few men quarrying regularly. Quarrying and farming are carried on together.

Dunn Bros., Hurley. The bed of stone is 4 to 5 feet thick, with 15 to 18 feet of rock stripping. The stone is of medium grain, of good blue color, and reedy. The lifts vary from 4″ to 8″.

The side seams and heads are well developed. The dip of the bed is to the southwest. The quarry is worked on a very small scale with two men. The product is hauled to Wilbur and Kingston.

Toole Bros., West Hurley. The bed is 4½ feet thick and rather rough. The stripping of rock averages 12 feet. The stone is of medium grain and good blue color. The lifts vary from 4″ to 12″ and are split into various thicknesses along the reeds. This quarry has been extensively worked, but, as the quarrymen say, "the rock has dipped down into the stone." The product of chiefly edge stone is sold to Hudson river bluestone co. at Wilbur. Three men are employed.

The other quarrymen working at various localities in this district are:

Thomas F. Scully, Hurley.

Fred Krantz, Hurley.

Frank McMullen, West Hurley.

In the Lapala and Roseville districts the following quarrymen are working.

Winchell Bros., Lomontville. The bed of stone is 4 feet thick, with 8 to 10 feet of stripping of rock and clay. The stone is of medium fine grain and fair blue color. The lifts vary from 4″ to 5″ and are worked mostly into edge stone. The vertical joint systems are as usual. The dip of the bed is to the north and west. Product is sold to Hewitt Boice at Kingston. A siphon is in use. Three men are employed during the year.

A. De Graff, Hurley. The bed of stone varies from 2 to 6 feet in thickness, with 14 to 18 feet of shale and rock stripping. The stone is of good color and grain, but some rough streaks in the bed make a great deal of waste. The dip of the bed is to the northwest. The quarry is equipped with hand pump. Stone is sold to different dealers on the Hudson. Product, flag and edge stone. Two men are employed.

Clearwater, Conner & Hotaling, Hurley. This quarry is on same ledge as De Graff's, and the thickness of bed and stone is the same. Different dealers buy the stone. Three men are employed.

Thomas Sampson, Hurley. The bed of stone is only 2 feet thick, but has a light top of 4 feet. The quarry is in the bed of Stony creek. The lifts are 4″ to 6″ thick, producing chiefly edge stone. The grain is fine and the color good. The stone is sold to Julius Osterhoudt at Wilbur. Four men are employed through the year.

W. H. Miller, Lomontville. This quarry is situated on what is known as the Irving ledge, which has been opened for 800 yards in a north and south direction. The bed ranges in thickness from 2 to 6 feet with a top of varying hight. The stone is fine grained, of good blue color, and reedy. The ledge is known for the great amount of large "rock" produced. This is the main product today. The vertical joints are very much stained with iron. The stone is sold to Hewitt Boice and the Hudson river bluestone co. Miller employs three men. Water drained by a siphon.

The following also quarry on this ledge:

Ennis & Jones, Lomontville. Two men employed.

John Clearwater, Hurley. Two men employed.

J. Scriver, Hurley. Three men employed.

William Gooches, Lomontville. Two men employed.

William R. Brodhead, Hurley. The bed of stone averages 6 feet, with stripping of clay, shale and rock of 14 feet. The stone is of the average quality of the district. The lifts vary from 2″ to 8″, and all varieties of stone are produced. A hand pump is used for draining the water. The output is sold to Hewitt Boice at Kingston. Three men are employed.

John J. Sampson, Hurley. The bed of stone is 4 to 5 feet thick, with a rock streak 2 feet thick dividing the bed. The stripping amounts to 9 feet of rock and clay; the latter is 1 foot thick. The product is of all varieties and is of the usual grade of this district. Hewitt Boice at Kingston is the buyer. Three men are employed.

Winchell Bros., Hurley. The bed of stone is 8 feet thick, with a top of shale 25 to 30 feet thick. The stone is fine grained, of good blue color, and reedy. The bed dips to the southwest gently. The ledge has been opened up 200 feet along the side seams. The lifts are heavy, 6″ to 9″, and the product is principally rock. Hewitt Boice owns the ledge and buys all the product. Four men are employed.

Cornelius Goebel, Lomontville. The bed of stone is 6 feet thick, with 12 to 14 feet of rock top. Some stone is taken out of the top rock, but very little. The bed dips north and west. The stone is of the average quality. All varieties of salable stone are quarried, and sold to Hewitt Boice at Kingston. A siphon is in use. Three men are employed during the season.

Robert Elliott, Hurley. The bed of stone is 12 feet thick, with 14 feet of rock stripping. The stone is fine grained, reedy, and of good blue color. The vertical joints are regular and stained badly with iron. The dip of the bed is to the north and west. The lifts vary from 3″ to 10″, giving a variety of products. The quarry is equipped with horse power pump and derrick. Hewitt Boice of Kingston buys the product. Four to five men are employed throughout the year.

The quarries south of the Lapala district are all small in size and number. The region through Atwood and Vly was quite productive at one time. South of Vly the Scarawan quarries are being worked on a small scale. The end of this productive line is at Mackey hill west of Kripple Bush, where a long ledge has been opened.

The following are at work in the vicinity of Vly and Atwood.

Green L. Davis, Atwood. A very small quarry between Atwood and Vly. The bed of stone is 4 feet thick, with 10 feet of rock and dirt top. The lifts vary from 4″ to 8″. The stone is of average quality and is sold at Wilbur to different buyers. One man employed.

Lockwood & Krom, Atwood. This ledge has been opened up for some distance. The bed is 4 feet in thickness, with 6 feet of rock and 1 foot of clay top. The stone is rather coarse grained and of good blue color. The lifts vary from 2″ to 6″ in thickness. The dip of the bed is to the north and west. The bed is said to work "hard," and the bedding planes are not smooth. The north and south joining is prominent, and the sides are stained with iron. The stone is hauled 12 miles to Kingston and 14 miles to Wilbur. Two men are employed. Besides the above firm the following are quarrying on the same ledge.

George Winchell, Atwood.

Bush & De Boice, Atwood. Three men are employed eight months in the year.

Charles Ennis, Atwood. One man employed.

The quarries in the Scarawan district are as follows.

Turner Bros., Stone Ridge. The ledge of stone is 12 feet thick, in which 3 feet is the thickness of the workable stone. No sharp line of demarcation between the rock and stone is to be seen. The rock and stone are interbedded. The stone is coarse grained, of good blue color and with few reeds. The top lifts are light, producing flag, while the lower lifts are heavier, 5″ to 8″. The north and south joints are prominent. The bed dips to the north and west. Two men are employed.

The following are also quarrying on this ledge.

Snow & Smith, Kripple Bush. Two men are employed eight months.

Wagner & Krum, Kripple Bush. This quarry is on ledge just above Turner Bros. and is of the same character. The bed of stone is 3 feet thick, interbedded with 9 feet of rock. Two men are employed.

The following operate on the same ledge occasionally.

J. H. Beatty, Vly. All the Scarawan quarries haul their stone to High Falls on the canal, where it is loaded on barges for shipment. Julius Osterhoudt is the buyer at High Falls.

Jason Beatty, Kripple Bush. This quarry is situated ½ mile east of the Scarawan quarries, but the stone is of the same quality and character. The bed is 3 feet thick, with 4 feet of rock top. The stone is hauled to High Falls to Julius Osterhoudt. One man is employed.

The opening on Mackey hill is 1 mile long and extends part way around the hill. The bed of stone is 10 to 12 feet thick, with a top ranging from 12 to 35 feet in thickness. The top is entirely shale, which when stripped has not been disposed of well, as the quarries are badly blocked in places with rubbish. The stone is rather fine grained, of good blue color and reedy. The lifts are very heavy, 10″ to 24″. The top lifts do not split well, but the lower ones do. The ledge dips to the south and west, and the water, following the dip, collects at the southern end, where it is removed by siphons. A number of firms are quarrying on the ledge, and many have hand derricks in use. The side seams and head-offs are all tight, sometimes requiring blasting in lower lifts. The product is edge stone and "rock," which is hauled to High Falls on the canal.

The following are quarrymen, all of Kripple Bush.

Osterhoudt & Barley. Two men employed eight months in the year.

Beatty & Vandermark. Two men employed the year round.

W. D. Roosa. Four men employed during the year. The product sold by the quarryman at Port Jackson to various markets. Quarry equipped with hand power derrick.

Davis Bros. Two men employed the year round.

Jacob McMullin. Two men employed the year round.

Rose Bros. Two men employed the year round. Quarry equipped with horse power derrick and pump.

Greene Bros. Two men work intermittently. Quarry equipped with hand derrick and siphon.

O. E. Christian. Two men employed intermittently.

Hector Connor. One man and two boys employed the year round.

To the west of the northern part of this main range of quarries, viz west of the Quarryville, Fish Creek and Highwoods districts, the ledges of stone are terraced one above another, forming as it were the foothills of the Catskill mountains. A number of quarries have been opened in these ledges, but only a few are worked at present. The stone is of poor quality, not evenly bedded and very apt to "slack" or disintegrate on exposure. Near Fawns a ledge 1½ miles long has been opened, but is now abandoned.

On the eastern face of the mountains, from the Mountain house to Woodstock, and in the Kaaterskill and Plaaterskill cloves quarries are being worked. This stone is known as the mountain stone and differs from the stone quarried lower down in the vertical scale, in color, texture and appearance. The color is very variable, the grain is almost invariably coarse, and few reeds are present. There is less danger from "slacking" or disintegration on exposure, and it is a stronger stone than the fine grained, reedy stone of Quarryville and other similar districts. There is a distinct preference, however, for the typical bluestone; so the mountain stone does not stand high with the buyers.

Quarries have been opened on at least eight different levels on the eastern side of the mountain. On the southern side only one quarry is in active operation. The beds of stone vary in thickness from 4 feet to 12 feet. The amount of top, or overburden, depends on the length of time the quarry has been worked. As the beds are worked out into the mountain, the top increases. When the quarries are first opened, the stone is lighter and sold for flag. As the bed is worked deeper into the side of the mountain, the stone becomes heavier, and rock and edge stone are the chief products. The large sized stones are rock, such as platforms etc.; edge stone is 20 inch curb, sills and jointers.

The top is of rock and slate of a very decided reddish color. This red in places runs into the bed, and a red stone is sometimes quarried, but is looked on with disfavor by the buyers. The beds are of a rather light blue color, which has a greenish tinge when dressed, or after being exposed to the weather. This greenish tinge is typical of the stone from this mountain and of the mountain to the south.

The joints run nearly north and south and east and west. The joints running north and south are known as side seams, while the east and west joints are called headers. "Blocks" is the name for the strips of stone between the side seams. The stone is quite free from reeds and does not slake after exposure. All splitting is done along the seams. The dip of the bed is very slight on the eastern side of the mountain to the west and south; while on the southern side west and north the beds are nearly horizontal.

The texture, or grain, varies from coarse to fine. It is a usual thing to find that the top lifts of a bed are fine grained, while the bottom lift is quite coarse. The coarse grained stone is stronger and less likely to slake; and is also heavier.

The stone from the different quarries on the mountain does not vary much. The same condition and variations of texture, color, and top are met with at all levels. The quarry openings show a thickness of these alternating beds of shale, rock, and bluestone of 2000 feet. The joints are tight and loose, varying with the different openings. The side seams are in many places stained with iron.

A number of ledges with good beds of stone are exposed, but not opened, as the owners do not care to have the mountain disfigured with the rubbish piles. The top is disposed of mostly by dumping down the mountain side.

The stone is all hauled to Malden and sold to the Ulster bluestone co.

West of Dutch Settlement and West Hurley the bluestone belt widens, stretching over the 500 foot plateau which borders the mountains on the southeast. The stone from this territory is hauled to Brodhead's Bridge and other stations on the Ulster and Delaware railroad.

Beyond Brodhead's Bridge, along the Ulster and Delaware railroad, stone is quarried in the mountains as far as Grand gorge. This stone is of various colors, but is sold in the market as bluestone. The stone is shipped by way of the Ulster and Delaware railroad to Rondout, where it is loaded on barges for shipment to the eastern markets by tide water.

The quarries on the terraces between the mountains and the Highwoods district are as follows:

Hommell Bros., Fawns. Quarry is 1¾ miles northeast of West Saugerties. The bed of stone is 8 feet thick, with 15 feet of shale top. The stone is medium grain, of good blue color, but reedy. The lifts are evenly bedded, but the stone works "scallopy." The product is chiefly edge stone, which is sold to Ulster bluestone co. at Malden. Two men are employed intermittently.

Hommell & Ransome, Fawns. Two men employed on same ledge. Quarry equipped with small hand derrick.

Wolven Bros., Fawns. Quarry 1½ miles northeast of West Saugerties and ½ mile south of Hommell Bros. The bed of stone is 4 to 5 feet thick, with 12 to 15 feet of red shale top. The stone is rather coarse grained and a good blue. The bed dips to the southwest. Side seams and heads are present and regular. These vertical joints are tight, making hard quarrying. The lifts vary from 4″ to 6″. Product is chiefly edge stone, which is sold to James Maxwell at Saugerties. Quarry equipment consists of a horse power pump and hand derrick. Two men are employed throughout the year.

The quarries in the vicinity of Palenville are as follows.

Sylvester Stone & Christopher Hawley, Palenville. Quarry northwest of Palenville on the mountain side at an elevation of 1160 feet. The bed of stone is 5 feet thick, with 20 feet of top, one half shale and one half rock. The stone is coarse grained and greenish blue. Some reeds are present, but split very unevenly. The lifts vary from 4″ to 20″. Both side seams and "headers" were present when this ledge was first opened, but the headers have run out. The bed dips to the south and west. The product is chiefly edge stone, which is hauled 13 miles to Ulster bluestone co. at Malden. Two to three men are employed. Two or three loads (3 to 4 tons each) a week are produced 8 months in the year.

Lee Wolven & Frank Simmons, Palenville. Quarry is 250 feet above Stone's. 9 feet of good stone are worked, which is covered with 18 feet of dirt and loose rock. The stone is of same quality and character as Stone's. The product is sold to Ulster bluestone co. at Malden. Two to three men are employed during the year. Three loads a week of four tons each.

Lyman Lamouree, Palenville. This quarry is 200 feet above Palenville, on the mountain side at an elevation of 780 feet. The quality of bed and character are the same as Stone's. The color is reddish. Bed is 10 feet thick with 20 feet of rock and shale top. One man employed intermittently.

Stewart & Dolan, Palenville. Two men employed very intermittently on the mountain.

P. A. Moon, Palenville. Quarry is situated just south of Otis elevated railroad, 300 feet from base of mountain. The bed is very irregular, 2 to 6 feet thick, with rock stripping of 8 feet. The product is principally flag and is a little more green than usual, but the stone is of poor quality, and the quarry is worked irregularly. Product sold to Ulster bluestone co. at Malden, and also locally. One man and one boy employed.

Frank Symmonds, Palenville. One man employed occasionally on same ledge as Moon. This bed when worked back into the mountain gives out; that is, the stone changes into "rock."

J. H. Wolven, Palenville. Quarry on north side of the Kaaterskill clove, 2¾ miles west of Palenville and 500 feet above the bottom of the clove at this point. The bed of stone is 8 feet thick, with 30 to 35 feet of top, including 7 to 8 feet of shale. The stone is of the greenish tinge characteristic of this district, and coarse grained. A few reeds are present. The lifts vary in thickness from 2″ to 8″. The dip of the bed here is north and west. The quarry is worked toward the north, the face running east and west. The product is hauled 15 miles to Ulster bluestone co. at Malden. A hand derrick is in use. Four men are employed during the year and six to seven loads of stone a week are drawn during eight months in the year.

The stone is comparatively soft for mill treatment, but tough, and may "chip out" under a plainer. The quarrymen say they have found streaks of coal and "shiny" in the beds. This latter is probably pyrites. The same ledge has been opened up farther east, but is not worked there now.

Hommell & Rightmeyer, Palenville. Quarry situated on south side of Kaaterskill clove, opposite Wolven. The bed is thin, 3 feet with 12 to 15 feet of rock top. The dip is to the southwest, showing gentle roll once existed where the clove has been eroded out. The stone is coarse grained and of greenish tinge. No reeds are present and the seams are irregular. Small pockets of coal and crystals of iron pyrites are found in many of the mountain quarry beds. The stone is hauled to Ulster bluestone co. at Malden. Two men are employed eight months in the year.

Lamouree & Haines, Palenville. Quarry just west of Palenville and 500 feet above the town. The bed of stone is 7 to 8 feet thick, with 15 to 20 feet of rock top. The quality and appearance of the stone are the same as the other stone from these mountains. This has been a very productive quarry. The bed dips to the southwest. The stone is sold to Ulster bluestone co. at Malden. Two men are employed.

W. Fuller, Saxton. Quarry situated 200 feet above Haines. The bed is 20 feet thick, with rock top of 25 to 40 feet. The stone is medium grained and a fair blue color, lacking the usual greenish tinge. The side seams are straight and regular, but the heads are very irregular. The lifts vary from 3″ to 10″. The bed dips to the south and west. The product is sold to Ulster bluestone co. at Malden. Two men are employed.

Valk & Hommell, Palenville. Quarry near Fuller's and below it. The bed of stone is 10 feet thick, with 10 feet of rock top. The bed is quite rough and some rock is interbedded with the stone, which is of medium grain and of greenish tinge. No reeds appear. The bed dips to the south and west. Both systems of vertical jointing are present. Lifts vary from 2″ to 4″. The product, principally flag, is sold to Ulster bluestone co. at Malden. Two men are employed.

M. T. Wasson, Palenville. Quarry is near Valk & Hommell's. The bed of interbedded rock and stone is 12 feet thick, with rock stripping of 14 to 20 feet. This is a very small quarry and very rough bed. The stone is of the usual character of the mountain stone, and is sold to the Ulster bluestone co. at Malden. Two men are employed.

Arbecker Bros., Palenville. Employing two men.

Howard Winne, Palenville. Employing one man. Work intermittently near Wasson's quarry.

Cook & Ransome, Palenville. Quarry 2 miles south of Palenville, 300 feet above base of mountain. The bed of stone is 8 to 10 feet thick, with rock top of 15 to 18 feet. The stone is of greenish blue color. It is coarse grained and free from reeds. The lifts vary from 2″ to 4″ and are rough. The systems of joining are well developed. The bed dips to the southwest. The quarry is equipped with hand derrick and siphon. The product is sold to Ulster bluestone co. at Malden. Two men are employed the year round.

The quarries in the vicinity of West Saugerties and Plaat Clove are all on the mountains at elevations varying from 400 feet to 2500 feet above the base of the mountains.

On the north side of the Plaaterskill clove the following quarries are in operation.

Hommell Bros., West Saugerties. The bed of stone is 6 feet thick, with 20 feet of rock top. The color is light blue and the grain is coarse. The lifts vary from 3″ to 6″, with few reeds. The bed is rather rough and uneven. Two men are employed.

Hommell & Snyder, West Saugerties. The bed of stone is 8 to 10 feet thick, with 30 to 35 feet of rock top. The stone varies in grain from fine in the top lifts to very coarse in the lower ones. The lifts vary from 4″ to 20″. Some reeds are present, along which the stone splits evenly and readily. The stone is blue, but has the greenish tinge typical of the mountain stone. The dip of the bed is west and south. The stone is sold to Ulster bluestone co. at Malden. Three men are employed the year round.

George Young, Plaat Clove. The bed of stone is 10 to 12 feet thick, and there are 15 feet of rock top. The stone is coarse grained and greenish blue. The bed is quite rough, and there is a great deal of waste in quarrying. The side seams are quite irregular. The lifts vary from 3″ to 12″. The product includes all varieties, and is sold to James Maxwell at Saugerties. Two men are employed eight months in the year.

Wase & Burt, Plaat Clove. This quarry is 1½ miles northwest from Plaat Clove postoffice. The bed of stone is 4 to 5 feet thick, with 12 to 15 feet of top, the most being hardpan. The stone is light blue with a greenish tinge and quite coarse grained. It is too hard for mill treatment. The vertical joining is very irregular. The lifts vary from 3″ to 4″. The product is chiefly thick flag, which is sold to James Maxwell at Saugerties. Two men are employed.

Schoonmaker & Young, Plaat Clove. This quarry is on the same ledge as Wase & Burt's, but the bed has thinned out to 2 to 2½ feet. The character and class of stone and products are the same. The product is sold to James Maxwell. Two men are employed intermittently.

Abraham Hommell, West Saugerties. Employed in quarrying on the north side of the clove at different localities.

On the south side of the clove and on the Plaaterskill mountain the following quarries are being worked.

Delemater & Hommell, West Saugerties. The bed of stone is 12 feet thick, with 10 feet of shale and rock top. The stone is coarse grained, of good blue color and free from reeds. The lifts vary from 1″ to 6″. The dip of the bed is to the south and west, in contrast to the north and west dip of the beds on the north side of the clove. The vertical joints are quite irregular and stained with iron. The product is chiefly flag, which is sold to Ulster bluestone co. at Malden. Two men are employed.

Becker Bros., West Saugerties. This quarry is on the same ledge as Delemater & Hommell's. The quality of the stone is the same, though the bed and top are not so heavy, being 8 feet and 10 feet respectively. The product is sold to Hudson river bluestone co. at Saugerties. Two men are employed.

Snyder & Hommell, West Saugerties. This is on same ledge as the two previous quarries, and the quality and color of stone are the same. The bed is 7 feet thick, with 12 feet of hardpan top. The product is sold to James Maxwell at Saugerties. Two men are employed the year round.

Erby & Egner, West Saugerties. The bed of stone is 9 to 14 feet, with a top of 50 to 65 feet of rock with shaly streaks. The stone is of fair quality regarding grain and color, and is soft enough for mill treatment. The quarry will be abandoned soon on account of the thickness of the top. The stone is sold to James Maxwell at Saugerties. Two men are employed eight months in the year.

Rightmeyer & France, West Saugerties. This quarry is on the northwest side of Plaaterskill mountain, 2300 feet above West Saugerties. The bed of stone is 5 to 6 feet thick, with 10 to 15 feet of rock top. The stone is gray and of medium grain. The seams are $\frac{3}{4}''$ to 4″ apart and are very even. The product is chiefly flag, and is hauled 12 miles to James Maxwell at Saugerties. Two men are employed throughout the year.

Ethan Yeager, West Saugerties. The quarry is just being opened on the same ledge with Rightmeyer & France's quarry.

Huff & Young, West Saugerties. This quarry is also on same ledge as Rightmeyer & France's, but farther east. The dip of this ledge is southwest. Stone is the same in color and texture along the ledge, but rougher. The product of flag is sold to James Maxwell. Two men are employed throughout the year.

John Shalk, West Saugerties. This quarry is situated on south side of the Plaaterskill mountain, 2450 feet above West Saugerties. There are two beds of stone worked, separated by shale and rock. The top bed is 4 feet thick and the bottom bed 5 feet. The stripping amounts to 10 feet of rock and clay. The lifts are light, $\frac{1}{2}''$ to 5″. The chief product is flag, which is sold to James Maxwell. The stone has a reddish tinge and is medium grained, and free from reeds. The seams are quite regular and smooth. One man employed.

Patrick Callahan, West Saugerties. The bed of stone is 3 feet thick, with 15 to 20 feet of rock top. The stone has a reddish tinge and is rather finer grained than the usual mountain stone.

The vertical jointing is quite irregular. The stone is carted to James Maxwell at Saugerties at an expense of 33⅓% of the value of the load. One man is employed.

Abraham Steamburgh, West Saugerties. The bed of stone is 7 feet thick with 20 feet of rock top. The stone is of the mountain character, coarse grained, reddish tinge and free from reeds. The product is all flag, and is sold to James Maxwell. Two men are employed eight months in the year.

Becker Bros., West Saugerties. The bed of stone is 5 feet thick, with 10 to 12 feet of rock top. The stone is coarse grained, of reddish tinge, and some reeds are present. The lifts vary from 2″ to 3″. The vertical joints are smooth and regular. The stone is soft enough to be worked in the mill. The product is chiefly flag, and is sold to different dealers at Saugerties. Two men are employed during the season.

Charles Cole, Plaat Clove. The bed of stone is 3 feet thick, with 12 to 15 feet of shaly rock top. The bed dips, as is usual in this district, to the west and south. The stone is of medium grain and reddish tinge. The product is mainly flag, as the lifts are quite thin. One to two men are employed.

Teetzel & Burt, Plaat Clove. The quarry is situated 2½ miles west of Plaat Clove postoffice. The bed of stone is 4 feet thick, with 25 feet of rock top. The stone is light colored blue, coarse grained and free from reeds. The bed dips to the south and west. The product is principally flag, and is sold to James Maxwell at Saugerties. The quarry is equipped with hand derrick. Two men are employed.

Dale & Bunt, Plaat Clove, are just opening a quarry in this district, employing two men.

Snyder & Lindsay, Plaat Clove, are likewise opening a quarry, employing two men.

Between West Saugerties and Woodstock numerous quarries have been opened at the base of the mountains and on the eastern face. The following are operating.

Myers & Doyle, West Saugerties. This quarry is 1½ miles southwest of West Saugerties, 1250 feet above the town. The bed of stone is 12 to 15 feet thick, with 25 feet of red shale and clay top. The top 4 feet of bed are red stone, while the lower part is light blue. The stone is all coarse grained. The bed is rather rough and hard to work. The vertical jointing is regular and smooth. The ledge has been opened up for 300 feet along the side seams. The product includes all varieties, and is sold at Saugerties to different dealers. Three men are employed throughout the year.

Bach & Burton, West Saugerties. Quarry is 2½ miles south of West Saugerties and 300 feet above the base of the mountain. The bed of stone is 12 to 14 feet thick, with 25 to 30 feet of shale rock and clay top. The stone is coarse grained, of light blue color and somewhat reedy. The dip of the ledge is to the south and west. The lifts vary from 2″ to 14″ in thickness. The thicker lifts must be split to 6″, or the reeds will open. The side seams and heads are regular and open. The product consists of edge stone and rock, which is sold to Hudson river bluestone co. at Saugerties. Two men are employed.

Plass & Byer, West Saugerties. This quarry is south of Bach & Burton's and above it. The bed of stone is 6 to 7 feet thick, with a rock top of 20 feet. The stone is rather fine grained and of fair blue color. Reeds are present. "Niggerheads," or round boulders, in the bed make it hard to work. The product is principally flag, which is sold to Hudson river bluestone co. at Saugerties. Two men are employed.

Fred Snyder, West Saugerties. This quarry is situated 2 miles south of West Saugerties at the foot of the mountain. The bed of stone is 8 to 9 feet thick, with 18 to 20 feet of rock top. The stone is dark blue and rather coarse grained. The vertical jointing is rather irregular, but both systems are present. The product is sold to James Maxwell at Saugerties. The quarry is equipped with hand derrick. Three to four men are employed during the year.

Doyle & Clove, West Saugerties. This quarry is near Snyder's, but on ledge below. The bed of stone is 6 to 7 feet thick, with 10 to 15 feet of shale top. 1 to 2 feet of rock are interbedded with the stone. The dip of the ledge is to the south and west. The stone is light blue and fine grained. Some reeds are present. The product is chiefly flag, as the lifts are light. The stone is sold at Saugerties to various dealers. Two men are employed throughout the year.

Albert Doyle, West Saugerties. Two men are employed in quarrying on the same ledge as Doyle & Clove, just south.

Oliver Holden, West Saugerties. The bed of stone is 15 feet thick, but on account of rough streaks there is a large amount of waste. 15 feet of shale cover the bed. The stone is of medium grain, fair blue color and reedy. This ledge has been opened for 250 feet in a north and south direction. The dip is to the west and south. The product is sold to the Hudson river bluestone co. at Saugerties. Four to five men are employed during the year.

Lawrence Wolven, West Saugerties. This quarry is on the same ledge as Holden's, but south. The bed is but 4 feet thick here, with 10 to 12 feet of shale top. The bed is badly broken up, but the stone is of the same character as Holden's. The joints are open 3″ to 4″. Two men are employed the year round.

In the vicinity of Daisy several small quarries have been opened.

Burton Bros., Daisy. Quarry is situated ½ mile south of Daisy. The bed of stone is 8 to 10 feet thick, with a rock top 10 to 20 feet thick. The stone is quite dark blue and of medium grain. The ledge has been opened 300 feet along the strike. The bed dips to the north and west. A stratum of shale appears between the bed and top rock. The thickness varies from 1 to 4 feet. The lifts vary from 3″ to 10″. The product, of various varieties, is sold to James Maxwell at Saugerties. Three men are employed.

The following operators also quarry on this ledge.

Abraham Cole & Son, Daisy. Two men employed throughout the year.

John Van Etten & Son, Daisy. Two men employed.

Peter Mower, Daisy. One man employed.

Ellis Wolven. Woodstock. Quarry is situated 1½ miles southwest of Daisy, and 1½ miles east of Woodstock. The quarry is a pit in the open field. The thickness of bed is 4 to 5 feet, with 1 to 2 feet of rock and 6 to 7 feet of clay top. The stone is dark blue and rather fine grained, and reeds are present in top lifts. The dip of the bed is to the northwest. The lifts vary from 3″ to 22″. The product is chiefly edge stone, which is sold to Ulster bluestone co. at Malden. Three to four men are employed during the year.

In the vicinity of Woodstock the following operators are working.

N. Mower, Woodstock. Quarry is on a ledge (1 mile east of Woodstock) which has been opened for some length. The bed of stone is very rough and 2 to 4 feet thick. The overburden is 8 to 10 feet of rock. The dip is to the west and north. The stone is fine grained in upper lifts and coarse in lower. It is of good blue color. The vertical joints are somewhat irregular and stained with iron. The product is sold to James Maxwell at Saugerties. The quarry is worked intermittently by two men.

Canine & Longendyke, Woodstock. Quarry on same ledge as Mower's. Two men employed intermittently.

Egbert Schoonmaker, Woodstock. Quarry is situated ½ mile east of Woodstock. The bed of stone is 6 to 7 feet thick, with 4 to 5 feet of rock and clay top. The bed is very irregular and dips rather sharply to the north and west. Water collects at the lower end and is drained by a siphon. The stone is medium grained and of dark blue color. Some pyrites is found in the bed and affects color of stone on exposure. The lifts vary from 2″ to 12″, and all varieties of stone are produced, and sold to James Maxwell at Saugerties. Two men employed during the year.

Levi Mann, Woodstock. Quarry situated ½ mile north of Woodstock. The bed of stone is 3 feet thick on an average, but is very irregular and rough. The top is of rock 8 feet thick. The stone is fine grained and reedy. The bed dips to the north and west at changing angles. The product of edge stone and rock is sold to James Maxwell. Two men are employed intermittently.

On the southeastern side of Overlook mountain several ledges have been opened and worked extensively. The quarries known as the " California " quarries were very productive, but have not been worked in some years on account of the very heavy top. The same ledge, however, has been opened to the north, and five different firms are quarrying. The bed of stone is 11 to 13 feet thick, with 18 to 30 feet of rock top. The stone is fine grained, reedy and of light blue color. The top lifts have a reddish tinge. The stone is split into thin layers, for, if left thick, the reeds weather open. The ledge dips to the west and north. The product, chiefly of flag, is sold to Hudson river bluestone co. and to James Maxwell.

The following are the operators, all of Woodstock.

M. Elliott. Four men employed.

McGhee & Waste. Three men employed.

McGhee & Herrick. Four men employed.

Edward McGhee. Four men employed. The quarry equipped with hand derrick.

Peter Keegan. Three men employed.

James Riley. This quarry is on a ledge below Elliott's. The bed of stone is 7 to 8 feet thick, with 10 to 15 feet of rock top, 4 feet of which are slaty. A shale parting appears between stone and rock. The stone is of medium grain, light blue and reedy. The lifts vary from 5″ to 6″. The bed dips gently to the north and west. Both systems of vertical jointing appear. The product is sold to James Maxwell at Saugerties. Four men are employed.

Whittaker Bros., employing two men and **Jack Murray** employing one, have small quarries on the side of Overlook mountain.

In the vicinity of Bearsville, 2 miles west of Woodstock, the following quarries are in operation.

Charles Yerry, Bearsville. Quarry 1 mile southwest of Bearsville on the side of the hill. The bed of stone is 6 to 7 feet thick, with 12 feet of rock top. The stone is of fairly good color and medium grain. The quarry has been extensively worked. The dip of the bed is to the north and west. The upper lifts produce flag and the lower ones edge stone, all of which is sold to Hudson river bluestone co. at Saugerties. The vertical jointing is quite irregular. One man employed intermittently.

Snake rock quarries

These quarries are on a low hill 1¼ miles south of Bearsville. The ledge has been opened 800 feet around the hill. The bed of stone is 10 to 12 feet thick, with 30 feet of rock top. The stone is of medium grain and fairly good blue color with a reddish tinge. The lifts are rather heavy, and the product consists of rock and edge stone. The bed dips to the north and west. The vertical jointing is regular and smooth. What water collects at the lowest point is drained by a siphon. The product is sold to Hewitt Boice at Kingston, and to the Hudson river bluestone co. at Saugerties. The cost of haulage is 50% of value of load.

The following are the operators.

Oscar Lasher, Woodstock. Five to six men employed during the season. Quarry equipped with derrick.

Brower & De Graff, Glenford. Three men employed during the year.

Stoutenburgh & De Graff, Glenford. Three to four men employed.

Stratton & Davis, Woodstock. Two men employed.

Bonsteil Bros., Woodstock. Two men employed.

John Hasenpflug, Glenford. This quarry is on ledge below the above quarries. The bed of stone is 4 to 5 feet thick, with 25 feet of rock top. The stone is of the same character as the ledge above. The lifts vary from 3″ to 8″. The product is mainly rock, which is sold to Hewitt Boice at Kingston. One man employed.

Flowers & Brower, Glenford. Quarry is situated on same ledge as Hasenpflug. Two men employed.

A. E. Shultis, Bearsville. Quarry situated 2 miles west of Bearsville. The bed of stone is 6 feet thick, with 8 to 9 feet of rock top. Red shale appears in top also. The stone is fine grained and of poor blue color. The bed dips to the west and north. The lifts are light, the product being nearly all flag. Two men are employed occasionally.

Samuel Shultis, Bearsville. This quarry is just west of Shady postoffice on the hillside 200 feet above the town. It is on a ledge which has been opened up in numerous places. The bed of stone is 6 to 8 feet thick, with 15 to 20 feet of top, mostly of red shale. The stone is fine grained, reedy and of poor color. The product is mainly flag. Three men employed.

George Leppo jr, Shady postoffice. Quarry 2¼ miles north of Shady. The bed of stone is 4 to 5 feet thick, with top of rock varying in thickness from 4 to 15 feet. The stone is coarse grained and light blue in color. The lifts vary from 1″ to 3″, the chief product being flag. The stone is hauled to Wilbur, 20 miles distant, and sold to Hudson river bluestone co. Three men are employed.

George Leppo sr, Shady postoffice. Quarry is ¼ mile northeast of that of George Leppo jr. The bed of stone is 6 to 7 feet thick, with 10 to 15 feet of rock top. The stone is of the same character as that just described. All varieties are produced, and sold to James Maxwell at Saugerties. Three men are employed.

Henry Carle, Lake Hill. Quarry is 1 mile north of Lake Hill in Mink hollow. The bed of stone is 4 feet thick, with 12 feet of rock top. The stone is of coarse grain and fair color. Some reeds are present, but they are very tight. The lifts are very heavy, 6″ to 12″. The stone was used for the Cooper lake reservoir dam. The lifts are too heavy for flag or edge stone. The face of the quarry runs north and south, and at the northern end the dip of the bed is to the north, while at the southern end the dip is to the south, showing a roll in the middle. Four men are employed intermittently.

C. Shultis, Willow postoffice. Quarry 2 miles north of Willow postoffice. The quarry is very small, the bed of stone being 4 feet thick, with 8 feet of rock top. The stone is fine grained and reedy, and is sold as flag to Hudson river bluestone co. at Saugerties, 21 miles distant. Two men are employed.

In the vicinity of Glenford the following quarries are in operation.

E. Miller, West Hurley. The quarry is 2 miles north of Glenford. The bed of stone is 3 to 4 feet thick, with 12 to 15 feet of rock top. The stone is coarse grained and of good blue color, and a few reeds are present. The dip of the ledge is to the west and south. The lifts vary from 5″to 18″ in thickness. The vertical joints are regular, but tight. The stone is sold to Julius Osterhoudt at Wilbur. Three men are employed.

John Jones, Woodstock. Quarry is on ledge 200 feet above Miller's quarry. The bed of stone is 5 to 6 feet thick, with 20 feet of top, 7 feet of which are rock, the balance shale. The stone is fine grained, of fair blue color and so reedy that the lifts have to be split thin to insure the stability of the stone. The thickness of the lifts varies from 3″ to 6″. The bed dips to the west and north. The product of flagstone is sold to Hudson river bluestone co. at Saugerties. Three men are employed.

Abraham Van Etten, Woodstock. The quarry is very small and is 2 miles northeast of Glenford. The bed of stone is 4 feet thick, with 10 to 12 feet of rock. The stone is fine grained, light blue and reedy. The product is principally flag. Two men are employed during the year.

Philip Brower, Glenford. Quarry 1 mile west of Glenford. The bed of stone is 5 to 6 feet thick, with 8 to 10 feet of interbedded shale and rock. The stone is of medium grain and good color. The bed is very irregular, and the dip is to the north and west. The vertical joints are regular and smooth. The product is sold to Rogers & Tappan at Wilbur. Two men are employed.

Kittle & Co., Glenford. Quarry situated 1¾ miles west of Glenford and just being opened. Four men are employed.

John Gross, Glenford. Quarry is 1½ miles west of Glenford. The bed of stone is 10 feet thick, with a rough streak 1½ feet thick in center of bed. The top consists of 13 feet of rock and

7 to 8 feet of clay. The lifts vary from 2″ to 7″. The stone is of medium grain, a dull blue color, and reedy. The product includes all varieties of edge stone and is hauled to Wilbur, 12 miles distant, at a cost of 90c a ton. Two men employed.

Wallace Grey, Glenford. The quarry is situated on hill 1 mile north of Glenford. The bed of stone is 7 to 8 feet thick, with a rock top of 20 feet. The stone is of good blue color, of medium grain, and reedy. The product is sold at Wilbur to various dealers. One man is employed.

Burkins & Flowers, Glenford. Quarry is ½ mile northeast of Glenford. The bed of stone is 10 feet thick, with 10 to 12 feet of rock overburden. The bed is somewhat rough, but the stone is of fair quality, fine grained and blue. Some reeds are present. The dip of the ledge is to the north and west. All varieties of stone are produced and sold to Rogers & Tappan at Wilbur. Two men are employed.

Johnson & Piert, Glenford. This quarry is situated on same ledge as Burkins & Flowers's. Two men are employed.

McAuliffe & Terwilliger, Ashton. Quarry is situated just north of Temple pond and 2 miles southwest of Glenford. The bed of stone is 7 to 8 feet thick, but stone and rock are interbedded, causing a great deal of waste. The top consists of soil and rock 2 to 3 feet thick. The stone is of medium grain, of dark blue color, and free from reeds. The lifts vary from 1″ to 5″. The dip of the bed is gentle to the north and west. The side seams are uniform and smooth, but the heads are quite irregular. The product is flag and edge stone, and is sold to Rogers & Tappan at Wilbur. Two to four men are employed.

Ostrander & Brower, Glenford, two men employed, and **D. E. Hyatt**, Ashton, one man employed, also quarry on this ledge adjoining McAuliffe & Terwilliger's.

David Firman, Shokan. Quarry 1 mile northwest of Temple pond on hillside. The bed of stone is 6 feet thick, with 10 to 12 feet of rock stripping. The dip of the bed is to the west and north. The vertical jointing is irregular. The stone is fine grained and of good blue color. One man is employed.

Robert Secor, Olive. One man employed on ledge adjoining Firman's.

John Russell, Ashton. Quarry is on ledge below Firman's. The bed of stone is 5 to 6 feet thick, with 5 to 7 feet of rock and clay top. The quarry is just opened. The grain of the stone is medium, and the color blue. One man employed.

Chase & Barclay, Ashton. Quarry situated 2 miles east of Boiceville. The bed of stone is 4 to 5 feet thick, with 10 to 15 feet of rock top. The bed dips very gently to the north and west. The stone is very dark blue, fine grained and reedy. The side seams and heads are well developed. The product is chiefly flag, which is sold to different dealers at Wilbur. Two men are employed.

Oliver Hughes, Ashton. Quarry situated 1 mile northeast of Ashton postoffice. The bed of stone is 4 to 5 feet thick, with rough streaks in it. The top is 4 feet thick and is of rock. The stone is fine grained, a good blue and free from reeds. The dip is to the west and south. The product is chiefly flag, which is sold to Rogers & Tappan at Wilbur. The cost of cartage is 85c a ton. One man employed intermittently.

Jones & Co., Ashton. Three men employed in quarry adjoining Hughes's on same ledge.

Greene & De Graffe, Ashton. Quarry 3 miles east of Ashton postoffice. The bed of stone is 4 feet thick, with 8 to 9 feet of rock and 1 foot of clay top. Streaks of shale appear in bed, which is rather rough. The dip is to the west and south. The stone is fine grained and of good blue color. The lifts vary from 2″ to 6″. The product is chiefly flag, and is sold to Rogers & Tappan at Wilbur. Two men are employed.

Hewitt Boice has a mill and dock at Brodhead's Bridge, and the stone from the territory south is hauled there. The prices paid the quarrymen are 15% to 20% lower than at the river docks, on account of the extra cost of freight to Rondout, which is 90c a ton. The quarries follow.

Beesmer & Hover, Olivebridge. Quarry situated ½ mile southeast of Olivebridge. The quarry is just opened. The bed is 4 feet thick, with 7 to 8 feet of rock stripping. The stone is of medium grain and good blue color. The product is sold to Hewitt Boice at Brodhead's Bridge. The quarry is equipped with hand derrick. Three men employed.

Van Kleek & Dudrey, Brodhead's Bridge. The quarry is on south side of Esopus creek, ¼ mile from Olivebridge. The workable bed of stone varies in thickness from 6 to 10 feet. A rough streak appears 3 feet below top of bed. The rubbish is dumped into the bed of the creek. The stripping is of rock 5 to 8 feet thick and 1 to 2 feet of soil. The stone is fine grained and of poor blue color. The vertical joints are uneven and stained with iron. The product is sold to H. Boice at Brodhead's Bridge. Two men are employed.

Eckert & Beesmer, Olivebridge. Two men employed.

Barton & Lyons, Olivebridge. Quarry on the ledge adjoining Van Kleek & Dudrey's, two men employed.

Aaron Bishop, Olivebridge. Quarry 1 mile southeast of Olivebridge. The bed of stone is 10 feet thick, with rock top of 14 feet. The dip of the bed is to the north and west. The stone is of medium grain and good blue color. The quarry is equipped with hand derrick. The product is sold to H. Boice at Brodhead's Bridge. Two men employed.

Howard Barton, Olivebridge. Quarry is situated on ledge above Bishop's. The bed of stone is 5 to 6 feet thick, with 15 feet of stripping of shale and clay. The stone is fine grained and of good blue color, but has a reputation for slaking. The product is sold to Hudson river bluestone co. at Wilbur. Two men are employed.

Dudley & North, Olivebridge. Quarry on ledge below Bishop's. The bed of stone is 2 to 3 feet thick, with 4 to 5 feet of stripping. The stone is of same quality as Bishop's. The product is chiefly flag, and is sold to H. Boice at Brodhead's Bridge. Two men employed.

Cornish & Bush, Olivebridge. Quarry is 3 miles southeast of Olivebridge. The bed of stone is 3 feet thick, with 5 feet of rock top. The stone is of ordinary quality and runs in heavy lifts. The product is chiefly rock, and is sold at Brodhead's Bridge and Kingston. Two men employed intermittently.

George Winne, Olivebridge. Quarry 3½ miles southeast of Olivebridge. Bed of stone is 5 feet thick, with 12 feet of rock top. The quality of the stone is ordinary. The bed is about worked out. The product is carted to Brodhead's Bridge. Quarry is equipped with hand derrick. Two men employed intermittently.

A. Barton, Olivebridge. Quarry 4 miles southeast of Olivebridge. The bed of stone is 4 to 5 feet thick, with a rock top of 8 feet, and 2 feet of clay additional. The quality of the stone is common. The lifts vary from 2″ to 10″. The dip of the bed is to the north and west. The vertical joints are uniform and smooth. The product includes all varieties, and is sold to H. Boice at Brodhead's Bridge. Quarry is equipped with horse power derrick. Three men are employed during the year.

Merrihew ledge

This ledge is situated 4½ miles south of Olivebridge and has been opened up 500 feet in an east and west direction. A large amount of stone has been produced, but the top is becoming too heavy for profitable work. The bed of stone is 4 to 5 feet thick, with 7 to 8 feet of rock, and 5 to 6 feet of clay overburden. The stone is close grained and of fair blue color. Few reeds appear in the lifts, which vary 2″ to 6″. The bed dips to the north and west gently. The systems of jointing are well developed in the ledge. The product includes all varieties of marketable stone. The following are the operators, all of Olivebridge.

Resne & Keator. Two men employed nine months in the year.

Ezra Palen. One man employed.

Carson & Merrihew. Two men employed.

Christiana & Beesmer. Two men employed.

G. De Witt. One man employed.

Egbert Van Kleek, Olivebridge. The quarry is situated 2½ miles southwest of Olivebridge. The bed of stone is 4 feet thick, with

12 to 15 feet of shale and rock top. The stone is of fair quality and comparatively free from reeds. The product is chiefly rock, which is sold to H. Boice at Brodhead's Bridge. One man is employed intermittently.

Michael Riley, Olivebridge. This quarry is 4 miles southwest of Olivebridge. There are three distinct beds of stone worked in this quarry, divided by shale. The top is of shale 14 feet thick, below which the first bed is 3 feet thick. A bed of shale 3½ feet thick separates this from the second bed which is 3 feet thick. Another bed of shale 4 feet thick separates the second from the third bed, which is 6 feet in thickness. The stone is fine grained and of good color. Some reeds are present. The bedding planes are very smooth and regular. No heads appear in the quarry, but the side seams are uniform. The product is chiefly rock, which is sold to H. Boice at Brodhead's Bridge. Four men are employed the year round.

George Chambers, Samsonville. A small quarry east of Samsonville. The bed of stone is 4 feet thick, with rock top of 10 to 12 feet. The dip is to the north and west. The stone is of ordinary quality. The product is sold at Brodhead's Bridge to H. Boice. One man is employed intermittently.

List of buyers on the Hudson river[1]

Hewitt Boice, Kingston

Three yards and mills at Rondout, Kingston and Brodhead's Bridge.

Rondout. There is a mill with three planers, two gang saws, one rubbing bed, one borer. The dock is equipped with four steam power derricks and a blacksmith shop.

Kingston. Dock is on Ulster and Delaware railroad, and is equipped with mill with three planers, three gang saws and one rubbing bed. Two steam derricks are in use in the yard.

Brodhead's Bridge. The mill is equipped with two planers and two gang saws. Two steam hoisting derricks are in use. Em-

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[1] For a statement of the present administrative conditions of the bluestone industry in this region and its consolidation under "Hudson river bluestone co." on Mar. 1, 1901, *see* p. 104.

ployees in three yards, 90. Five barges and one schooner are in use for transporting the stone to market.

Value of business per year, $300,000 to $350,000 (estimated).

Hudson river bluestone co. Rondout

Docks at Malden, Saugerties, Glasco, Rondout and Wilbur, with mill equipment as follows:

Malden. Eight saws, eight planers, two rubbing beds, two boring machines, five steam derricks.

Rondout. Eight saws, nine planers, two rubbing beds, one boring machine, two steam derricks, one traveling crane.

Wilbur. Four saws, six planers, two rubbing beds, one boring machine, four steam derricks.

Employ about 200 men yearly and operate 15 barges.

Value of business, about $500,000.

Julius Osterhoudt, Rondout

Docks at Wilbur and High Falls.

Wilbur. The mill is equipped with three gang saws, one rubbing bed, three planers and one boring machine. Three steam power derricks are in use on the dock. 40 employees.

High Falls. One hand power derrick is in use. Four employees.

Five barges and one schooner are used for transportation.

Value of business per year, $175,000.

Ulster bluestone co. Malden

Docks at Malden and Glasco.

Malden. Mill is equipped with 10 saws, eight planers, two rubbing beds and one borer. 50 men are employed. Five steam derricks are in use in the yard.

Glasco. One hand derrick is the equipment. Three employees. Four barges are in use.

Value of business per year, $250,000 to $350,000 (estimated).

James Maxwell, Saugerties

Docks at Saugerties and Glasco. No mill at either place. One hand derrick at Saugerties. 20 employees.

Condition of the bluestone industry in Ulster county

The quarries within easy hauling distance of the river docks are becoming worked out. This does not mean that the beds of stone are worked out in all cases, but the stripping in many places has become so heavy that no profit is left to the quarrymen after paying rental and cartage. The beds dip to the west at a small angle 5° to 6°, and, with the crude methods used when the top reaches a thickness 2½ to 3 times (with a few exceptions) that of the bed of stone, the profit vanishes. The workable beds are also limited in extent. This is true in both the two main districts. Probably in the vicinity of Saugerties, the most productive district, not one half as many men as formerly are working now. A great many of the quarrymen have gone back to the mountains or along the Ulster & Delaware railroad, or into Delaware, Broome and Sullivan counties. The cost of cartage from the mountains to the river is very high, running up to 50% of the value of a load. Freight on the Ulster & Delaware railroad is also quite high.

QUARRIES IN BROOME, DELAWARE AND SULLIVAN COUNTIES

The quarries in these counties have been opened on the hillsides, on both banks of the Delaware river in New York and Pennsylvania, as far north as Tuscarora in Broome county, and south to Pond Eddy in Sullivan county.

The product of these quarries reaches the market by the way of the Erie railroad. Bluestone is also quarried along the main line of the Ontario and Western railroad from Franklin Depot in Delaware county to Hurleyville in Sullivan county, and along the Port Jervis and Monticello railroad.

A few quarries have been opened along the Delhi branch of the Ontario and Western railroad. Switches have been put in at convenient points on the lines of the railroads for shipping the stone. The buyers have small docks at these switches. Few mills are established in this district, the rock for mill treatment being shipped in the rough to mills nearer the markets.

The stone quarried in these counties differs from the Ulster county product in several characteristics. It is softer, it works east and west instead of north and south. It is coarser grained. The color is not so good, tending toward a gray. It is less liable to slaking, and fewer reeds are found in the lifts.

The ledges of stone are more pockety than the Ulster county stone. The vertical jointing is more irregular, specially the east and west joints. Less shale is found in the stripping, and the dip is not persistent in any one direction.

The quarries have nearly all been opened high up on the hills; so the drainage is natural. "Black jack" and "sap" are peculiarities of these quarries alone. "Sap" rock is the discolored greenish gray stone which is near the joints. The discoloration extends into the bed from 1 to 3 feet on each side of the joint. "Black jack" is a soft, claylike material, which occurs in the ledges in lens-shaped forms. It crumbles under the hand and contains a great deal of iron. It is due to an alteration of the rock, and when occurring may, as the quarrymen say, "eat out" the whole bed and ruin the quarry.

The prices paid the quarrymen are much lower than at the docks on the Hudson, because of the difference in cost of transportation to market. But the proximity of the railroads lessens the cartage charges.

In the isolated districts business seems to be in a fair condition, with an active demand at Oxford.

Quarries in Delaware, Sullivan and Broome counties

Deyo & Son, Franklin Depot. Quarry is situated 1¼ miles west of Merrickville station on the Ontario and Western railroad and ¾ of a mile east of Franklin Depot.

Vertical section shows

Soil	2 feet
Stone	2 feet
"	2 feet
Rock	1 foot
Stone	2 feet
Shale	6″
Rock	2½ feet
Stone	5 feet

H. T. Dickinson, photo.

Bluestone quarry of Henry St John, 1 mile east of Walton N. Y.

Plate 8

H. T. Dickinson, photo.

Bluestone quarry of Frank Bond in Oxbow hollow, 3½ miles from Walton N. Y.

Plate 9

H. T. Dickinson, photo.

Bluestone quarry of George Davis, 2½ miles east of Walton N. Y.

This section is taken at the point where the face is at its maximum hight. The face is 600 feet long. The system of jointing is the same as in Ulster county, and regular. The stone is medium fine grained, of light blue color with greenish tinge, and free from reeds. The lifts vary in thickness from 1″ to 7″ and are smooth and even. The bed dips slightly to the south and east. The stone is rather soft and is suitable for mill work. The product is chiefly flag and large rock, which is sold by Deyo & Son directly to dealers in Weehawken and local dealers.

The stone is shipped from the Merrickville station of the Ontario and Western railroad at a cost of $1.75 a ton to Weehawken. Four men are employed during the quarrying season of eight to nine months. The quarry has been open seven years.

In the vicinity of Walton the following quarries are in operation.

George Davis, Walton. Quarry is on west side of Marvin hollow, 2½ miles east of Walton. The bed of stone is 10 to 12 feet thick, with 14 feet of rock and 3 feet of soil overburden. The bed is horizontal and with even lifts, which vary from 1″ to 11″ in thickness. The vertical joints are rough and irregular. The stone is of medium grain and gray blue, when not discolored from sap near the joints. Some reeds are present, which are used in splitting the stone. The product includes flag edge stone and rock, which is sold to dealers at Weehawken. 50 to 60 cars a year are shipped during the season. Three men are employed. A hand derrick is in use.

Frank Bond, Walton. Quarry is situated in Oxbow hollow on the eastern side, 4½ miles east of Walton. The quarry is on ledge showing bed of stone 8 to 10 feet thick, with 25 to 35 feet of rock and 5 feet of earth top. The stone is light blue, fine grained and even bedded, with lifts varying from 2″ to 7″. Side seams are prominent, but not exactly vertical. The headers are few. The bed is horizontal. The product is flag and platform, and is shipped at Colchester Station on the Delhi branch of the Ontario and Western railroad. A hand derrick is part of the equipment. Two to three men are employed.

Ralph Cairns, Walton. Quarry is situated on south side of west branch of Delaware river, $1\frac{1}{2}$ miles east of Colchester Station. This quarry was operated for a number of years and abandoned. Cairns began operations last year. The ledge has been opened up for 900 feet in an east and west direction. The face shows a maximum hight of 55 feet, 30 feet of shale and rock at the top. Bed of stone 8 to 10 feet, 2 to 3 feet of shale, and bottom bed of stone 10 to 11 feet thick. The characteristics of the stone vary with its position in the bed. At the eastern end of the quarry the top bed is red and thin bedded, while at western end the stone from the top bed is blue and the lifts are thicker. The lower bed is fairly regular throughout in regard to color and grain, but the stone from it in the eastern end has few reeds and is hard to split, while at the western end the stone.is reedy and splits easily and well.

The western end of the quarry has not been opened up as deeply as the eastern end. The bluestone has a greenish tinge and is of medium fine grain. The lifts vary from 2″ to 22″. The product includes flag, edge stone and rock, which is shipped at Colchester Station on the Ontario and Western railroad (Delhi branch). The quarry is equipped with two hand derricks. Three men are employed.

William Cairns, Walton. Quarry situated on south side of West branch of Delaware river, $2\frac{1}{2}$ miles east of Walton, in same range as Ralph Cairns's quarry. The bed of stone is 9 feet thick, with 22 to 23 feet of rock stripping. The dip is a gentle one to the west. The face has a length of 500 feet. The two systems of vertical jointing are well developed. The stone is medium fine grained, light blue and somewhat reedy. The product is shipped at Colchester Station. The cost of cartage is 90c a load. 25 cars were shipped during the past season. The quarry is equipped with a hand derrick, and four men are employed.

J. Merritt, Hamden. Quarry is 2 miles south of Hamden on hillside. It is small and is worked intermittently only. The bed of stone is 8 to 9 feet thick, with 6 feet of rock and 12 to 15

Plate 10

To face p. 70

H. T. Dickinson, photo.

Bluestone quarry of J. Merritt, 2 miles south of Hamden N. Y.

Plate 11

H. T. Dickinson, photo.

Bluestone quarry of I. J. Moore, Pine creek south of Walton N. Y.

H. T. Dickinson, photo.

Bluestone quarry of W. G. Underwood on N. Y. O. & W. R. R. between Cadosia and Rock Rift N. Y. This is a new opening and shows a 3 foot bed of clay between two beds of stone feet of dirt top. The bed is irregular and horizontal. It is divided by irregular vertical joints. The stone is fine grained and gray blue. The product is shipped at Hamden on the Ontario and Western railroad (Delhi branch).

A small quarry has been opened at Delhi for the local market. It is worked intermittently only.

I. J. Moore, Pineville. Quarry in Pine brook hollow 3 miles west of Walton. The stripping of rock and clay is 4 to 15 feet thick, and covers a bed of stone which is coarse grained and bluish gray, 5 feet thick. The lifts vary from 2″ to 6″, the lower ones being quite rough. The vertical jointing is quite irregular. The stone is shipped at Pine switch on the Ontario and Western railroad to Schenectady. Three to four men are employed.

Ellsworth Huntington, Rock Rift. Quarry is situated above Draper's switch 2 miles north of Apex. The ledge has been opened around the hill for 300 feet. The bed of workable stone is 12 feet thick, with 12 to 14 feet of rock top. The stone is greenish gray and coarse grained. The bed is divided by the usual joints, which are regular and smooth. It dips to the northeast 14 inches in 20 feet. The lifts vary from 2″ to 12″. The product includes flag, curb, steps, etc. 30 to 40 cars are shipped each year to various points. Three to four men are employed.

T. Slossenburg, Hancock. Quarry is just west of Kerry switch, 4 miles north of Cadosia on Ontario and Western railroad. The quarry is small and not worked regularly. The bed exposed is 4 feet thick, with 12 feet of rock stripping. The stone is thin bedded, coarse grained and of gray color. The bed dips gently to the west. The face along the side seam is 75 feet long. Flag is the product, and is shipped at Kerry switch by way of the Ontario and Western railroad.

W. G. Underwood, Hancock. This quarry is just south of and on ledge below Slossenburg's. The quarry is just being opened and shows 2 beds of stone, 2 and 6 feet thick, separated by a stratum of earth 3 feet thick. The probable explanation of this is that the top bed has been broken off the main ledge and shoved outward on the drift earth above the lower bed. The stone is greenish gray and coarse grained. The product is chiefly flag, which is carted to Kerry switch. Four men are employed.

Peter Fritz, Hancock. Quarry is ¾ of a mile northwest of Cadosia on west side of valley. The bed of stone of 20 feet has a rock and clay top 30 to 35 feet thick. The stone is of medium grain and reedy. The face is 250 feet long in the direction of the side seams, which are irregular. The lifts vary from 4″ to 12″. The bed dips to the west. The product of flag and edge stone is sold to Kirkpatrick at Hancock.

E. J. Cotter, Hancock. Quarry situated 2 miles east of Hancock on north side of East branch of Delaware river. The quarry is rated as being one of the best in the district. The product is nearly all sold as rock to mills at different places near New York. It is shipped by the Ontario and Western railroad from Gravel bank switch. 65 to 70 carloads are shipped each year. The bed of stone is 17 feet thick, with rock top of 35 to 50 feet. The bed is divided by the regular jointing systems. The side seams are regular, but the headers are not. The lifts vary from 2″ to 4″, depending on the block. The stone is bluish gray except where stained with sap, where it is greenish gray. The grain is medium fine. The quarry is equipped with hand derrick. Six to 10 men are employed.

Roy Wheeler, Hancock. Quarry is 2 miles east of Cadosia on south side of East branch of Delaware river. The top is 10 to 15 feet thick and of thin bedded rock. The bed is 6 feet thick and dips to the south gently. The lifts are 1½″ to 3″ thick and very even and smooth. The side seams are uniform, but the headers are irregular. The ledge has been opened up 200 feet along the line of the headers. The stone is coarse grained and greenish blue gray. Flag is the main product, and is sold at the Tunnel switch on the Ontario and Western railroad to Randall Bros. Three men are employed.

Leahey Bros., Hancock. Quarry 3 miles east of Cadosia, 15 feet above the East branch of Delaware river. The quality of the stone is very fair. It is grayish blue and fine grained. The bed is 25 feet thick, with 45 feet of rock top. The bed is horizontal and at east end of quarry is very rough. The side seams are regular, but head-offs are not. The lifts vary from 2″ to 20″. Some reeds are present. The product is chiefly flag, and is hauled to Tunnel switch on the Ontario and Western railroad, where it is sold to Randall Bros. 20% of the value of each load is paid for cartage. Two men are employed.

James Nevins & Sons, Fish Eddy. This firm has a mill at Tyler's switch between Fish Eddy and Hancock, where it saws, planes and rubs the product of its quarry, which is 1 mile northwest of the mill on the hillside. The mill is equipped with three gang saws, two diamond saws, two planers, and two rubbing beds. Three derricks (two fitted for steam power) are in use. 10 men are employed nine months in the year in the mill. 50 cars a year of dressed stone are shipped, principally to New York. The apartment house in New York on 10th avenue, between 57th and 58th streets, is an example of the construction of this stone. The chief product of the mill is finely dressed house trimmings, steps and platforms. The mill was formerly near Walton. The quarry is operated by contract by Irving Carver, who is paid 2½c an inch thick per square foot for rock quarried, and 45c a cubic yard for stripping. The bed of stone is 16 feet thick, with 30 to 35 feet of rock stripping. The stone is of medium grain, gray blue color and rather soft. The bed is horizontal, and divided by irregular vertical joints. Black jack occurs in the bed in spots. The quarry is equipped with hand derrick, steam boiler and drill. Three to four men are employed.

Christopher Proskine, Fish Eddy. Quarry is situated 1½ miles east of Fish Eddy. The opening is very small and shows 4 feet of bed, with 10 to 12 feet of rock top. Cross bedding appears in the ledge, causing waste. The stone is coarse grained and blue gray, and is quarried for flagging. The stone is hauled to Fish Eddy and shipped by the Ontario and Western railroad.

G. W. Swartwout, Read Creek. Quarry situated on hillside on west side of Delaware river (East Branch), 2 miles north of Fish Eddy. The ledge has been opened 250 feet in the direction of the side seams, which are irregular. The bed of stone is 4 to 5 feet thick, with rock top of 20 feet. The stone is coarse grained and gray blue. Much of it is stained with sap. The bed dips to the south and west. The lifts are 2″ to 2½″ thick, producing flag chiefly, which is shipped at Fish Eddy. Two to three men are employed intermittently.

Sydney Skinner, East Branch. This quarry is on hill across the river from Swartwout's. The quarry is very small and is just being opened. 3 feet of bed are exposed, with 6″ of shale and 6″ of clay top. The bed is horizontal, and the seams are 2″ to 3″ apart. The stone is of medium coarse grain and greenish gray color. Below the bed a rough streak occurs. The product of flag is hauled to East Branch and sold to Rhodes.

This is as far south on the line of the Ontario and Western railroad as the quarries were visited. A few other quarries are being worked near East Branch.

As before remarked, there are a number of quarries at Deposit that were not seen. The description of those that were visited follows.

S. F. Whittaker & Co., Deposit. Quarry is 2½ miles south of Deposit on west side of Delaware river in Broome county. The face along the side seams is 600 feet long and at the maximum hight is 35 feet, of which 7 feet are workable stone. The stripping of 12 to 28 feet is rock, shale and earth. The stone is of medium grain and rather dark blue color. Some reeds are present. The bed dips to the southwest at a noticeable angle. The product is sold to Deposit stone co. Three to four men are employed during the season.

Charles Linkroum, Deposit. Quarry 4½ miles south of Deposit near Pennsylvania state line. The bed of stone exposed is 13 feet thick, with top 12 to 35 feet thick of rock, shale and earth. The bed is horizontal. The lifts vary from 1½″ to 8″. The grain of the stone varies from the top down. The stone from the upper lifts is coarse grained, while in the lower lifts the stone is finer grained and reedy. The color is fairly good blue throughout. The side seams are fairly regular, but as usual the heads are rough and uneven. The product includes flag and edge stone, which is sold to Travis & Kingsbury at Hale Eddy. Four men are employed.

Kinney & Lee, Hale Eddy. This quarry is just above Linkroum's and is a new opening. 12 feet of bed are workable, above which are 8 feet of rock and 6 feet of dirt. The lifts are nearly all thin, 1″ to 2″, and the product is chiefly flag. The stone is rather fine grained and when not discolored by sap is of good blue color. The bed is horizontal and is divided by vertical joints of the usual direction. The east and west joints are very irregular. Travis & Kingsbury at Hale Eddy buy the stone. The cost of cartage is 10¢ of the value of the load. Four men are employed.

Curtis & Smith, Sherman Pa. Quarry lies just north of Pennsylvania line, 5 miles south of Deposit. The bed of stone is 5 feet thick, with 15 to 30 feet of shale top. The stone is fine grained and compact. It is of gray blue color, except where discolored by sap. The bed is horizontal, and the seams 3″ to 8″ apart. The face of the quarry is east and west, 200 feet long. Both systems of vertical jointing are present. The product is chiefly flag and edge stone, which is sold at Hale Eddy to Travis & Kingsbury. Three men are employed.

Hobbs & Tupper, Hale Eddy. These men work on same ledge as Curtis & Smith. Two men are employed. Both quarries are in Broome county.

John F. Sprague, Oquaga Lake. Quarry is 1½ miles southeast of Oquaga Lake. The quarry has been open for a number of years and was worked extensively for a time. The scale of operations is now small, and the main ledge is not worked. Some outside blocks are being worked into flag. The bed of stone in main ledge is 8 feet thick, with 12 to 20 feet of rock top. The stone is uniformly coarse grained and gray. The vertical joints are well developed and straight. The lifts run quite heavy in the main ledge, 6″ to 10″. The stone is free from reeds. The bed is horizontal. The outside blocks are thin bedded and produce flag 1″ to 2″ thick, which is as smooth as a board. It is the intention of the owner to put in a derrick, strip the main ledge, and quarry stone on a somewhat larger scale. The product is sold at Hale Eddy and Deposit.

Andrew Weyman, Deposit. Quarry 1 mile south of Oquaga Lake. The quarry is very small. The bed of stone is 5 feet thick, with 8 feet of shaly top. The stone is thin bedded, gray and coarse grained. The product, which is flag, is hauled to Hale Eddy. It is worked only intermittently.

Riley Shellman, Deposit. Quarry is situated on Sand pond hill, 2½ miles south of Deposit, in Broome county. The bed of stone is 4½ feet thick, with 15 feet of rock top, which is broken. The bed dips to the west slightly and is divided by regular vertical joints north and south. The east and west joints are uneven and rough. The stone is fine grained, compact and gray blue. Near the joints the stone is discolored by sap. The lifts vary from 1½″ to 4″ in thickness. Few reeds are present. The ledge has been opened 250 feet along the side seams. The product of flag and curb is sold at Deposit to Deposit stone co. Three men are employed.

P. J. Madden, Deposit. Quarry is situated in Broome county south of McClure postoffice on hill south of Erie railroad. This is quite an extensive quarry, and is worked on a larger scale than usual in the district. The bed of stone is 12 feet thick and has an overburden of red shale 25 feet thick. The red shale is not often found in this vicinity. Just below the shale and above the bed is a stratum of rock 4 feet thick, which has a greenish tinge. The north and south vertical joints, or side seams, are regular and smooth, but the other system of vertical jointing is very irregular. The ledge has been opened around the hill 150 feet. The lifts vary from 6″ to 20″ in thickness, but are reedy and can be split into 2″ flag if necessary. The stone is fine grained, compact and a light gray blue. The quarry is favorably situated near the Sand bank switch on the Erie,

H. T. Dickinson, photo.

Bluestone quarry of Conrow and Hauyck, north of Deposit, showing "black jack" where Mr Madden has a loading dock. The product includes all varieties of stone. Six to 10 men are employed the year round. The quarry is equipped with a hand power derrick.

Patrick McAvoy, Deposit. Quarry situated on Shaeffer hill 2½ miles north of Deposit. The quarry is very small, showing 4 feet of thin bedded, coarse grained stone. The bed dips to the northeast rather sharply and is covered with a top of thin bedded rock 12 to 15 feet thick. The vertical jointing is very irregular. The product is chiefly flag, which is sold at Deposit to Kirkpatrick Bros.

John W. Scott, Deposit. Quarry 2½ miles northeast of Deposit on Rooney hill. The bed is horizontal and 9 feet thick at the maximum. The top is of red rock 10 to 15 feet thick, some of which is worked into salable stone. The seams are 6″ to 8″ apart. The face of the quarry runs 125 feet north and south. The stone is fine grained, light gray blue and very dense. The product is chiefly edge stone, which is sold to Kirkpatrick Bros. at Deposit. Two men are employed.

Conrow & Hauyck, Deposit. This firm is quarrying on the northern end of the ledge where Scott is quarrying. Here black jack occurs, which has eaten the bed down to 4½ feet. The black jack is lens-shaped, soft and crumbles in the hand. Two men are employed.

F. D. Walley, Deposit. Quarry is 2 miles north of Deposit on west side of Delaware river. The bed of stone is 10 feet thick, with a 2 foot streak of rough rock 3 feet below the top of bed. The stone below the rough streak is of better quality than above it. The bed pitches to the south and west gently. The stripping consists of 5 feet of rock and 13 feet of earth containing boulders. The stone is fine grained and gray blue. The side seams are regular, but the headers are very rough. The lifts vary from 2″ to 8″. The product is sold to Kirkpatrick Bros. at Deposit. Two men are employed.

George Shellman, Deposit. Quarry 5½ miles from Deposit on west side of Delaware river. The bed of stone is 6½ feet thick, with a top (varying from 7 to 15 feet in thickness) mostly of rock.

The stone is of medium grain and blue when not discolored by sap. The lifts are evenly bedded and range from 3″ to 6″ in thickness. The bed is horizontal. The side seams are regular and smooth, but no heads are to be seen. The stone is sold to Kirkpatrick Bros. at Deposit. Two to three men are employed.

Shellman & Warner, Deposit. This firm is just opening a quarry north of Walley's quarry. Three to four men are employed.

Near Hale Eddy the following quarries are in active operation.

Ostram & Freeman, Hale Eddy. Quarry is situated 1 mile north of Hale Eddy. The bed of stone is 6½ feet thick, with 12 feet of top, 4 feet of which are earth and the balance rock. The stone is badly stained with sap and has only occasional streaks of blue. It is fine grained and dense. The top rock is very hard and can be drilled only with difficulty. The seams are irregular, having a tendency to shift and grow, causing a large amount of waste. 10% of the value of each load is paid for cartage to Hale Eddy, where the stone is sold to Travis & Kingsbury.

G. N. Lord, Hale Eddy. Quarry is in Broome county, ¾ of a mile east of Hale Eddy on south side of Delaware river. The bed of stone is 7 feet thick, with 11 to 13 feet of rock top and 4 feet of earth. The stone is fine grained and of a good blue. Near the joints it is stained with sap. The bed dips to the southeast. The side seams are quite regular and smooth. The lifts vary from 3″ to 6″. The product is chiefly flag and edge stone, which is sold at Hale Eddy to Travis & Kingsbury. One man is employed.

Jones & Adams, Hale Eddy. This quarry is ¼ of a mile east of Lord's and in the same range. The bed of stone is 7 feet thick, covered with 12 to 25 feet of rock and earth. The face of quarry extends east and west 150 feet. The north and south joints are straight and even, while the east and west joints are very irregular. The bed is horizontal, with seams 2″ to 6″ apart. The seams are quite apt to shift and grow. The stone is sold at Hale Eddy to Travis & Kingsbury. Three men are employed.

On both sides of Rood and Sands creeks, which flow southward into the Delaware, quarries have been opened. Those in active operation follow.

Arthur Beagle, Hale Eddy. Quarry on western side of the west branch of Rood creek, 2 miles from Erie railroad. The ledge has been opened up 500 feet long in a north and south direction. At its maximum hight the face is 50 feet, of which 16 feet are stone, the balance being rock (in which some shale occurs) and earth. The bed dips slightly to the south and west. The side seams and heads are quite regular, the average area of a block being 2000 square feet. The bed of stone has been shown to be 25 feet thick, but, owing to the tightness of the lifts at the bottom, the stone can not be quarried. The stone is rather coarse grained, of fairly good blue color (specially the lower lifts) and reedy. It is maintained that these reeds will not open. The lifts vary in thickness from 2″ to 6″. The product consists of flag and edge stone, which is sold to Travis & Kingsbury. Three men are employed.

Beagle & Mayo, Hale Eddy. This firm is quarrying on the same ledge as Arthur Beagle. Its product is sold to Kirkpatrick Bros. at Rood creek switch on the Erie railroad. A hand power derrick is in use. Three men are employed.

Patrick Griffen, Hale Eddy. Quarry is on west side of eastern branch of Rood creek. The ledge is covered with 2 feet of earth; then come in succession 4 feet of rock, 6 feet of stone, 4 feet of shale and rough stone, and at the bottom 2½ feet of stone. The bed dips to the south and east. The two systems of vertical jointing are present. The stone is coarse grained and has a greenish blue appearance. The product of flag is sold to Travis & Kingsbury at Rood creek switch. Two to three men are employed.

Van Aken & Minko, Hale Eddy. Two men are employed in quarrying on same ledge as Griffen.

Richard Kennedy, Hancock. Quarry situated on eastern side of Rood creek 2½ miles north of Erie railroad. The bed of stone here is 9 feet thick, with top ranging from 10 to 25 feet of rock.

The stone is coarse grained and greenish gray blue in color. The face of the quarry is 450 feet long in an east and west direction. The bed was 15 feet thick in the early history of the quarry, but "the bottom has pitched up and pinched it out." The vertical joints are irregular, as is the dip. The product is hauled 3 miles to Hale Eddy at a cost of 20% of the value of the load. It is sold to both local dealers. Two men are employed.

Shaefer Bros., Hancock. This quarry, on eastern side of Rood creek and 3 miles from Erie railroad, is said to be one of the best quarries in this vicinity. The quarry face is 800 feet long in an east and west direction. The dip of the strata is to the east, where the water collects and is drained by a ditch. The bed of stone averages 14 feet in thickness. Overlying it are 3 feet of rock and 10 to 20 feet of earth. The vertical jointing is not uniform, but has the usual direction. The lifts vary from 4″ to 44″ in thickness. The stone is medium fine grain and of fair blue gray color. The product is chiefly rock, but some edge stone is cut. The quarry is equipped with hand power derrick. Six men are employed during the year.

Thomas Roche, Hancock. Two men are employed quarrying on Shaefer's ledge west of the opening. The stone is all hauled to Rood creek switch on the Erie railroad and sold to both local dealers.

Elmer Beagle, Hancock. Quarry on west side of Rood creek, 3½ miles from Erie railroad. This quarry face shows but 4½ feet of bed, with 20 to 25 feet of interbedded rock and shale. The stone is coarse grained. The top lifts are gray and the bottom are gray blue. Black jack occurs here and has eaten out 3 feet of the bed, which was 8 feet thick when the quarry was first opened. The vertical seams are irregular. The bed dips slightly to the west. The product is chiefly flag, which is sold at Rood creek switch to Travis & Kingsbury. The cost of cartage is 20% of the value of the load of stone. Two men are employed.

Bert Lee, Hancock. Quarry is situated on the hill on the west side of Rood creek and on the north side of the Delaware river.

The opening is not large, showing 6 feet of bed with 12 to 15 feet of rock top. The stone is thin bedded, medium coarse grained and grayish blue in color. The vertical joints are irregular in direction. The seams are 1½″ to 4″ apart, and some are rough. The bed has a slight pitch to the west. The product of flag is sold to Kirkpatrick Bros. at Rood creek switch. Two men are employed.

Travis & Kingsbury, Hancock. This is a firm of buyers and quarrymen. The quarry is on north side of Delaware river, 4½ miles northwest of Hancock. The opening is an old one and is 1200 feet long in an east and west direction. The western end only is being worked. There are two beds of workable stone. The top bed, 7 feet thick, is separated from the lower bed, 5 feet thick, by a rough streak 5 feet thick. Above the top bed there are 25 feet of rock and 1 to 2 feet of clay. The beds pitch rather more sharply than usual to the north. The stone is coarse grained and ranges in color from light blue to greenish gray. The vertical joints are quite irregular in direction. The beds at the eastern end of the opening are horizontal, which shows the variation of the dip. This is a common feature of the quarries of this district. The stone is carted to Travis & Kingsbury's yards at Rood creek switch. Seven to eight men are employed.

Robert Moore, Hancock. Quarry 5½ miles north of Hancock on west side of Sands creek hollow. The face of the ledge has been opened 300 feet east and west, and shows bed of 12 feet of stone covered with 8 to 15 feet of rock top. The seams are even and 1″ to 6″ apart. The stone is rather coarse grained and of good blue color when sap has not discolored it. The bed is horizontal. The stone is worked into flag chiefly, which is sold to Randall Bros. at Hancock. Four men are employed.

Crozier & Bahan, Hancock. This firm is opening a quarry on the Moore ledge. Two men are employed.

Fitch & Randall, Hancock. Quarry 5 miles northwest of Hancock on west side of Sands creek. The bed of stone is 7 feet thick, with 5 to 6 feet of rock and earth top. The quarry was opened this season. The stone is coarse grained and greenish blue. The lifts vary from 1½″ to 4″. Randall Bros. at Hancock handle all the product, which is chiefly flag. Four men are employed.

Rice & Co., Hancock. Quarry is 3 miles northwest of Hancock on western side of Sands creek near the top of the hill. The ledge has been opened 300 feet north and south along the side seams. The stripping, amounting to 30 feet of rock covered with a layer of earth, covers a bed of stone 15 feet thick, with lifts varying from 6″ to 24″. The stone is coarse grained and gray blue. Sap has discolored the bed near the joints. Reeds are present and are of the type which tighten on exposure. The product is principally curb and rock, which is sold to Kirkpatrick Bros. at Sands switch on the Erie railroad. Three men are employed.

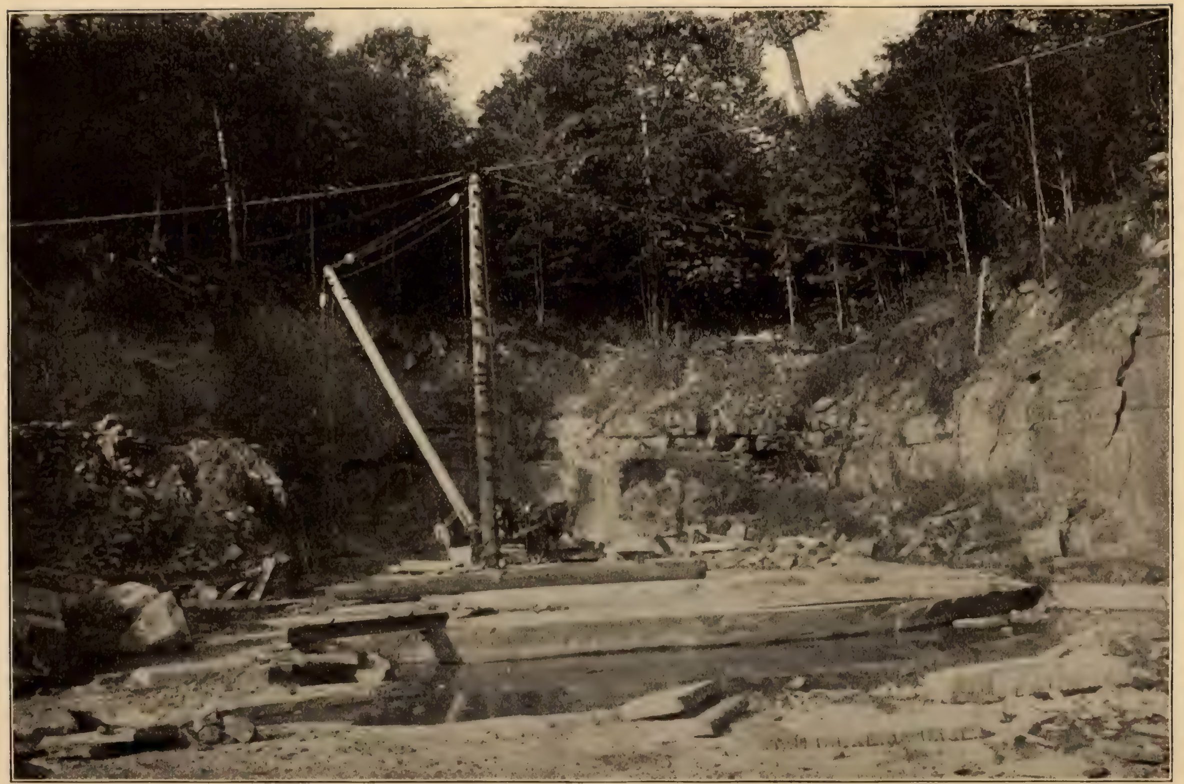
M. J. Ford, Hancock. Quarry is situated on west side of Sands creek 2½ miles northwest of Hancock. The bed of stone is 8 to 9 feet thick with 22 to 25 feet of rock, shale and earth top. The stone is coarse grained and the lower lifts are of fairly good blue color. The upper lifts are greenish gray. Some cross bedding appears in the ledge, causing waste. The vertical joints are irregular and stained with iron. The lifts vary from 1¼″ to 5″. The product includes all varieties of stone, which is sold to Randall Bros. at Hancock. Three men are employed. Cost of cartage to Hancock is 17% per value of load.

Patrick White, Hancock. Quarry is situated on the same hill as Ford's, but several ledges above. The bed of stone is 10 to 11 feet thick, with 20 feet of rock top. The bed dips somewhat more sharply than usual to the west. The bed is divided by joints, which are not exactly vertical, dipping slightly to the east. The stone is even bedded, the lifts varying from 2″ to 9″ in thickness. The stone is coarse grained and greenish gray blue. The product includes flag and edge stone, which is sold to G. W. Kazenstein, a small buyer at Hancock on the Scranton branch of the Ontario and Western railroad. Two men are employed.

Edward Kearney, Hancock. This quarry is just opened on a ledge above Ford's and below White's. The bed of stone worked

Plate 14

To face p. 83



H. T. Dickinson, photo.

Bluestone quarry in Sands creek hollow near Hancock N. Y.

so far is 4 feet thick and covered with a rock top of 10 to 15 feet. The stone is coarse grained and light gray blue. The lifts vary from 1″ to 3″. The stone is sold to Randall Bros. at Hancock. Two men are employed six months in the year.

Johnson & Dirig, Hancock. Quarry is 3 miles northwest of Hancock on east side of Sands creek. The ledge has been opened 700 feet around the edge of the hill. The quarry has been worked extensively and is now producing a medium amount of stone. The face has a maximum hight of 52 feet, 40 feet of which are pencil and 12 feet bed. The upper 3 feet of bed are thin bedded and suitable for flagging; but the lower lifts are very heavy, with few reeds which are hard to split, the seams being 2 to 3½ feet apart. These heavy lifts are sold as rock to Kirkpatrick Bros. at Sands switch. The bed dips slightly to the south. The system of jointing is regular and smooth. 20% of the value of each load is paid for cartage. Two to four men are employed, eight months in the year.

Arnold Grimsback, Hancock. This quarry is on west side of Bear brook hollow 1 mile northwest of Hancock. This quarry, known as the Baily quarry, was at one time a great producer of stone, but is now worked at one end only. The face is 450 feet long, north and south, and shows a bed of stone ranging from 5 to 15 feet in thickness. The top is very heavy, 10 to 40 feet thick and of rock. The stone is coarse grained and of good gray blue. The lifts vary from 3 inches to 4 feet in thickness. The stone is worked into edge stone and rock. Little flag is produced, on account of the heavy lifts. The product is sold to Randolph Bros. at Hancock. One man is employed.

Hanrahan & Cahill, Hancock. This quarry is 2 miles northwest of Hancock in Bear brook hollow. The bed of stone is 8 feet thick, with 7 feet of clay and shale top. The stone is even bedded (the seam being 1½″ to 6″ apart) of medium fine grain and a dirty blue color. The product is flag and edge stone, which is sold to Kirkpatrick Bros. at Hancock. The cost of cartage is 17% of the value of each load. Two men are employed. The quarry has been opened 10 months.

P. Hanrahan, Hancock. A very small quarry situated on Coon hill 3 miles north of Hancock. The bed of stone is 4 feet thick, with 8 to 10 feet of rock and shale top. The bed is quite rough, dipping gently to the northeast. The stone is of medium grain and grayish blue, lifts varying from 2″ to 3″. The product is chiefly flag, sold to Kirkpatrick Bros. at Hancock. Two men employed.

Thomas Scully, Hancock. The quarry is situated on the point of the hill ½ mile north of Hancock. The bed is horizontal and 10 to 14 feet thick. It is covered with a top of rock 25 to 30 feet thick. The stone is of medium grain and gray blue in color. Reeds occur in the lifts, which split easily. A rough streak appears in some parts of the bed and causes waste. The two systems of vertical jointing are as usual in the district. The north and south joints are the more regular. The lifts vary in thickness from 3″ to 12″. It is said that quarrying can be carried on all the year without affecting the stability of the stone. The face of the quarry is 250 feet long. The product consisting of rock, edge stone, and some flag, is bought by Kirkpatrick Bros. at Hancock. The quarry is equipped with hand power derrick. Four men are employed.

O'Rourke & Stewart. Quarry is situated near Women pond 6 miles east of Hancock. The bed averages 6 feet in thickness and is covered by thin bedded rock 12 to 15 feet thick. The bed dips to the southwest at a noticeable angle. Cross bedding appears in the top. The stone is coarse grained and a bluish gray, and flag is the chief product. The vertical jointing is irregular. The product is chiefly flag, which is carted to Stockport and sold to Kirkpatrick Bros. Two to three men are employed.

Comfort & Wood, Hancock. Quarry is 1 mile west of O'Rourke & Stewart's. The bed of stone is 6 feet thick and covered with 12 to 14 feet of rock and clay. The opening is not large. The north and south vertical joints are well developed and regular, but the east and west joints are not uniform. The stone is coarse grained and gray blue. The product is sold to Kirkpatrick Bros. at Stockport.

Between Stockport and Lordville there are three quarries in operation: two of Henry Prigge's and one of John Cuddike's. The product from these quarries is shipped by the Erie railroad at Kilgore's switch. One of Prigge's quarries is situated on hillside north of Delaware river and ½ mile northeast of Kilgore's switch. The thickness of the workable bed averages 6 feet and is of even, thin bedded, grayish, fine grained stone, which is reedy. The stripping consists of 2 feet of rock and 10 to 35 feet of earth containing boulders. The bed dips slightly to the northwest. The vertical joints are irregular and curved. The lifts vary in thickness from 2″ to 4″. The product is chiefly flag. Three to four men are employed.

The other quarry of Prigge's is on the same hill as the above, but on the western side. The bed of stone dips to the west and is 10 feet thick. There is a rough streak 3 feet thick in the middle of the bed, all of which is waste. The top is 40 to 45 feet thick, 10 feet of which are red clay, the balance being thin, irregular bedded rock. The stone is fine grained, gray blue and reedy. It is said that these reeds will not open by weathering. Four to five men are employed.

John Cuddike, Lordville. Quarry situated 1 mile north of Kilgore's switch on west side of hollow. The opening is small, but interesting on account of the lens of black jack which occurs in the top, which is of shale and rock and 16 feet thick. The stone is of medium grain and is gray blue. The even bedded lifts are 4″ to 8″ thick. The thickness of the workable stone is 4½ feet. Two men are employed.

List of docks and stone buyers along Erie and Ontario and Western railroads

Kirkpatrick Bros. Hancock

Erie. Deposit: 125 cars a year (estimated), three men employed.
Rood creek switch: 150 cars a year, three men employed.
Hancock: 200 cars a year, four to five men employed.
Stockport: 40 to 50 (20 ton) cars a year.
Lordville: 300 (20 ton) cars in 1899, four employees.
O. & W. Tyler's switch: 40 to 50 cars a year.

Travis & Kingsbury, Hale Eddy

Erie. Hale Eddy: 250 cars a year, two to three men, hand derrick.

Rood creek switch: 450 (20 ton) cars a year, two to four men employed, hand derrick.

Randall Bros. Hancock

O. & W. Tunnel switch: 50 cars a year.

Erie. Hancock: 250 cars a year, two men employed.

Deposit stone co. Deposit

Erie. Deposit: 200 (20 ton) cars a year, two men employed loading.

Sand bank switch: 25 cars a year, two men employed loading.

Sands creek switch: 125 (20 ton) cars a year, three men employed.

P. J. Madden, Deposit

Erie. Sand bank switch: 150 to 200 cars a year.

Henry Prigge, Lordville

Erie. Kilgore's switch: 40 to 50 cars a year, two men employed.

Standard bluestone co. Jersey City

Erie. Lordville: 196 (20 ton) cars a year, two yardmen.

G.W. Kazenstein, Hancock

O. & W. Hancock: 125 cars a year.

Average value of carload of stone of 20 tons is $90.

During 1900 the cost of freight from above docks to markets in Jersey City was $1.55 a ton, in New York $2.15 a ton and in Philadelphia $2 a ton.

QUARRIES IN THE SOUTHCENTRAL COUNTIES

Oneonta, Otsego co.

Bluestone quarry of Olds & Miller, situated north of West Davenport, 5 miles east of Oneonta. A very fine quality of hand dressed stone is produced. The stone is of good blue color and fine grained, and takes tooling nicely. The bed of stone is 8 feet thick with 8 to 9 feet of stripping of rock and clay. The lifts vary from 4″ to 8″ and are smooth. The product includes flag and all varieties of edge stone. The market

Plate 15

Quarry of F. G. Clarke bluestone co. Oxford N. Y.

is chiefly in Oneonta and other towns along the Delaware & Hudson railroad.

Several other small quarries have been opened near Oneonta for common building stone, but are worked only at irregular intervals.

Oxford, Chenango co.

The largest quarry of bluestone in New York is situated northwest of Oxford on the west side of the Chenango valley, 150 feet above the railroad. The quarry was first opened in 1874 and operated in a small way till 1880, when F. G. Clarke (later F. G. Clarke & Son and F. G. Clarke bluestone co.) took hold and began quarrying on a large scale. The bed of stone has a total thickness of 18 feet, and the stripping, or overburden, consists of 40 feet of drift earth, in which are imbedded large boulders and 25 feet of solid rock. The top 10 feet of bed is divided by horizontal seams 4″ and upward apart. The stone from this bed is used chiefly for platforms. The bottom 8 feet is of two lifts 4 feet thick, and known as " liver" rock. Liver rock is very dark blue and can be worked equally well in all directions; and is used chiefly for house trimmings and building stone. The stone is a good blue, fine grained and softer than the Ulster county stone. The following tests and analyses are interesting.

Stone from the quarries of the F. G. Clarke bluestone co.

TESTS MADE AT THE NEW YORK STATE MUSEUM, UNDER THE DIRECTION OF PROF. J. C. SMOCK

Specific gravity	2.7113
Weight, per cubic foot	168.97
Percentage of water absorbed	1.11
Weight of water per cubic foot	1.876
Percentage of gain in weight in CO_2 gas	.0024
Weight increased in lb (per cubic ft)	.0041
Percentage of gain in sulfurous acid	.064
Weight increased per cubic ft	.108
Freezing and thawing test	No effect

CRUSHING TEST MADE UNDER THE SUPERVISION OF THE ASSISTANT ENGINEER EMPLOYED IN TESTING MATERIAL FOR THE PEDESTAL OF THE STATUE OF "LIBERTY ENLIGHTENING THE WORLD," AP. 20, 1884

Dimensions

1st cube, 3 in. x 2.936 in. x 2.786 in. = 8.18 sq. in.
2d “ 3 in. x 2.77 in. x 2.776 in. = 7.699 “
3d “ 3 in. x 2.888 in. x 2.802 in. = 8.092 “

No. 1 bore a strain of 103,700 lb before crushing on its quarry bed

No. 2 bore a strain of 103,600 lb before crushing on its quarry bed

No. 3 bore a strain of 98,340 lb before crushing not on its quarry bed

The 1st stood a strain of 12,677 lb to the sq. in.
“ 2d “ 13,472 “
“ 3d “ 12,152.7 “

ANALYSIS MADE BY W. E. GIFFORD, CHEMIST, 54 PINE ST. NEW YORK

Silica	77.56
Alumina	10.65
Oxid of iron	4.59
Oxid of manganese	.09
Lime	.34
Magnesia	1.22
Potassa	2.15
Soda	.9
Water	1.93
Undetermined matter and loss	.57
	100

The strata are horizontal and the situation of the quarry is such that the drainage is natural. The quarry face is 1000 feet long in a north and south direction and is being worked at various points. The stripping is carried on during the winter season and is done by blasting. The earth is carted away by wagon, and the rock is piled up east of the face by the derrick.

A wire tramway was in use for stripping, but has been found to be of little advantage. The bed of stone is blasted out, holes being bored by steam drills and reamed out according to the Knox system. A channeling machine was formerly used. The quarry is equipped with three steam power derricks. A mill equipped with planers, gang saws and rubbing bed is run in connection with the quarry. Here the stone is prepared for the various demands of the market. 100 men are employed in quarrying and dressing the stone. 1000 carloads have been shipped this year by the Ontario and Western railroad to various points. The market is chiefly in New York and Pennsylvania towns. A special car capable of carrying a stone 25 feet x 15 feet is used by the company in shipping the largest stone.

Examples of construction in which the Oxford bluestone has been used are, the lower portions of Aldrich court, 41-43 Broadway, New York; the steps in the terrace approaching the capitol at Washington; the steps, platforms and column bases of the capitol at Trenton N. J.; St Lawrence hall, New Haven Ct.; the state prison for insane criminals at Matteawan N. Y.; the Oxford bank building at Oxford; and the Trinity Memorial church at Binghamton N. Y.

South Oxford, Chenango co.

F. G. Clarke bluestone co. operates a quarry 1 mile east of the railroad. The face is 600 feet long in a north and south direction. A top bed of 4 feet is quarried mainly for flagging. It is covered with a top of 4 feet of clay. Underneath the bed of flag is shale 15 feet thick, covering the liver rock 9 feet thick. The same system of quarrying is in use as at Oxford. The quarry is equipped with hand derricks and drills. The flag is shipped from Coventry Station by the railroad, but the liver rock is sent to Oxford for mill treatment. 50 men are employed throughout the year.

Several small quarries have been opened in the vicinity of South Oxford for flagging at Tyner, Walker's Corners and Springfield Flats.

King's Ferry, Cayuga co.

Quarry of Cusick & Murray is ½ mile south of King's Ferry. This quarry has been opened 10 years, and produces flagging, curb and cross walks for the towns of Elmira, Waverly, Auburn, Ithaca, and others in New York state. The stone is dark blue, fine grained and easily split to a thickness of 2″. Very little dressing is done except for the curb and cross walks. The product is hauled to King's Ferry station and shipped by the Lehigh Valley railroad. The face of the quarry is 800 feet long in a northwest and southeast direction. The bed of stone is 22″ thick and divided by two systems of vertical jointing running northeast and southwest, and northwest and southeast. The vertical joints are from 2 to 60 feet apart. The bed is covered with 14 feet of dirt and 6 feet of shale. Stripping is done by blasting and handled by carts and wagons. In the shale top at the southern end of the quarry a 5″ stratum of stone occurs 14″ above the top of the main bed. The equipment of quarry includes two derricks (one hand power, one steam power) and a blacksmith shop. 20 men are employed the year round. The output averages 200 cars a year.

The prices obtained f. o. b. King's Ferry are, 9c to 15c a square foot for flag according to size and thickness; 25c to 30c a linear foot for 20″ curb; rock, 3c to 4c an inch per square foot.

Goodyears, Cayuga co.

J. G. Barger quarries flagging and building stone on a small scale here. The quarry was worked very little during the summer of 1900.

Trumansburg, Tompkins co.

Cusick & Murray are operating a quarry near Halseyville 2 miles west of Trumansburg on south side of Taughannock creek. The product is chiefly flagging, and is sold at the same points as the stone from the King's Ferry quarry. Three beds are being worked, separated by beds of shale. 15 to 18 feet of soil and 4 feet of shale cover the top bed, which is 4 feet thick. Between the top and middle bed which is 2 feet thick are 6 feet of shale. Then come 4 feet more of shale and a bed of stone 2 feet thick.

Plate 16

To face p. 91

H. T. Dickinson, photo.

Bluestone quarry of J. T. Hunt, 6 miles north of Trumansburg N. Y., 1 mile west of Lake Cayuga

The face of the quarry runs north and south, and is 500 feet long. The jointing is north and south. Drainage is natural. The stone is a very dark blue, fine grained and easily split. A hand power derrick and steam drill are part of the equipment. Five to six men are employed during the year. The stone is shipped from Taughannock Falls station on the Lehigh Valley railroad.

On both sides of Taughannock creek, just below the falls, flagstone is being quarried by two operators, F. C. Biggs employing two to three men, and Peter O'Hara employing six to seven men. The bed worked is 3 to 4 feet thick and covered with 6 to 10 feet of soil. The stone is dark blue, fine grained and reedy. The lifts vary from 6 inches to 1 foot, but can be split easily to 2″. Drilling is done by "jumper" drills, otherwise the quarrying is the same as in Ulster county. The product is shipped at Taughannock Falls by the Lehigh Valley railroad to Syracuse, Rochester, Ithaca and Sayre Pa. Each operator has a hand derrick.

Several quarries ¾ of a mile west of the shore of Cayuga lake have been opened, but have not been worked in late years.

J. T. Hunt of Farmer operates a small quarry 6 miles from Trumansburg and 1 mile west of Cayuga lake. The product is flag of a reddish tinge and is quarried for local uses.

Ithaca, Tompkins co.

Sandstone of the Portage horizon is quarried 1½ miles south of Ithaca on the hillside above and below the Delaware, Lackawanna and Western railroad track. The stone is used for flagging, common building stone, and is crushed for road metal. The stone is a dark bluish gray and fine grained. The beds vary from 10 to 16 feet in thickness and have occasional streaks of shale in them. The stripping of earth is 6 to 20 feet thick. The stone is thin bedded, the distance between the seams averaging 2″. The two quarries produce road metal and are equipped with steam crushers and drills.

Wilbur J. Bates operates a quarry on the hill in the southern part of the town intermittently. The bed is 35 feet thick, a great deal of which is waste. The lifts vary from 2″ to 10″ in thickness, and in the lower part of the bed are very uneven. The stone is very dark with a slight reddish tinge, and fine grained. The vertical joints dip slightly to the east and run north and south. The dip of the bed is at a gentle angle to the south. The product is used for road metal and foundations. Some trimmings are cut, such as sills and lintels. The quarry is equipped with a crusher.

"Sandstone" for the Cornell university buildings was quarried on the site of Cascadilla hall and at a quarry in front of the main building, but lower on the hillside. Another quarry was opened near the McGraw-Fiske mansion and Fall creek. The stone in Cascadilla hall is the best from these local quarries.

A quarry on E. State street is operated by Driscoll Bros. (contractors). Stone is quarried as needed. The bed of stone is 22 feet thick, with 18 to 20 feet of top. The vertical joints run east and west, and are smooth and regular, 6 to 10 feet apart. Lifts vary from 2″ to 4″. The stone is fine grained, dark colored and of red and green tinges. The product is used locally for trimmings and foundation work.

Penn Yan, Yates co.

3 miles south of Penn Yan and ½ mile east of Keuka lake a quarry has been opened by S. Thayer. The quarry is very small, and the product is rough foundation stone, which is used locally. The stone is very coarse grained and shaly. The vertical joints are very irregular. 10 feet of rock cover the 4 feet of bed of stone.

F. E. Hoyt and Warren Sanford have opened quarries south of Penn Yan, but they have not been worked for several years.

James Woodruff's quarry is 3½ miles south of Penn Yan and 1½ miles east of Keuka lake. The bed of workable stone is 2 feet thick with 5 feet of shale and earth top. The stone is fine grained, dark blue, and compact. The bed is horizontal. The product is rough building stone, which is used in Penn Yan for foundations.

Himrod, Yates co.

Evan Potter's quarry is situated 1½ miles east of Himrod. The stone is fine grained and very dark blue. The bed is 2 feet

Plate 17

H. T. Dickinson, photo.

Bluestone quarry of Genesee Valley bluestone co., 3 miles south of Portageville N. Y. on Pennsylvania R. R.

thick with 3 feet of shale and earth overburden. The product is all rough building stone, some of which is used for culverts on the roads. Louis Cheney has also worked a small quarry near Himrod, but not for some time.

Watkins, Schuyler co.

No quarries are worked continuously here, but there is an opening in the hill 1½ miles south of Watkins, made by the Elmira and Watkins electric road, that is worked intermittently. The face at the back is 50 feet high and 200 feet long. Stone and shale are interbedded, the thickness of the stone approximating 12 feet. The stone is fine grained, even bedded and very dark blue. It is not handsome, but durable. The stone has been used for culverts on the electric railroad between Watkins and Elmira.

Portage, Livingston co.

The quarry of the Genessee Valley bluestone co. is 3 miles south of Portageville, just west of the Western New York and Pennsylvania railroad in Wyoming county. It has been worked for many years, and a large amount of stone has been produced.

The excavation is rectangular in shape, 120 feet x 210 feet. The stripping is of clay 20 to 40 feet thick, and increases on the western side. A great deal of trouble is experienced with the top, as part of it is in the nature of quicksand, and slides occur during the wet season, filling the opening with earth, sand and rock. The bed has been worked to a depth of 42 feet, divided into lifts by mud seams 2 to 8 feet apart. The lifts run in the following thicknesses vertically: 8 feet, 2 feet, 1½ feet, 3 feet, 2½ feet, 1⅔ feet, 1⅔ feet, 8 feet and 14 feet. The second lift from the bottom, 8 feet thick, contains a streak of stone containing a large amount of iron and is known as "black rock." This is of poor color and is sawed into flag. Just above the black rock the best stone is produced. The stone is fine grained and soft. The best is greenish blue. It is homogeneous in texture, easily worked and presents a very fine finish.

A representative specimen of this stone gave the following tests: Specific gravity 2.695, weight per cubic foot 168 lb, water absorbed 2.97%.

The loss by treatment with dilute H_2 SO_4 was .42%. Freezing and thawing tests produced but slight scaling. At a temperature of 1200° to 1400° F the color changed to a dull red. There were no checks, and the strength of the specimen was but little impaired. It is said to harden on exposure, and if quarried during cold weather will check badly from frost. Owing to the depth of the pit below the surrounding country, water is troublesome. It is removed by means of a steam pump. The quarry is also equipped with Wardwell channeling machine, Rand drill and steam derrick. The blocks are cut out by the channeling machine, which cuts to 5 feet 9 inches. The blocks are wedged out and lifted by the steam derrick. Drilling is done when necessary. A mill is run in connection with the quarry, where the stone is sawed, planed and rubbed for market. 37 men are employed during the quarrying season, which lasts from Mar. 15 to Nov. 30.

The stone is marketed chiefly in New York city. A side track runs into the quarry from the railroad. The price for block stone averages 60c a cubic foot. 42 to 43 carloads are shipped each month during the season.

Warsaw, Wyoming co.

Stone known in the trade as Warsaw bluestone is quarried by two firms 3½ miles south of Warsaw and 2 miles west of Rock Glen on the Erie railroad. Both quarries are on the same ledge of stone, within 25 yards of each other. The names of the firms are Warsaw bluestone co. and Otis & Gage. The latter firm has just begun operations this year.

The quarry formerly worked by the Warsaw bluestone co. at Rock Glen has been abandoned for some years, though the mill still stands and is connected with the present quarry by a railroad track. The bed of stone now worked is 35 feet thick. The top 5 feet are black rock and practically waste. The overburden consists of hardpan holding broken rock and is 15 feet thick. The bed is horizontal so far as can be seen. The lifts vary from 6 inches to 8 feet in thickness. In quality, color

Plate 18 To face p. 94

H. T. Dickinson, photo.

Bluestone quarry of Warsaw bluestone co. at Rock Rift near Warsaw

Plate 19

To face p. 95

H. T. Dickinson, photo.

Bluestone quarry of Otis and Gage at Rock Glen near Warsaw and grain the stone is very similar to the Portage bluestone. It holds the color well on exposure and is easily worked.

The quarries are in the shape of irregular pits, the vertical joints forming the sides and ends. The blocks are cut, however, by channeling machines. The channel makes a cut 5 feet 9 inches in depth, 2½″ wide at top and 1¼″ wide at the bottom; 18 to 20 linear feet can be cut every 10 hours. The level of the beds is below that of the surrounding country and water is very troublesome. It is handled by steam pumps.

The equipment of the Warsaw bluestone co. consists of a Wardwell channeling machine, three drills, a steam pump, two steam hoisting derricks; and a mill at Rock Glen with 12 gang saws, two planers, one borer, one circular saw, one lathe and four steam hoisting derricks. 45 men are employed in the quarry, and 20 men in the mill during the season.

Otis & Gage have a mill in course of erection within 100 yards of their quarry. A gravity railway connects the two. The mill is to be fully equipped with saws, planers, lathes etc. At the quarry there is in operation one Sullivan channeling machine, one steam drill, a steam hoisting derrick and a steam pump. 50 men are employed in quarry and mill.

Both mills are connected with the Erie railroad by side tracks. The market for this stone is in New York, Elmira, Corning, Binghamton, Philadelphia and Washington.

The following are examples of its use in construction: St Joseph's school at Buffalo; catholic school at Middletown; catholic church at Binghamton; armories at Brooklyn, Hudson, Hornellsville and Tonawanda; Vassar college at Poughkeepsie; residences at Corning, and the residence of N. S. Beardsley at Warsaw.

Waverly, Tioga co.

Gilbert Edgecomb's quarry is 2 miles north of Waverly, west of the Lehigh Valley railroad on a hillside. The quarry is 100 feet above the level of the valley. The hight of the face at the back is 75 feet, and the length 125 feet in a north and south direction. The bed is covered with 4 feet of earth. The stone is coarse grained, thin bedded and blue to gray in color. The product is rough building stone. It is used locally for foundations and in bridge building on the Delaware, Lackawanna and Western railroad. The quarry was opened in 1870.

Elmira, Chemung co.

The quarries are on the western face of the hill forming the eastern boundary of the valley between Horseheads and Elmira. Two quarries only are in active operation, but a number of openings have been made.

W. B. Pratt's quarry has been opened 50 years. The hight at back is 40 to 60 feet. The bed of stone is not more than 25 feet thick and is thin bedded. It is covered with 25 feet of clay and shale top. The shale is made use of in the manufacture of paving brick. The stone is gray to very dark blue and fine grained. It is quarried by drilling deep holes and blasting. No dressing is done. The product is used for foundation work and cellar walls in Elmira. Six to seven men are employed during the season, which lasts seven or eight months in the year. A steam drill and hand derrick are part of the equipment.

A. Voight's quarry is 3½ miles north of Elmira on the same range as Pratt's. The bed of stone is 20 to 25 feet thick, with shaly streaks running through it. The stripping is 14 to 16 feet thick, 10 feet of which are shale, the balance being drift earth.

The stone varies in color from red to blue. It is fine grained and very dense. The vertical jointing, as at Pratt's quarry, is north and south and east and west. The product is rough building stone which is used locally. A hand derrick is in use. Two to four men are employed. The price of stone in Elmira averages $1 per perch.

On the hills bounding the valley of the Chemung river between Elmira and Big Flats, quarries have been opened on the lands of H. T. Clark and Sarah A. Conklin, but, owing to the long haul to market, are little worked.

QUARRIES IN THE SOUTHWESTERN COUNTIES

Corning, Steuben co.

But two quarries are being worked this season at Corning, though a number have been opened there in years past. Edward Kelly's quarry is situated 1½ miles southwest of Corning on a hillside. The stone is fine grained and gray, specially in the upper part of the bed. In the lower part of the bed the stone has a pinkish blue appearance.

At the top are 30 feet of shale and dirt, in which there are a few courses of good stone. Below this are 8 feet of stone, which is blasted out and broken up for rough foundation work. This quarry has produced a better quality of stone, which was dressed and used in the reformatory buildings at Elmira and in the catholic church at Corning. The equipment consists of a hand derrick. Two to three men are employed according to demand.

George Barnard's quarry is ¾ of a mile southeast of Corning. The ledge has been opened up 250 feet in an east and west direction. The hight of the face is 50 feet, of which 30 feet are shale and consequently worthless.

The lifts vary from 3 inches to 2 feet and are fairly regular. The stone is gray with a pink tinge, fine grained and somewhat reedy. The vertical joints are quite smooth and have an east and west direction. The product is all foundation stone and its market is local. The quarry is equipped with hand derrick.

A. I. Martin owns a quarry ½ mile west of Mossy Glen, but it has not been worked for the last two seasons. The bed is 6 feet thick, with 6 feet of clay top. The stone is fine grained, bluish gray and reedy. It is used for foundation work.

Bath, Steuben co.

The quarry of W. and George Jinks is 2 miles northeast of Bath and 250 feet above the valley, on hillside. The hight of the face at the back is 50 feet, of which 20 to 25 feet produce marketable stone, the upper 30 feet being shale and clay. The courses of stone vary in thickness from 3″ to 18″ and are interstratified with shale. The strata are horizontal. The stone is fine grained and of a light gray color. It has been used for cut stone in the protestant episcopal church and county buildings at Bath, but is now quarried only for foundation work.

Just below this quarry another opening has been made in the hill. 15 feet of face are exposed, 8 feet of which are salable stone. The stone is gray, but has a whitish tinge. The lifts are somewhat heavier than in the quarry above.

The quarry of V. Holmes is situated 1¼ miles southwest of Bath. The ledge exposed is 45 feet thick. On top are 12 feet of clay and shale. Below this the courses of stone are interstratified with the shale. There are probably 8 feet of stone in the bed. The stone is fine grained and dark gray. It is quarried for cellar and rough work. It has not been worked the past season.

Near the Soldiers home at Bath stone has been quarried for the foundations of buildings and for road metal. The face is 125 feet high and 300 feet long. The sandstone is even bedded, of a gray color, and interstratified with shale. The vertical jointing is rough and irregular, but has a north and south and east and west direction. The dip is to the south and west and the lower strata are so covered with rubbish that it is impossible to determine the difference in quality of the stone in the beds.

Cohocton, Steuben co.

No quarries have been worked the past season at Cohocton on account of lack of demand for the stone.

Fred Zimmers's quarry lies 2½ miles due west of Cohocton. The bed of stone, 4 feet thick, is covered with 15 feet of shale, in which some stone is interbedded. The product has been used for foundation work. The stone is fine grained and light gray. The quarry has not been worked for three years.

F. F. Woodworth's quarry is 3 miles northeast of Cohocton and two miles southeast of Atlanta, on a hillside 250 feet above the valley. 8 feet of shale and soil cover the 30 feet of stone courses, which vary in thickness from 3 inches to 2 feet. The

Plate 20

H. T. Dickinson, photo.

Sandstone quarry of F. F. Woodworth at Cohocton N. Y., not worked for some years

beds are nearly horizontal and divided by vertical joints, which run north and south and east and west, but are rough and irregular. The product is flag, which is sold locally and also shipped abroad by way of the Erie and Delaware, Lackawanna and Western railroads.

Dansville, Livingston co.

Only one quarry is worked at Dansville, that of Jacob Schubmehl, which is on the south end of hill which forms the eastern boundary of the valley in which Dansville lies. It is 2½ miles southwest of the town above the Delaware, Lackawanna and Western railroad. The quarry face is 600 feet long, in an east and west direction, and 50 feet high. The top is of shale 15 feet thick, and beneath it shale and stone are interstratified. The stone is light gray and fine grained. In the lower courses the stone has a greenish tinge. The beds average 2½ feet in thickness. There is an abundance of reeds or splitting planes in the stone. The product is chiefly rough foundation work, and the market a local one.

Hornellsville, Steuben co.

Two quarries are being worked at Hornellsville. James May's quarry is 1¾ miles south of the town on a hillside, 100 feet above the valley. Two openings, 7 rods apart, on the same ledge, are being worked. A vertical section shows 10 feet of clay and broken rock, and 20 feet of stone. The stone is fine grained and bluish gray in color. The bed dips to the southwest gently. The stone is divided by vertical joints running n. 50 e. and s. 40 w. The stone is susceptible to disintegration if quarried during cold weather. The product is chiefly common building stone for local consumption. Two to three men are employed during the year.

Joseph S. Cobb's quarry is in the same range as May's, and the stone is very similar. The face of the quarry is 900 feet long and 50 feet high at the back. There are 8 feet of stripping of clay, 25 feet of light blue sandstone (which is used for rough work) and 12 feet of blue gray stone. The lower bed is used for cut stone, and the trimmings in the Bryant & Park schoolhouse at Hornellsville are from this quarry. As the ledge is worked into the hill, the lifts become very heavy and hard to handle. This is caused by the ledge being opened up such a long distance. Three men are employed during the year.

Belmont, Allegany co.

Leander Gordon and Eugene Pease own quarries near here. Gordon's quarries are ½ mile northwest of the village. There are two openings: one near the road, producing flag, and one farther back for building stone. The flag quarry is very small. The stone is fine grained and gray. The bed is 4½ feet thick, with 5 to 6 feet of dirt on top, and dips to the northwest. The lifts vary from 2″ to 8″. The flag is for local consumption. The quarry for building stone has a depth of bed of 18 to 20 feet, with 6 to 7 feet of shale overburden, in which some stone is interbedded. The stone is of the same quality as the flag quarry, but runs in heavier lifts, 12″ to 24″. The stone when cut has a pleasing appearance, but stains on exposure. The quarry has not been worked in some time.

The quarry of Eugene Pease is 2½ miles southwest of Belmont. The bed is 12 feet thick, but the upper 10 feet are badly broken and are used only for common building stone. The lower 2 feet produce some cut stone. The stone is of medium grain and greenish gray. The top is 4 feet thick and of soil. The product is all sold locally.

Angelica, Allegany co.

William Tracy has opened a flag quarry 1½ miles south of the village. It has been opened one year. The bed of stone is 4 feet thick, interbedded with shale. The lifts vary from 8″ to 2 feet, and can be split. The stone is light gray and fine grained. The bed is nearly horizontal and is divided by a series of irregular vertical joints. The product is sold in Angelica, Belmont, and other neighboring villages.

Belvidere, Allegany co.

H. Whitcomb's quarry has not been worked in 10 years.

Cuba, Allegany co.

Jesse Adams works a quarry just south of the Erie railroad station. The length of face in an east and west direction is

500 feet, and the maximum hight 30 feet. The bed is 8 feet thick, and dips to the south 1 in 7. The top of 10 to 22 feet is of shale, broken rock and dirt. In this there is some stone good enough for rough work. The stone is light gray and fine grained. The lifts vary from 2″ to 12″ in thickness. The product is used locally for common work.

Rockville, Allegany co.

Quarry of A. Searles 1 mile south of Rockville station. The bed of stone is 5 to 6 feet thick and is rough. 8 feet of soil and broken rock cover the bed. The stone is light gray and fine grained. The lifts vary from 6″ to 12″. The vertical jointing is northeast and southwest and northwest and southeast. Cross bedding appears in the bed. A line fence divided this quarry from Earl Herkimer's quarry, which is on the same ledge. The product is used locally in the surrounding towns for flagging and foundation work.

Belfast, Allegany co.

No quarry has been worked near Belfast in seven years.

Olean, Cattaraugus co.

The quarry of the Olean bluestone co. has been abandoned for five years, and the mill has been torn down.

John McCann is working a quarry 2½ miles south of Olean in Wild Cat hollow. The bed of stone is 12 feet thick and is covered with a top of 8 feet of broken rock and soil. The stone is fine grained and has an oily appearance when first quarried, but turns light gray on exposure. The quarry face is 700 feet long and extends around the hill. The ledge has been worked this way to avoid the heavy top, in working into the hill. The lifts vary from 8″ to 2 feet. The stone is used for common stone and curbing in Olean. The common stone sells for $1.25 a perch and the curb for 18c a linear foot. Two to three men are employed.

Joseph Rounds quarries stone on the same ledge south of McCann.

Jamestown, Chautauqua co.

Six openings have been made in the eastern part of the town, in the hill on the right bank of the Chautauqua lake outlet, and one on the left bank of the outlet. The latter quarry is that of the Jamestown shale paving brick co. This quarry was originally opened for building stone, but the amount of shale became so great that the brick works were built to dispose of it. Now the quarrying of the stone for building is a minor affair. The ledge opened is 62 feet thick. The upper 25 feet are of shale and thin layers of stone, all of which is used for making brick. Below occurs the stone for building purposes. The stone is bluish, fine grained, and hard. The vertical joints are at irregular distances apart.

The systems run n. 30 w. and s. 55 w., the first being vertical, the second pitching steeply to the northwest. The lifts vary from 6″ to 14″. The product includes common building stone and cut work. It is sold in Jamestown for $6 to $7 a cord.

The quarries on the right bank of the outlet are at irregular intervals, the distance from the first to the last being about ¾ of a mile. They have been worked extensively at one time, but are small producers now. The maximum hight of face exposed is 65 feet. Below the top 5 feet of earth, stone and shale are interbedded. The upper courses produce only common building stone, while the lower beds are thicker, of better color and grain, and are cut for house trimmings for local market. No machinery of any kind is in use, but three of the openings are provided with hand derricks.

Watts Flats, Chautauqua co.

No quarries are in operation here.

North Clymer, Chautauqua co.

Two quarries on the same ledge have been worked ½ mile east of the railroad station. The bed of stone is 20 feet thick, but the top 4 feet are too rough for good stone. Above the bed are 3 feet of earth. The lifts vary from 1 foot to 3½ feet. The bed dips gently to the northeast. The stone is light gray and fine grained, and liable to weather badly. The quarries are owned by P. J. Reed and B. P. Smith, but have not been worked for three seasons.

This stone has been used for bridge abutments in Buffalo and on the Buffalo, Rochester and Pittsburg railroad.

Westfield, Chautauqua co.

Albert Elliott's quarry. A small quarry situated 2 miles northeast of Westfield and ¼ of a mile south of Lake Erie. The top of earth 4 to 5 feet thick covers a bed of stone 3 feet thick, with seams 2″ to 3″ apart. The stone is fine grained and blue gray. Some shale is interbedded with the stone, which latter has been used in arches for bridges and foundations. The quarry is very small and is worked only intermittently.

Laona, Chautauqua co.

Several quarries have been opened here on a line running northwest and southeast, which passes just north of Laona. Five or six quarries are on this line, but the only quarry that has been worked for some time is that of George R. Moore. This quarry is 1½ miles northwest of Laona. The opening is in an open field. The bed of stone is 5 feet thick, with top of 6 to 8 feet, 2 feet of which are shale, and the balance earth. The stone is fine grained and grayish blue. The lifts vary from 3″ to 6″ and are rather rough. The product is used for foundations in Dunkirk and Fredonia. 500 cords of stone worth $6 a cord at the quarry have been taken out of the quarry the past season.

John Wagner's quarry is the most southern on the belt and is just north of Laona. It has not been worked for a few years. It was opened 40 years ago. Some cut stone for trimmings has been produced from this quarry.

Franklinville, Cattaraugus co.

There is a sandstone quarry here which was not visited. No details are known.

Reorganization in the Hudson river valley

The bluestone interests in the vicinity of Rondout are now controlled by the following firms: Hudson river bluestone company, Malden, Saugerties, Glasco, Rondout, Brodheads Bridge and Wilbur; John Maxwell, yards at Saugerties, Glasco and Catskill; J. J. Sweeney & Son, Saugerties; and E. Riseley, West Hurley.

The Hudson river bluestone company has absorbed the business of Hewitt Boice, Rondout; Julius Osterhoudt, Wilbur; J. J. Sweeney, Wilbur; Rogers and Tappan, Wilbur and T. J. Dunn & Co., Malden. This company is working its own quarries at Cold Brook, Mt Pleasant, Arkville and Kingston. These quarries are all fitted with steam derricks and drills, employ about 300 men and operate 15 barges. Yearly value of business, $500,000.

INDEX

(*Pages 113–114 were bulletin cover pages*)

Appendix 3

Mineralogy 2

Museum bulletin 58

2 Guide to the Mineralogic Collections of the New York State Museum

Published monthly by the

University of the State of New York

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New York State Museum

FREDERICK J. H. MERRILL Director

Bulletin 58

MINERALOGY 2

GUIDE TO THE

MINERALOGIC COLLECTIONS

OF THE

NEW YORK STATE MUSEUM

BY

HERBERT P. WHITLOCK C.E.

University of the State of New York

New York State Museum

FREDERICK J. H. MERRILL Director

Bulletin 58

MINERALOGY 2

GUIDE TO THE

MINERALOGIC COLLECTIONS

OF THE

NEW YORK STATE MUSEUM

PREFACE

The kindly reception given to the *Guide to the Study of the Geological Collections of the New York State Museum*, published in 1898, and the evidences of its utility as a teachers' aid in the schools of the state, have made it seem desirable to continue this method of treatment in regard to the other branches illustrated in the New York State Museum.

Mr Whitlock, assistant in mineralogy, has accordingly, prepared for publication the following bulletin and it is offered to the citizens of the State of New York in the hope that it will meet a material want and aid many teachers in their instructional work in mineralogy by supplementing the textbooks now available.

FREDERICK J. H. MERRILL
Albany N. Y. July 14, 1902 *Director*

PART I

GENERAL PROPERTIES OF MINERALS

INTRODUCTORY DEFINITIONS

The science of mineralogy embraces a knowledge of all natural inorganic substances of definite chemical composition which go to make up the crust of the earth, and, so far as our knowledge extends, of other solid bodies in the universe.

Minerals, in the sense adopted in the following pages and generally in science, constitute only a part of the mineral kingdom. A mineral must be a homogeneous substance, that is, it must be of the same nature throughout. Many rocks which seem to the unaided eye to be composed of a single substance are shown by more careful examination under the microscope to be made up of more than one substance. A mineral must also have a definite chemical composition as expressed by a chemical formula. Thus, obsidian, or volcanic glass, though frequently quite homogeneous, is not classed as a mineral owing to its lack of definite composition.

Again, it is customary to exclude from the list of mineral species all substances which have not been formed by the processes of nature and such mineral substances as have been directly produced by organic life. Under this head are excluded laboratory and furnace products such as the carbonate of lime produced by passing carbon dioxid through limewater. which is not a mineral species though it has the same composition as the mineral calcite or natural carbonate of lime. Phosphate rock is not classed as a mineral owing to its organic origin though it has essentially the same composition as the mineral apatite which is the natural phosphate of lime.

The rocks which compose the earth's crust are either single minerals, such as marble, a massive form of calcite, or aggregates of two or more minerals. An example of the latter case is granite, composed of three or more separate and distinct minerals which may readily be recognized as different: a glassy mineral showing rough surfaces along the fracture, which is called quartz; a white, pink or salmon colored mineral which shows on the fracture a series of smooth surfaces and which is called a feldspar; and a black fibrous mineral which is known as hornblende.

Crystallization

When a substance in the condition of a liquid or a gas becomes solid it is often seen that this solid has a regular outline, smooth, bright sides or faces and sharp angles. This results from the fact that the particles or molecules of the substance, which while it was liquid or gaseous rolled about on one another, have been in some way arranged, grouped and built up. To illustrate this, suppose a quantity of small shot to be poured into a glass, the shot will represent the molecules of a substance in the liquid state, as for example a solution of alum. If, now, we suppose these same shot to be coated with varnish or glue so that they will adhere to each other and imagine them grouped as shown in fig. 1 they will represent the arrangement of the molecules of the alum after it has become solid or crystallized. This arranging, grouping and piling up of the molecules is called crystallization and the solid formed in this way is called a crystal. Fig. 2 and 3 show the shot arranged to reproduce two common forms of crystals.

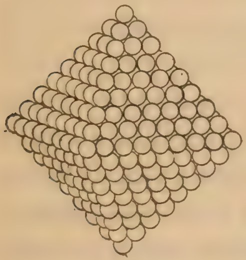

Fig. 1

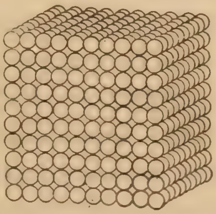

Fig. 2

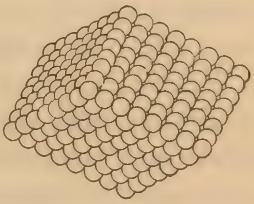

Fig. 3

There are many common examples of crystallization. The snowflakes, which are formed by the cooling of watery vapor in the air, are composed of small crystals which are quite apparent to the eye and are often of great beauty and regularity of form. The same may be said of the frost which forms on a window pane. The formation of crystals may be reproduced in a very striking manner; take for example a strong solution of salt and set it aside in a shallow dish over night; after the water has evaporated the bottom of the dish will be found covered with small cubic crystals of salt. The forces of nature working much more slowly but in a similar way have produced the vast deposits of native salt or halite which sometimes yield very large crystals.

Crystal masses

When a number of crystals are formed in a limited space the individual crystals intersect and lap over one another producing what is known as crystal masses. If this intersecting is carried to such an extent as to entirely fill the bounded space, leaving no interstices between the crystals, the mineral is said to be massive. The term massive in its broader sense includes mineral masses which do not show definite crystal faces but which in most cases can be shown to be distinctly crystalline by means of cleavage and optical properties. Experiment and study of mineral deposits show that a liquid substance which is cooled slowly or a solution which is concentrated gradually tends to form large and perfect crystals while substances which are solidified rapidly produce small and ill defined crystals, often giving rise to massive forms. A substance which displays no evidences of crystallization is said to be amorphous as distinct from crystalline. Glass is a good example of an amorphous substance.

Laws of crystals

A complete study of all known forms of crystallized substances has shown that the formation of crystals is subject to the following laws:

1 Law of constancy of interfacial angles

2 Law of symmetry

3 Law of simple mathematical ratio

Law of constancy of interfacial angles

In all crystals of the same substance the angle between any two like faces is constant. Fig. 4 and 7 show two crystals of the mineral zircon, both being composed of the faces marked *p* and *m*. An examination of fig. 5, 6, 8 and 9,

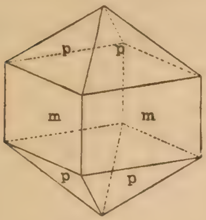

Fig. 4

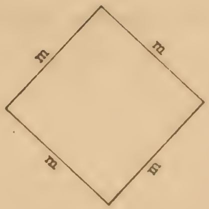

Fig. 5

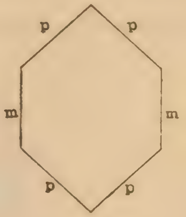

Fig. 6

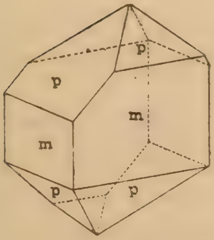

Fig. 7

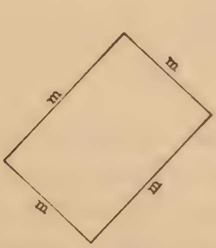

Fig. 8

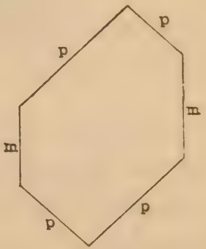

Fig. 9

which show sections through fig. 4 and 7, will demonstrate that the angles between *m* and *m* in fig. 5 and 8 are equal as are also the angles between *p* and *p* and between *p* and *m* in fig. 6 and 9. Compare the cardboard model 6[1], which shows the same crystal as fig. 4. Fig. 10 shows a distorted octahedron of magnetite, the shaded form within the outline representing the normal octahedron equally developed in all directions; the faces of the outer and inner forms are parallel each to each. The cardboard model 1 is an ideal octahedron.

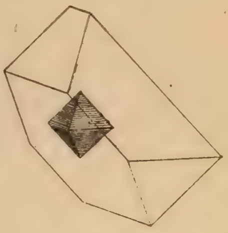

Fig. 10

Law of symmetry

By symmetry is meant the degree of regularity with which the faces and angles of a crystal are grouped about points, lines and planes. Thus a crystal may be symmetric to a plane, symmetric to a line or axis, symmetric to a point or center.

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[1] The cardboard models will be found in a pocket attached to the cover.

A crystal is symmetric to a plane when it may be so divided by that plane that every face, edge and angle on the one side is repeated on the opposite side. In fig. 11, which represents a crystal of pyroxene, the shaded space shows the intersection of the crystal by a plane of symmetry, and it will be observed that the portion of the crystal lying to the right of the plane is related to the portion lying on the left in the same way that the reflected or mirrored image of the half crystal is related to the direct image. Fig. 12 shows fig. 11 as seen from above.

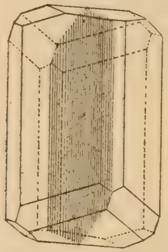

Fig. 11

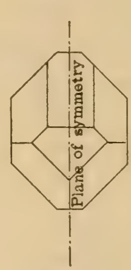

Fig. 12

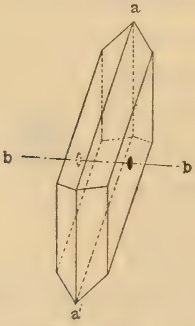

Fig. 13

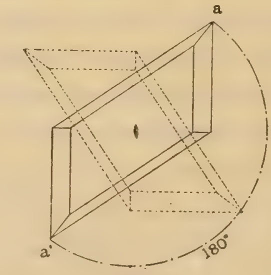

Fig. 14

A crystal is said to be symmetric to an axis of binary symmetry when it occupies the same position in space twice during one revolution about the axis, the coinciding positions being 180° apart. A consideration of fig. 13 and 14 will make this clearer; in fig. 13 *b* is an axis of binary symmetry and if the crystal is revolved as shown in fig. 14 the point *a* will have to traverse an arc of 180° and coincide with *a′* before the crystal will occupy the same position in space. An axis of binary symmetry is indicated by this sign ⬬ .

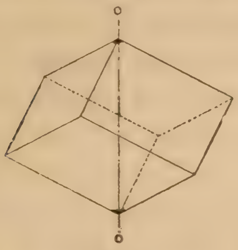

Fig. 15

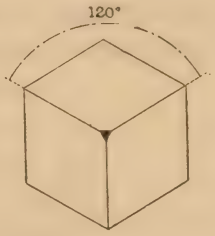

Fig. 16

Similarly a crystal is said to be symmetric to an axis of trigonal symmetry when it occupies the same position in space three times during one revolution about the axis, the coinciding positions being 120° apart. Fig. 15 and 16 show a crystal of calcite, *c*–*c* being an axis of trigonal symmetry, indicated by the sign ▲. Compare model 7.

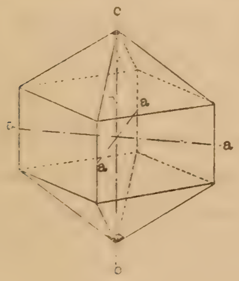

Fig. 17

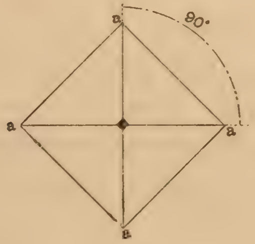

Fig. 18

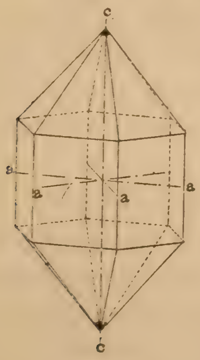

Fig. 19

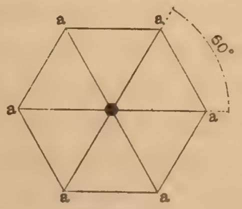

Fig. 20

A crystal is symmetric to an axis of tetragonal symmetry when it occupies the same position in space four times during one revolution about the axis, the coinciding positions being 90° apart. Fig. 17 and 18 show a crystal of zircon, *c–c* being an axis of tetragonal symmetry indicated by the sign ◆.

Hexagonal symmetry is shown when a crystal occupies the same position in space six times during one complete revolution about the axis of symmetry, the coinciding positions being 60° apart. Fig. 19 and 20 show a crystal of quartz, *c–c* being an axis of hexagonal symmetry indicated by the sign ⬢.

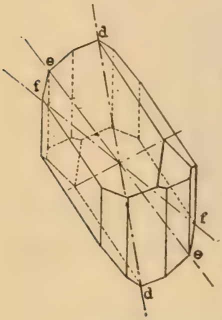

Fig. 21

A crystal is symmetric to a point or center when every imaginary straight line passing through that point intersects the crystal at its two extremities in similar faces, edges or solid angles. This is the least symmetric of all the conditions so far discussed and is illustrated by the crystal of chalcanthite or blue vitriol shown in fig. 21.

Crystallographic axes

The relations between the faces of a crystal are best studied by assuming certain directions within the crystal called axes. Such axes may, in the more symmetric groups, be axes of symmetry, and when the crystal is symmetric to one or more planes of symmetry, they bear a definite relation to those planes.[1] Three (in one system four) such axes are chosen, their relative inclination and lengths forming a basis for classifying all crystals into six systems.

If the symmetry of a crystal permits the grouping of faces around one axis to be identical with the grouping of faces around another, the two axes are said to be interchangeable. In fig. 17 and 18 the axes marked *a* are interchangeable but

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[1] In the normal groups of the isometric, tetragonal, hexagonal and orthorhombic systems, the axes are found at the intersection of the planes of symmetry, and in the normal group of the monoclinic system two axes lie in the plane of symmetry and a third is perpendicular to it.

a and *c* are not interchangeable. The same statement holds good for fig. 19 and 20. Cardboard models 6 and 7 will help to make this clear. Fig. 16, 18 and 20 show that if one crystallographic axis is also an axis of trigonal, tetragonal or hexagonal symmetry the other crystallographic axes will be at right angles to it and interchangeable.

Crystal form

When every face of a crystal cuts the axes to which it is referred at the same relative distances from the center or intersection of the axes, the crystal is said to be composed of a single crystal form. Two such crystals are shown in fig. 22 and 23 from which it will be noticed that all the faces of each crystal form are similar. Compare models 1, 2, 3, 4 and 5, all of which are crystal forms. Crystals may be composed of a single crystal form or of combinations of two or more forms. Such a combination is shown in fig. 24 which is made up of the two forms shown in fig. 22 and 23.

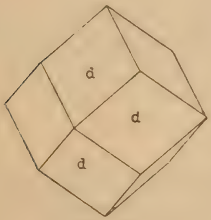

Fig. 22

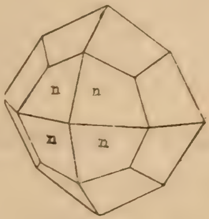

Fig. 23

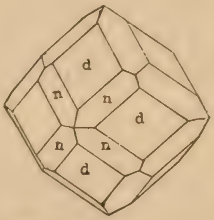

Fig. 24

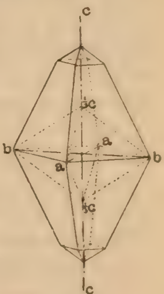

Fig. 25

Law of simple mathematical ratio

If the faces of a crystal are extended to intersect the axes it will be found that these points of intersection lie at the ratio distance *a*, *b*, and *c* characteristic of the substance, or at distances which are simple multiples or fractions of these ratio distances. Should a plane be parallel to one or two of the axes its intercepts, or in other words the relative distances from the center at which it cuts these axes, are infinity. Assuming the axes *a-a*, *b-b* and *c-c* (fig. 25) of the ratio or unit lengths of sulfur, that is to say,

$$\text{a–a} : \text{b–b} : \text{c–c} : = 0.813 : 1 : 1.903$$

possible crystal faces of sulfur might have intercepts

$$\begin{array}{rcl} \text{a} : \text{b} : \text{c} : & = & .813 : 1 : 1.903 \\ 3\text{a} : \text{b} : \text{c} : & = & 3(.813) : 1 : 1.903 \\ \text{a} : \text{b} : \tfrac{1}{3}\text{c} : & = & .813 : 1 : \tfrac{1}{3}(1.903) \\ \infty : \text{b} : \text{c} : & = & \infty : 1 : 1.903 \text{ etc.} \end{array}$$

The quantities by which the ratio distances of any substance must be multiplied to give the intercepts for any ordinary crystal form of that substance are infinity and such simple numbers as 1, 2, 3, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{3}{2}$, etc. Fig. 25 shows the crystal resulting from the combination of the crystal forms a:b:c: and a: b:$\frac{1}{3}$c of sulfur.[1]

Systems of crystallization

Crystals of all known forms, however varied and complicated, may be classified under the following six systems of crystallization, which will be taken up in detail.

1 Isometric
2 Tetragonal
3 Hexagonal
4 Orthorhombic
5 Monoclinic
6 Triclinic

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[1] Instruments employed for the measurement of interfacial angles are known as goniometers and are represented by two types: 1) contact goniometers which measure on a graduated half circle the angle obtained by directly applying to the faces of the crystal two pivoted arms; 2) reflection goniometers which operate on the principle of reflection from the brilliant crystal faces of the image of a point of light. The crystal is attached to a rotating graduated circle on which the required angle is read. Of the two types the latter is by far the more accurate particularly for small crystals.

The polarizing microscope, which is extensively used in determining the optical properties of minerals and in the study of rocks, differs from the ordinary microscope in three essential features.

1 It is equipped with a revolving stage centered in the axis of the microscope and graduated on the circumference.

2 Below the stage is inserted a device which polarizes the light that passes from the reflector, that is to say only those rays of light that vibrate parallel to a certain plane are transmitted.

3 Above the stage is placed a similar polarizing device called the analyzer which transmits the light that vibrates in planes perpendicular to the plane of the lower polarizer.

These two polarizing devices, known as nicols prisms or "nicols," are constructed from cleavage rhombohedrons of transparent calcite and are so arranged that they are readily inserted or removed.

Isometric system

Crystals included in the isometric system can be referred to three interchangeable axes at right angles to each other.[1] The molecular structure of the mineral with respect to these axes is revealed not only by the outward form of the crystal but by the property, common to all isometric minerals, of transmitting polarized light equally in all directions. By virtue of this property a thin section of an isometric mineral cut in any direction will remain dark when viewed in a polarizing microscope between crossed nicols or when observed in a similar way in the tourmalin tongs. There are five groups, differing slightly in symmetry, included in the isometric system, three of which contain nearly all the isometric minerals known.

Any mineral of which definite crystals are found produces forms which show the symmetry of a distinct group, and *it is impossible to find in nature a crystal whose symmetry would place it in more than one group.*

Normal group

Fig. 26

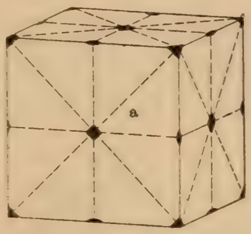

Fig. 27

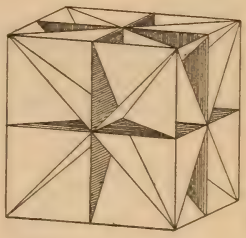

Fig. 28

The general symmetry of this group is shown in fig. 26 and 27. The crystallographic axes are axes of tetragonal symmetry and any form belonging to the group, as for example the cube shown in fig. 27, must be symmetric to the planes which inter-

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[1] In the ideal representation of an isometric crystal these axes are equal. Such a condition, however, seldom occurs in nature, the crystal being distorted in various directions. In the following brief outline, as well as in the description of mineral species, the diagrams represent ideal crystals and the reader's attention is directed to the symmetry and distribution of the faces shown, which are invariable however much the actual crystal may be distorted.

sect, as shown in fig. 28. The shaded planes of fig. 28 intersect in axes of tetragonal symmetry, the white planes intersect in axes of trigonal symmetry.

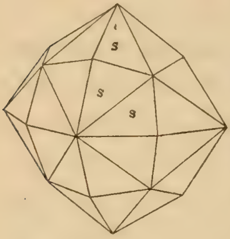

Fig. 29

Hexoctahedron. The hexoctahedron (fig. 29) is composed of 48 faces, each cutting the three axes at relatively different distances. The faces, which are scalene triangles, are grouped around the trigonal axes in groups of six.

Cube. The cube (fig. 27, model 2) is composed of six square faces each of which is parallel to two axes. This crystal form is represented by a number of minerals, the most common being galena, fluorite, halite, etc.

Dodecahedron. The dodecahedron (fig. 30, model 3) is composed of 12 rhombic faces, each of which cuts two axes at the same relative distance and is parallel to the third. This crystal form is quite common in garnet, and is found to a less degree in magnetite and other minerals.

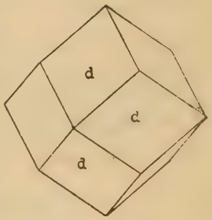

Fig. 30

Tetrahexahedron. The tetrahexahedron (fig. 31) is composed of 24 faces each of which is parallel to one axis and cuts the other two at relatively unequal distances. The faces, which are isosceles triangles, are grouped in fours about the axes of tetragonal symmetry and the long edges are parallel to the edges of a cube or hexahedron. This crystal form, in combination, is well illustrated by copper, fluorite and other minerals.

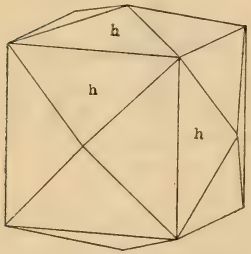

Fig. 31

Octahedron. The octahedron (fig. 32, model 1) is composed of eight equilateral triangular faces which cut the three axes equally. Good examples of this form may be found in crystals of magnetite and spinel.

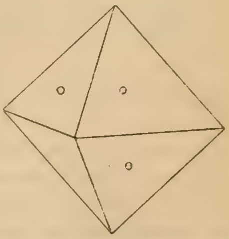

Fig. 32

Trisoctahedron. The trisoctahedron (fig. 33) is composed of 24 faces, each of which cuts two axes at equal distances and the third at a distance which is relatively greater. The faces are isosceles triangles and are disposed in groups of eight about the axes of tetragonal symmetry and in groups of three about the axes of trigonal symmetry. The trisoctahedron is occasionally found in combination with other forms as in galena.

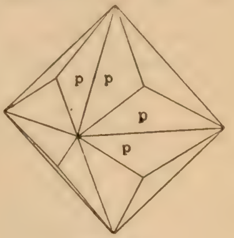

Fig. 33

Trapezohedron. The trapezohedron (fig. 34) is composed of 24 faces each of which cuts two axes at equal distances and the third at a distance which is relatively less. Garnet, leucite, analcite and other minerals crystallize in trapezohedrons.

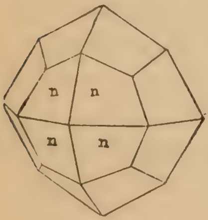

Fig. 34

Of the above named crystal forms the cube, dodecahedron and octahedron alone present an unvarying constancy of form, the cube and octahedron being identical with the familiar geometric forms. In the hexoctahedron, tetrahexahedron, trisoctahedron and trapezohedron the variations in the relative values of the axial intercepts give rise to a number of variations under each form, each subject to the law of simple mathematical ratio. The series of tetrahexahedrons shown in fig. 35–37 serves to illustrate this point. Fig. 35 and 37 are forms occurring in copper and fig. 36 is frequently observed on crystals of fluorite.

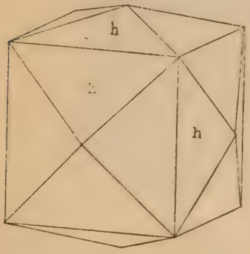

Fig. 35

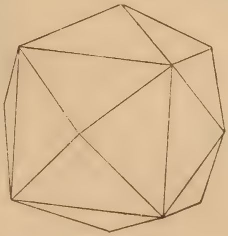

Fig. 36

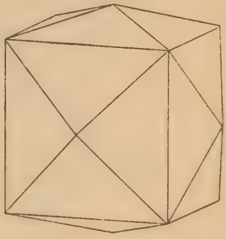

Fig. 37

Some of the combinations of forms in this group are given in fig. 38–43, the lettering of the faces being the same as that used for the corresponding simple forms.

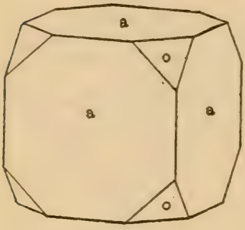

Fig. 38

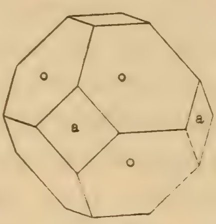

Fig. 39

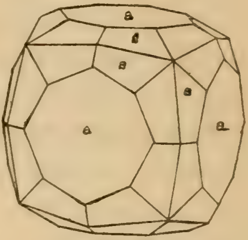

Fig. 40

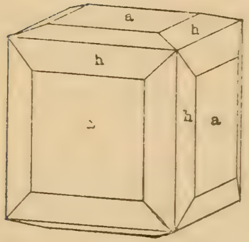

Fig. 41

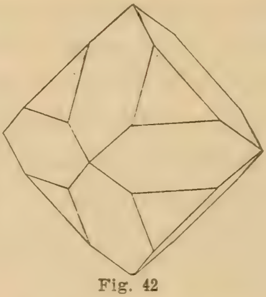

Fig. 42

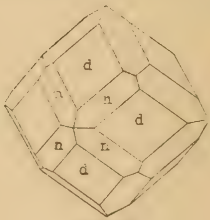

Fig. 43

Pyritohedral group

The general symmetry of the pyritohedral group is shown in fig. 44. The crystallographic axes are axes of binary symmetry

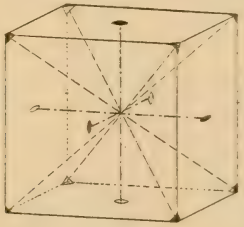

Fig. 44

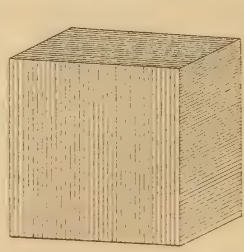

Fig. 45

and forms of this group are symmetric only to the shaded planes of fig. 28. The cube, octahedron, dodecahedron, trisoctahedron and trapezohedron, which occur in this as well as in the preceding group, are here distinguished by striations, natural etching and modifying faces which clearly show their binary symmetry; as for example the cube of pyrite shown in fig. 45, which occurs striated in the directions of the alternate parallel edges of each square face.

Pyritohedron. The pyritohedron (fig. 46, 47, model 4) is named from the species pyrite, of which it is a characteristic form.

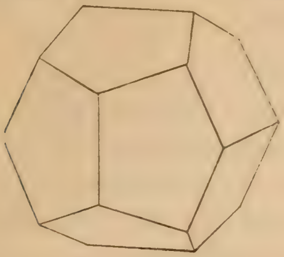

Fig. 46

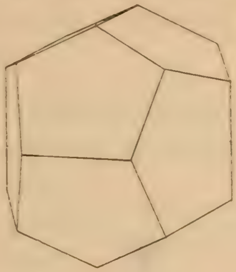

Fig. 47

It is composed of 12 pentagonal faces, each of which is parallel to one axis and meets the other two at unequal distances. As will be seen from fig. 46 and 47 the pyritohedron exists in complementary forms, fig. 46 being known as the *plus* and fig. 47 as the *minus* form. The 24 faces of the plus and minus pyritohedrons have the same position in space as the 24 faces of the corresponding tetrahexahedron of the normal group.

Diploid. The diploid (fig. 48, 49) is composed of 24 quadrilateral faces each of which meets the axes at unequal distances. The complementary plus (fig. 48) and minus (fig. 49) forms bear the same relation to the hexoctahedron of the normal group

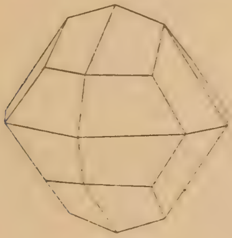

Fig. 48

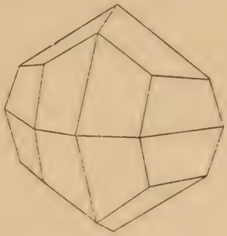

Fig. 49

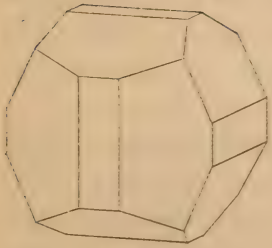

Fig. 50

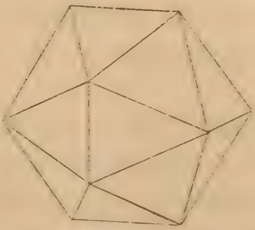

Fig. 51

Fig. 52

as the plus and minus pyritohedrons do to the tetrahexahedron. Fig. 50–52 show combinations of forms in this group and represent crystals of pyrite and cobaltite.

Tetrahedral group

The general symmetry of this group is shown in fig. 53. The crystallographic axes are axes of binary symmetry and the crystals of this type are symmetric to the six white planes of fig. 28. The cube, dodecahedron and tetrahexahedron occur in this group but are readily distinguished from the same forms of the normal type by the degree of symmetry shown in their combinations with other forms. The axes of trigonal symmetry indicated in fig. 53 constitute a characteristic feature of the group.

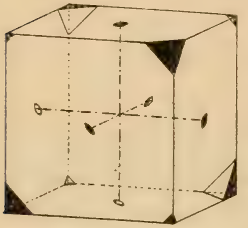

Fig. 53

Tetrahedron. The tetrahedron (fig. 54, 55, model 5) is composed of four equilateral triangular faces each of which meets the axes at equal distances. Two tetrahedrons are possible and are known as plus (fig. 54) and minus (fig. 55), the eight faces composing them corresponding to the eight like faces of the octahedron.

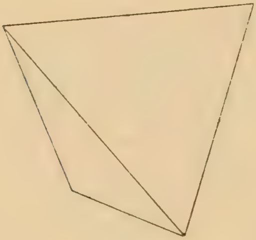

Fig. 54

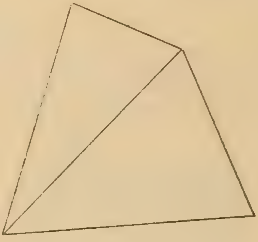

Fig. 55

Trigonal tristetrahedron. The trigonal tristetrahedron (fig. 56, 57) is composed of 12 triangular faces each of which meets two axes at equal distances and the third at a distance which is relatively less than the intercept on the other two. A plus trigonal tristetrahedron is shown in fig. 56 and the corresponding minus form in fig. 57; these bear a relation to the trapezohedron of the normal group similar to that of the tetrahedron to the octahedron.

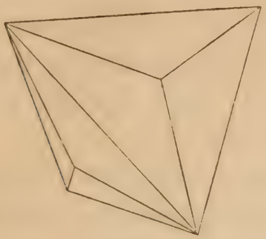

Fig. 56

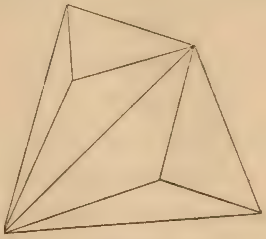

Fig. 57

Two other forms, the tetragonal tristetrahedron (fig. 58) and the hexakistetrahedron (fig. 59) are occasionally found in combination. Some combinations in this group are shown in fig. 60–65.

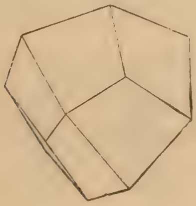

Fig. 58

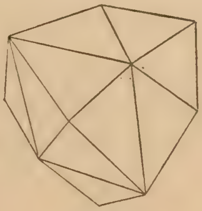

Fig. 59

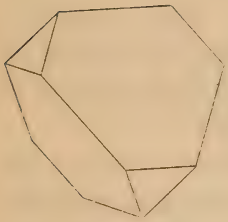

Fig. 60

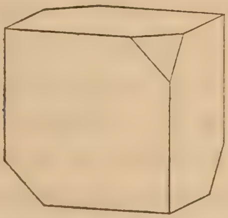

Fig. 61

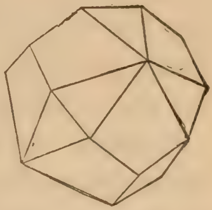

Fig. 62

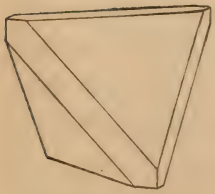

Fig. 63

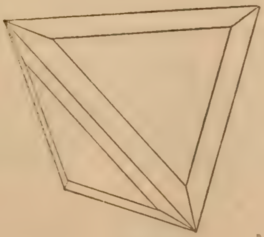

Fig. 64

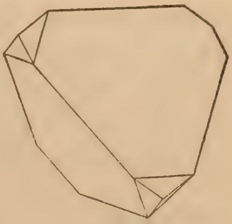

Fig. 65

Tetragonal system

Crystals in the tetragonal system can be referred to three axes, all at right angles to one another, two of which are equal and interchangeable (denoted in fig. 66 by *a*) and the third (*c*) is at right angles to the plane of the other two and is of a different length (greater or less) from the *a* axes.

The relative lengths of the *a* and the *c* axes vary in each tetragonal species, though there are several instances where this ratio differs to such a small degree in several species as to warrant placing them together in what is known as an isomorphous group.[1]

Normal group

The general symmetry of this group is shown in fig. 66. The vertical axis *c* is an axis of tetragonal symmetry and the horizontal axes *a a* are axes of binary symmetry. There are moreover two axes of binary symmetry which bisect the angles between the axes *a a*. Any form in the group is symmetric to the planes shown in fig. 67. Compare model 6.

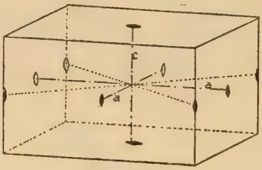

Fig. 66

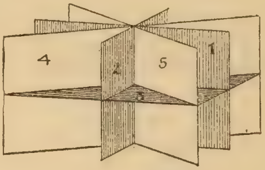

Fig. 67

Pyramids. A form composed of planes which intersect the horizontal axes *a a* at equal distances and which also intersect the vertical axis *c* is known as a pyramid of the first order and is composed of eight isosceles triangular faces. When the intercept on *c* as compared with that on *a* gives the axial ratio for any species the form is said to be the unit pyramid for that species. Fig. 68 shows the unit pyramid of zircon, the value of *c* for zircon being .64. Fig. 69 shows the unit pyramid of octahedrite where $c=1.777$.

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[1] See p. 45.

For each tetragonal species there may be several pyramids of the first order intersecting the vertical axis at multiples or fractions of the unit length *c* and producing steeper or flatter forms than the unit pyramid.

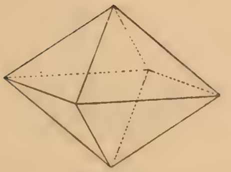

Fig. 68

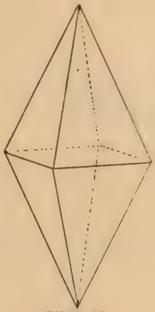

Fig. 69

The pyramid of the second order is composed of eight isosceles triangles each of which is parallel to one horizontal axis *a* and intersects the second horizontal axis *a* and the vertical axis *c*.

The second order pyramid of zircon is shown in fig. 70.

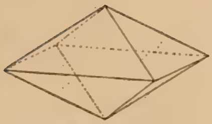

Fig. 70

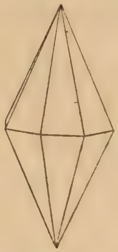

Fig. 71

The ditetragonal pyramid (fig. 71) is composed of 16 isosceles triangular faces intersecting the horizontal axes at unequal distances and also intersecting the vertical axis.

Prisms. For each type of pyramid in the normal group there is a corresponding prism having the same relative intercepts on the horizontal axes as the pyramids of the same name, and having every face parallel to the vertical axis. These prisms are denoted as follows:

Prism of the first order, having four faces, represented in fig. 72 by the faces marked *m*.

Prism of the second order, having four faces, represented in fig. 73 by the faces marked *a*.

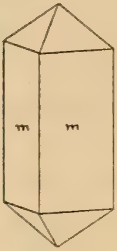

Fig. 72

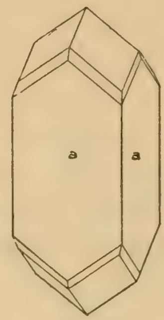

Fig. 73

Ditetragonal prism, having eight faces.

The basal plane or base consists of a pair of planes parallel to the horizontal or basal axes.

The symmetry of this group can be best observed by considering what is called the termination of the crystal, that is, the way in which the planes are grouped about the extremity of the vertical axis; two such terminations are shown in plan in fig. 74 and 75. Some of the combinations in the normal group are shown in fig. 72–80.

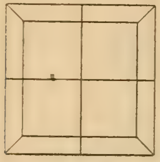

Fig. 74

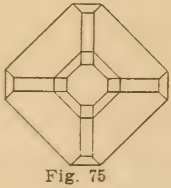

Fig. 75

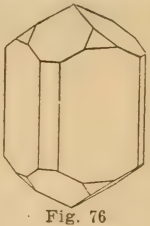

Fig. 76

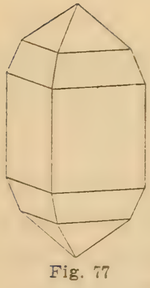

Fig. 77

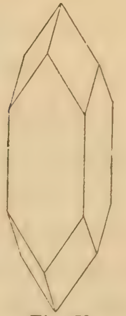

Fig. 78

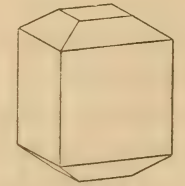

Fig. 79

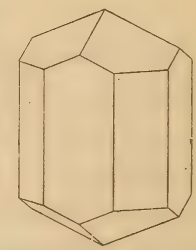

Fig. 80

Pyramidal group

The general symmetry of this group is shown in fig. 81; as in the normal group the vertical axis is an axis of tetragonal symmetry; a single plane of symmetry passes through the horizontal axes, which are not axes of binary symmetry as is the case in the normal group.

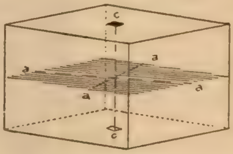

Fig. 81

The forms which have been described under the normal group occur also in the pyramidal group with the exception of the ditetragonal prism and pyramid.

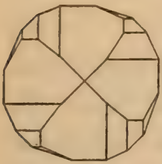
Fig. 82

The relation between the symmetry of this group and that of the preceding one may be best studied by referring to fig. 82 which shows the termination of a pyramidal crystal. The absence of vertical planes of symmetry, characteristic of this group should be noted.

Two new forms occur, namely: prism of the third order, represented in fig. 84; pyramid of the third order, represented in fig. 83 by the faces marked *x*.

The relations of the pyramid and prism of the third order to the corresponding forms of the first and second order are shown in fig. 84. Fig. 83 represents some combinations in this group.

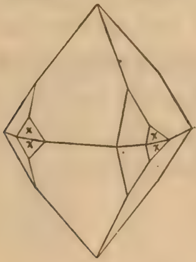

Fig. 83

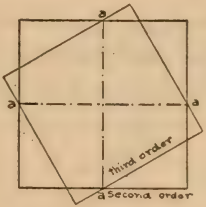

Fig. 84

Sphenoidal group

The general symmetry of this group, which is shown in fig. 85, is somewhat analogous to that of the tetrahedral group of the isometric system. The crystallographic axes are axes of binary symmetry and there are moreover, two vertical planes of symmetry (fig. 67, no. 4, 5).

This symmetry admits of two new forms.

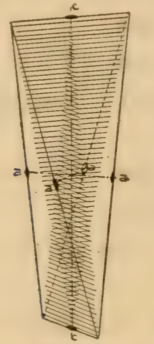

Fig. 85

Fig. 86

1 The tetragonal sphenoid (fig. 85, 86) is composed of four isosceles triangles which meet the horizontal axes at equal distances; they also intersect the vertical axis. Two sphenoids are possible which include all the faces of the pyramid of the first order of the normal group. The form is analogous to the tetrahedron of the isometric system.

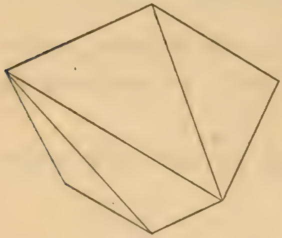

Fig. 87

2 The tetragonal scalenohedron (fig. 87) is composed of eight scalene triangles, which intersect the horizontal axes unequally. As with the sphenoid there are two complementary scalenohedrons possible for every different ratio of the intercepts on the horizontal axes. Up to the present time the scalenohedron has been found only in combination with other crystal forms of this group.

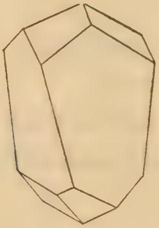

Fig. 88

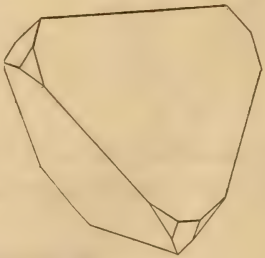

Fig. 89

Some of the combinations in this group are shown in fig. 88 and 89, which illustrate crystals of chalcopyrite.

Hexagonal system

There are in general many points of resemblance between hexagonal crystals and those which are included in the tetragonal system. This analogy is accentuated by the fact that the molecular structure of the minerals in both systems as exhibited in their optical properties show striking similarity. Hexagonal as well as tetragonal crystals are said to be optically uniaxial; that is, in every crystal of these two systems a section cut normal to the vertical axis will remain dark when viewed between crossed nicols in the polarizing microscope; any other section will show an interference color which changes to darkness or "extinction" at regular intervals as the stage of the microscope is rotated.

Hexagonal crystals are referred to four crystallographic axes, one of which is vertical and perpendicular to the plane of the other three; this vertical axis, as in the tetragonal system, is indicated by *c*. The three horizontal axes are interchangeable and at 60° from each other; they are indicated by *a*.

A Hexagonal division

Normal group

The general symmetry of this group is shown in fig. 90 and 91. The vertical axis is an axis of hexagonal symmetry and each basal axis is an axis of binary symmetry; there are also three axes of binary symmetry bisecting the angles between the crystallographic axes. Crystals in this group are symmetric to a plane of symmetry through the basal axes and to six planes of symmetry passing through the vertical axis and each of the axes of binary symmetry. The nomenclature of the forms is analogous with that used in the normal group of the tetragonal system, the forms being briefly stated as follows:

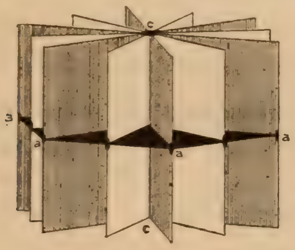

Fig. 90

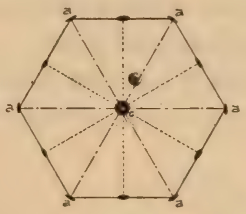

Fig. 91

PYRAMIDS

	FIG.
Pyramid of the first order	92
Pyramid of the second order	93
Dihexagonal pyramid	94

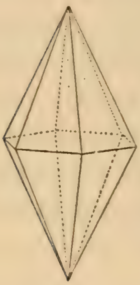

Fig. 92

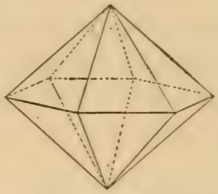

Fig. 93

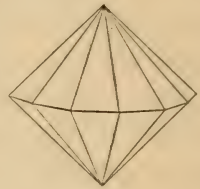

Fig. 94

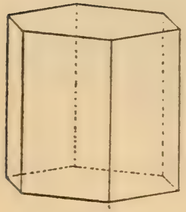

Fig. 95

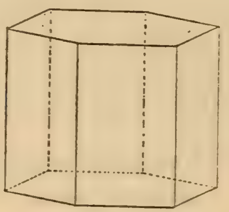

Fig. 96

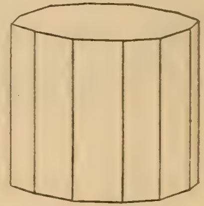

Fig. 97

PRISMS

	FIG.
Prism of the first order	95
Prism of the second order	96
Dihexagonal prism	97

The basal pinacoid is shown terminating the prisms in fig. 95-97. The relation of these forms to one another is shown in fig. 98. Two combinations in the normal group are shown in fig. 99 and 100, which represent crystals of beryl.

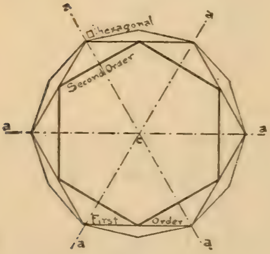

Fig. 98

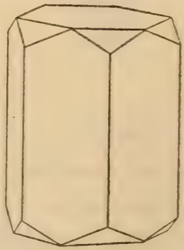

Fig. 99

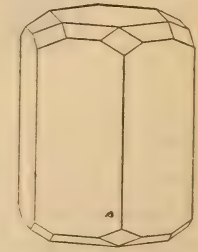

Fig. 100

Pyramidal group

The symmetry of this group resembles that of the pyramidal group of the tetragonal system in that crystals of this type are symmetric to the horizontal plane of symmetry shown in fig. 90. The vertical axis (*c*) is an axis of hexagonal symmetry. Fig. 101 gives an idea of the general arrangement of faces about this axis. The third order pyramid and prism, indicated in plan in fig. 102, are of frequent occurrence in this group, as well as the pyramids and prisms of the first and second order described above.

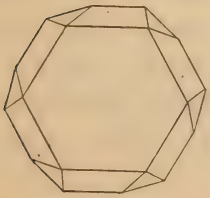

Fig. 101

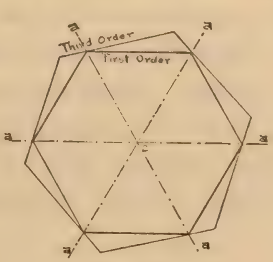

Fig. 102

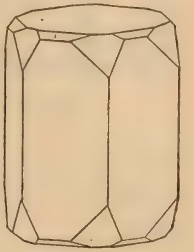

Fig. 103

The crystal of vanadinite shown in fig. 103 illustrates a combination of pyramidal forms. Apatite and pyromorphite are common minerals in this group.

B Rhombohedral division

The groups which come under this division differ from the hexagonal forms hitherto discussed in the essential feature of a vertical axis of trigonal symmetry which gives to the termination of rhombohedral crystals a trigonal as distinct from a hexagonal aspect. Compare fig. 104, which shows a termination of a rhombohedral crystal, with the hexagonal terminations shown in fig. 91 and 101. Compare also model 8 with model 7.

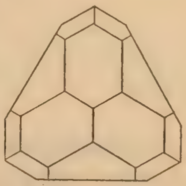

Fig. 104

Rhombohedral group

Forms in this group are characterized by a vertical axis of trigonal symmetry and three horizontal axes of binary symmetry, these axes being identical with the crystallographic axes. They are also symmetric to three planes which intersect in the vertical axis as shown in fig. 105.

Rhombohedron. The rhombohedron (fig. 106, 107, model 8) is composed of six rhombic faces, each of which intersects two basal axes at equal distances, is parallel to the third and cuts the vertical axis (*c*). The two rhombohedrons possible for every relative value of the vertical intercept are complementary plus (fig. 106) and minus (fig. 107); the 12 faces of the plus and minus rhombohedrons include all the faces of a hexagonal pyramid of the first order having the same relative intercepts. Some rhombohedrons of calcite of varying vertical intercepts are shown in fig. 107-9.

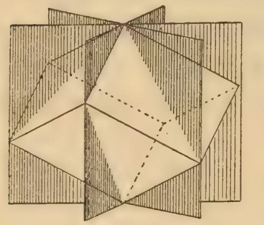

Fig. 105

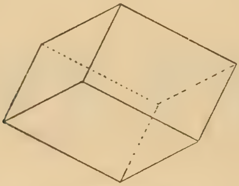

Fig. 106

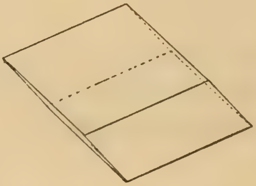

Fig. 107

Fig. 108

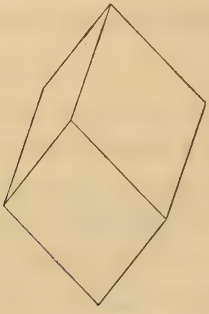

Fig. 109

Scalenohedron. The scalenohedron (fig. 110) is composed of 12 scalene triangular faces each of which cuts all four axes. As with the rhombohedron two forms are possible for every value of the vertical intercept. These are related to the dihexagonal pyramid in the same way that the rhombohedron is related to the pyramid of the first order.

The remaining forms of the rhombohedral group are geometrically the same as the corresponding forms of the normal group and are: prism of the first order; prism of the second order; pyramid of the second order; basal plane.

Some of the combinations in this group are shown in fig. 111-13.

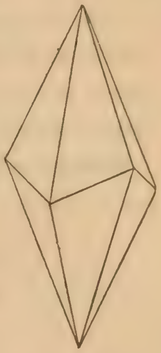
Fig. 110

Rhombohedral-hemimorphic group

Comparing this group with the preceding one, the main points of difference to be noted are the lack of symmetry to a point, which is characteristic of hemimorphic crystals, the two extremities of the vertical axis showing dissimilar modifications, and the fact which results from the above, namely, that the horizontal axes are no longer axes of binary symmetry. A crystal of tourmalin, which is an important species of this type, is shown in fig. 114 and serves to illustrate the main features of the group.

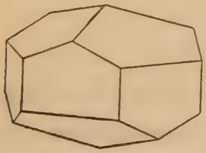
Fig. 111

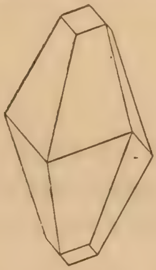
Fig. 112

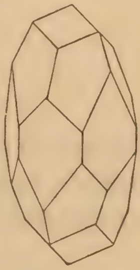
Fig. 113

Trirhombohedral group

Trirhombohedral crystals are characterized by the absence of planes of symmetry; they are, however, symmetric to a point.

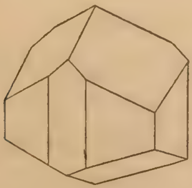
Fig. 114

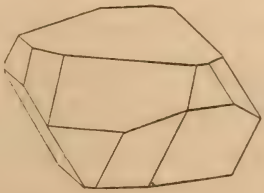
Fig. 115

The vertical axis is an axis of trigonal symmetry. The minerals ilmenite, dolomite, phenacite, dioptase and willemite occur in forms of this group. Fig. 115 shows a crystal of ilmenite.

Trapezohedral group

The forms in this group possess the lowest grade of symmetry in the hexagonal system, having no plane of symmetry and no center of symmetry; the vertical axis is, however, an axis of trigonal symmetry and the three horizontal axes (*a*) are axes of binary symmetry.

Trapezohedron. The trigonal trapezohedron (fig. 116, 117) is a characteristic form of this group and consists of six trapezohedral faces each of which cuts all the axes. Four trapezohedrons are possible; two plus, called respectively right-handed (fig. 116) and left-handed (fig. 117), and two minus forms which are also right-handed and left-handed. The 24 faces of these four forms constitute the planes of a dihexagonal pyramid.

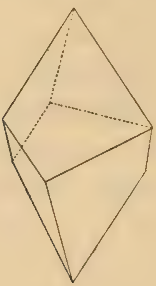
Fig. 116

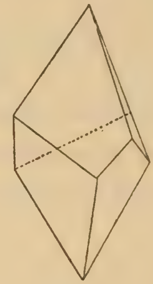
Fig. 117

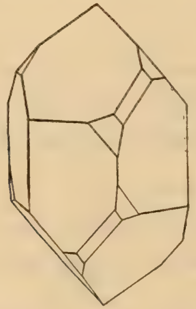
Fig. 119

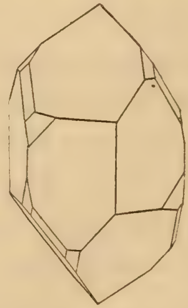
Fig. 120

The two crystals of quartz shown in fig. 119, 120 show the trigonal trapezohedron in combination with other forms of the group; they are termed respectively right-handed and left-handed forms.

Trigonal pyramid. The trigonal pyramid (fig. 118) consists of six triangular faces, each of which cuts two basal axes (*a*) at equal distances and the third at a distance which is relatively half as great, each face also interests the vertical axis.

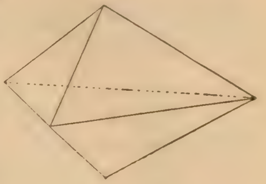

Fig. 118

Orthorhombic system

Crystal forms included in the orthorhombic system are referred to three unequal uninterchangeable axes at right angles to one another. These axes are shown in fig. 121; the shorter horizontal one, called the brachyaxis, is designated by *a*, the longer horizontal axis, called the macroaxis, by *b* and the vertical axis by *c*. The relative position of the macro and brachy axes in a crystal of any orthorhombic species is determined by the intercepts of a face occurring in that species, called a unit plane. The unit plane is selected from among those which cut both *a* and *b* axes and is preferably a plane which intersects all three axes. The intercepts of the *a* and *c* axes in terms of *b* constitute the axial ratio, which is a constant for each orthorhombic species. Difficulty is sometimes experienced in properly orienting an orthorhombic crystal owing to the fact that the crystal is often flattened in the direction of the macroaxis; thus in fig. 122, which shows a crystal of cerussite in plan, the brachyaxis *appears* to be longer than the macro because the crystal is elongated in the direction of *a*.

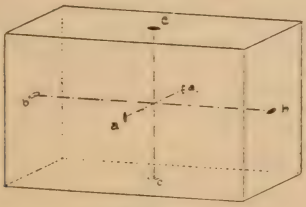

Fig. 121

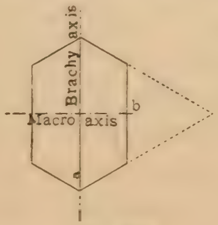

Fig. 122

Normal group

Forms of the normal group are symmetric to three planes of symmetry intersecting in the crystallographic axes, which are axes of binary symmetry (fig. 123).

Pinacoids. Planes which are parallel to two orthorhombic axes are known as pinacoids; they consist of two parallel planes and take their names from the axes to which they are parallel, thus:

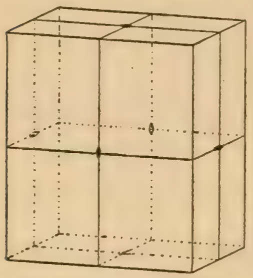

Fig. 123

The basal pinacoid is parallel to both basal axes *a* and *b*.

The macropinacoid is parallel to the macro and the vertical axis.

The brachypinacoid is parallel to the brachy and the vertical axis.

Fig. 123 shows the intersection of these three pinacoids, the resulting solid being analogous to the cube of the isometric system and the second order prism and base of the tetragonal system.

Prisms. Prisms cut both horizontal axes, and are parallel to the vertical axis; they are composed of four faces, opposite pairs being parallel. The unit prism for any species intersects the basal axes at relative distances which give the axial ratio for that species. In fig. 124, which shows a basal section of the mineral topaz, such a unit prism is indicated, the axial ratio for topaz being a:b=.529:1. Prisms occur intersecting the basal axes at distances proportionately more or less than the axial ratio subject to the law of rational indexes. These are called respectively macro or brachy prisms according as they are more nearly parallel to the macro or brachy axis than the unit prism. A macro and a brachy prism are shown in fig. 124.

Fig. 124

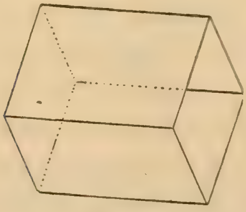

Fig. 125

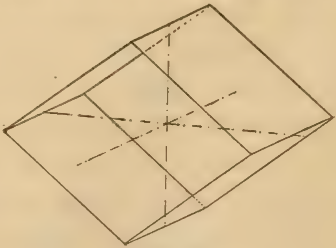

Fig. 126

Domes. Domes may be considered horizontal prisms; they are parallel to one horizontal axis and cut the other horizontal axis and the vertical axis. Like the pinacoids they take their names from the axes to which they are parallel thus:

The macrodome (fig. 125) is parallel to the macroaxis and cuts the brachy and the vertical axes.

The brachydome (fig. 126) is parallel to the brachyaxis and cuts the macro and the vertical axes.

Macrodomes and brachydomes are often repeated in series, the relative value of the vertical intercepts being subject to the law of rational indexes.

Pyramids. The single type of pyramid found in this system is shown in fig. 127 and is composed of eight faces each cutting all three axes. The unit pyramid for any species intersects the axes at distances corresponding to the axial ratio for the species.

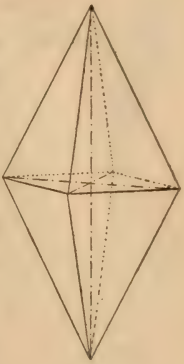

Fig. 127

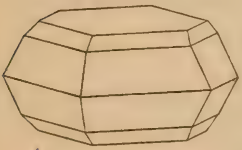

Fig. 128

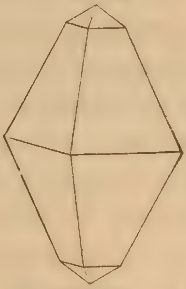

Fig. 129

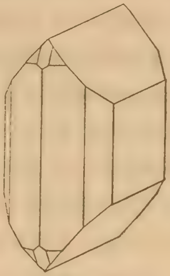

Fig. 130

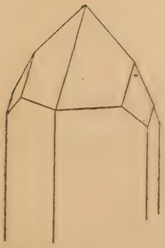

Fig. 131

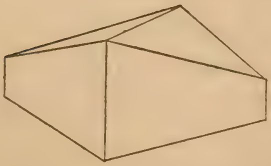

Fig. 132

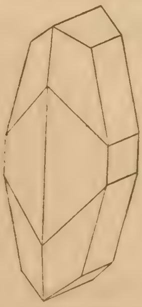

Fig. 133

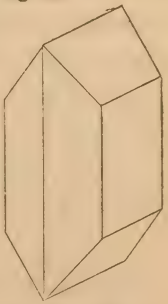

Fig. 134

As in the case of the prisms there are macro and brachy pyramids bearing relations to the unit pyramid analogous to those described under the prisms. Some combinations in this group, which includes many important species, are shown in fig. 128–34.

Hemimorphic group

The comparatively few species crystallizing in this group occur in forms which are symmetric to two planes of symmetry passing through the basal axes and intersecting in the vertical axis which is an axis of binary symmetry. The two extremities of the vertical axis are not modified in the same way, giving a different termination to the two extremities of the crystal. The crystal of calamin shown in fig. 135 gives a good example of this type.

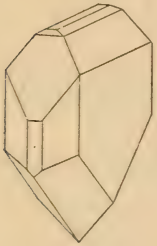
Fig. 135

Monoclinic system

Crystal forms in the monoclinic system are referred to three unequal uninterchangeable axes, two of which are inclined at an angle to each other, the third being perpendicular to the plane of the other two. The inclined axis which is placed vertical is designated by *c*, the other inclined axis by *a* and the normal or orthodiagonal axis by *b*.

A monoclinic crystal is represented conventionally with the orthoaxis (*b*) extending from right to left and the clinoaxis (*a*) dipping downward from back to front, the acute angle between the vertical and clino axes being designated by β (fig. 136). The statements regarding axial ratio under the discussion of the orthorhombic system apply in the case of monoclinic species with the additional note that the angle β varies for every species and constitutes one of the factors to be determined.

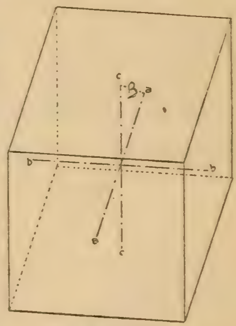

Fig. 136

Normal group

Forms of the normal group are symmetric to one plane of symmetry, which is the plane of the clino and vertical axes, and to one axis of binary symmetry, which is the orthoaxis (fig. 137).

Pinacoids. As in the normal group of the orthorhombic system, the monoclinic pinacoids are parallel to two axes and consist of pairs of parallel planes.

The basal pinacoid is parallel to both basal axes *a* and *b*.

The clinopinacoid is parallel to the clino and the vertical axis.

The orthopinacoid is parallel to the ortho and the vertical axis.

Fig. 136 shows the intersection of these three pinacoids.

Fig. 137

Prisms. The monoclinic or inclined rhombic prism cuts both horizontal axes and is parallel to the vertical axis. The clino and ortho prisms of this group are entirely analogous, in their relations to the unit prism, to the macro and brachy prisms of the preceding system. Fig. 138 shows an inclined rhombic prism terminated by a basal pinacoid.

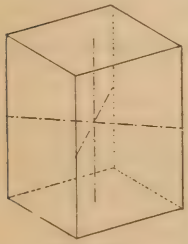

Fig. 138

Domes. The clinodome (fig. 139) consists of four faces parallel to the clinoaxis cutting the ortho and vertical axes; the faces are parallel in opposite pairs. The four faces which are parallel to the orthoaxis and intersect the other two, by reason of the lack of symmetry constitute two pairs of planes which are known as hemiorthodomes, the planes lying in the acute angle β being known as plus and those in the obtuse angle as minus. The plus and minus hemiorthodomes are shown in fig. 140.

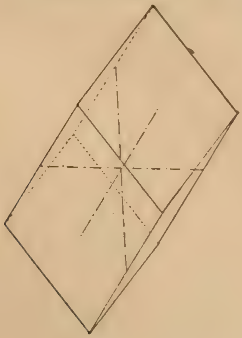

Fig. 139

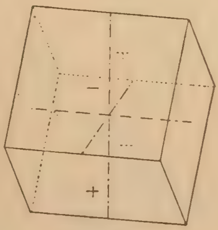

Fig. 140

Pyramids. For the same reason that the above mentioned faces are hemiorthodomes, the monoclinic forms which cut all three axes are hemipyramids. Faces in the acute angle β are plus hemipyramids and those in the obtuse angles are minus hemipyramids (fig. 141, 142). As in the case of the prisms there are unit, ortho, and clino hemipyramids.

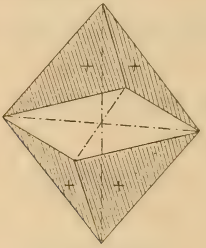

Fig. 141

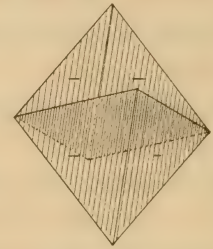

Fig. 142

Some combinations in the group are given in fig. 143–148.


Fig. 143

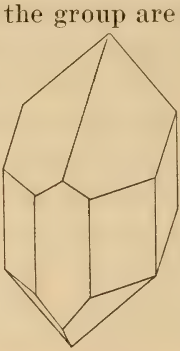
Fig. 144

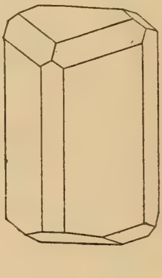
Fig. 145

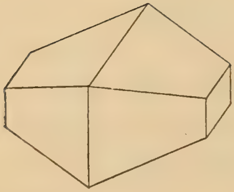
Fig. 146

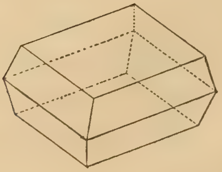
Fig. 147


Fig. 148

Triclinic system

The least symmetric of the six systems includes all forms which are referable to three unequal uninterchangeable axes all of which are inclined to one another. The axes are designated as in the orthorhombic system. The angle between *b* and *c* is called α, that between *a* and *c*, β and that between *a* and *b*, γ. These angles are distinct for every triclinic species (fig. 149).

The similarity in molecular structure between minerals of the orthorhombic, monoclinic and triclinic systems indicated by their crystallization is further accentuated by their optical properties, crystals of all three systems being optically biaxial; that is, there are two directions in which polarized light is transmitted through them without double refraction. Lines bisecting the angle between these optic axes bear a close relation to the symmetry and outward form of the crystal.

Fig. 149

Normal group

Crystals occurring in this group are symmetric only to a center, which is the point of intersection of the crystallographic axes. This symmetry admits of forms occurring only in the pairs of faces;[1] thus all prismatic and dome forms which in the orthorhombic system are represented by four faces here occur as hemiprisms and hemidomes, two faces alone being required to satisfy the symmetry of the class. Similarly, pyramidal forms which in the orthorhombic system consisted of eight faces are replaced by four complementaryforms each consisting of two parallel planes. Compare model 11, which shows a triclinic or doubly inclined rhombic prism. With the above exceptions

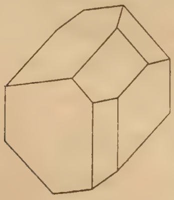

Fig. 150

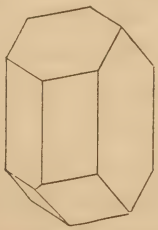

Fig. 151

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[1] See p. 10, fig. 21.

the forms are identical in nomenclature with those of the orthorhombic system.

Two examples of triclinic crystals are shown in fig. 150 and 151 which represent respectively axinite and albite.

Variations in form

Reference has been made (p. 13) to the variations between the mathematical development of a crystal form or combination of forms and the actual mineral, crystallizing in those forms, as it is found in nature. This distortion is often misleading to a beginner, cubes and other forms of the isometric system being frequently elongated in the direction of one axis to such an extent as to resemble crystals of the tetragonal, the orthorhombic or even the hexagonal system. The reader is advised to observe carefully crystals of known minerals and to bear constantly in mind the symmetry of the group to which they belong.

Crystals of mineral species from the same locality show a predominance of one or two forms, which gives to such crystals a distinguishing character known as crystal habit. Minerals which occur widely distributed often show great variety in crystal habit, producing forms which are of great interest and beauty; quartz and calcite are notable examples.

Grouping of crystals

Though the crystals of many minerals occur isolated and developed alike on all sides, having somewhat the regularity of the ideal representations, it is far more common to find them grouped together in clusters, lining the interior of cavities, springing from the accompanying rock or lying embedded in the matrix. In some species the crystals show a tendency to arrange themselves in pairs, the faces of one individual being symmetrically disposed with respect to the other but in reverse position. This intergrowth of like crystals produces what is known as a twin crystal, the resulting solid being frequently of considerable complexity. A twin crystal may be recognized by reentrant angles which distinguish it from a simple crys-

1 Quartz, New Baltimore N. Y.

2 Calcite, Fontainebleau, France

tal, all the dihedral angles of which slope outward. A twinned octahedron is shown in fig. 152; the penetration twin cube, common in fluorite is shown in fig. 153 (compare also pl. 18_1); a scalenohedron of calcite twinned parallel to the basal plane is shown in fig. 154, and a tetragonal twin of cassiterite in fig. 155. Aggregations of crystals frequently occur grouped in parallel position as shown in pl. 1_1.

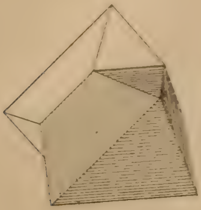
Fig. 152

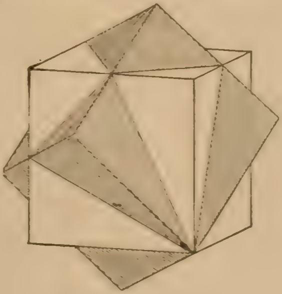
Fig. 153

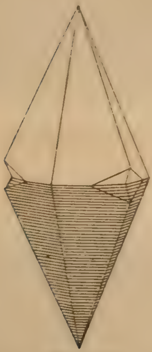
Fig. 154

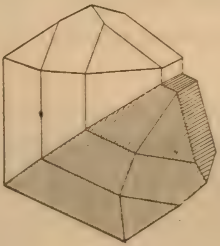
Fig. 155

Surface irregularities

Surface irregularities, occurring as they do on like faces of some crystals, often constitute a valuable means of determining the symmetry and consequently the group and system. Such markings on the faces of pyrite have been noticed in a former paragraph.[1] They are due in general to various causes which interrupt the perfect growth of the individual, producing low parallel furrows called striae or striations, angular depressions or prominences and dull faces. Curved faces are sometimes produced, as in the case of diamond.

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[1] See p. 16.

Inclusions

Foreign bodies inclosed within a crystal are described under the general name of inclusions. They may be solid, liquid or gaseous in nature and organic or inorganic in origin. In general, inclusions result from rapid crystallization, as in the case of the calcite crystals shown in pl. 1_2; these show the typical rhombohedron of calcite, though containing a large percentage of the quartz sand carried by the solution from which they were crystallized.

Crystalline aggregates

Under this head are included the great majority of mineral specimens made up of aggregates of imperfect crystals. Many masses of material which appear to have no crystalline structure can be proved by optical and other physical tests to be composed of crystalline grains.

1 **Columnar structure.** Minerals possessing a columnar or fibrous structure present the appearance of bundles of slender columns.

parallel columnar, example beryl, pl. 2_1
bladed, example cyanite, pl. 2_2
fibrous, example serpentine (chrysotile) pl. 3_1

2 **Lamellar structure.** The mineral is composed of layers or leaves.

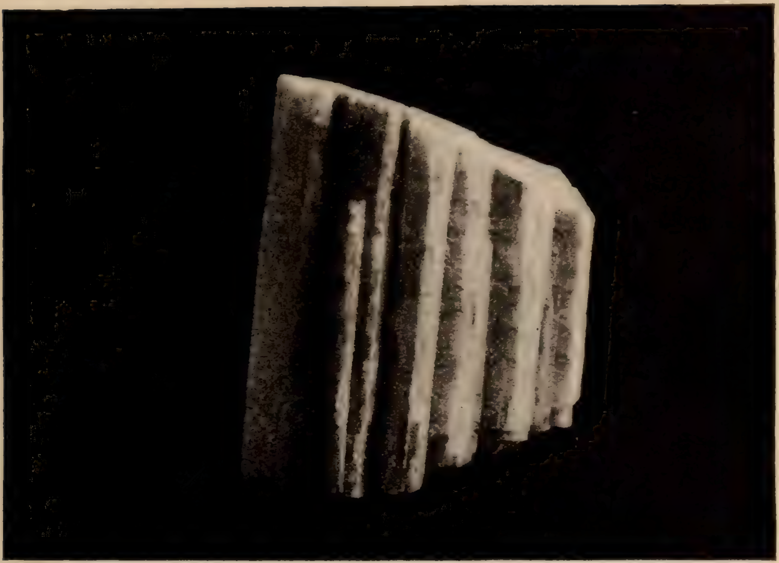
curved lamellar, example talc, pl. 3_2
foliated or micaceous, example muscovite, pl. 4_1

3 **Granular structure.** The crystalline particles consist of angular grains of about the same size.

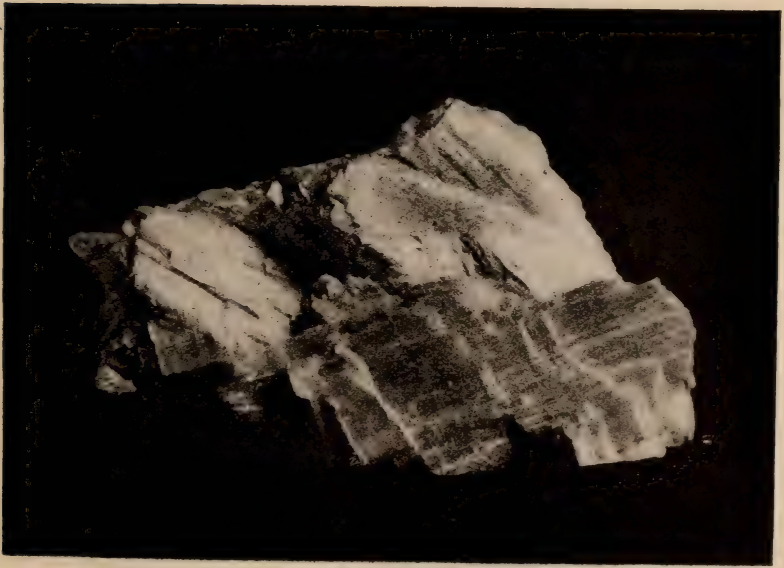
coarse granular, example magnetite, pl. 4_2
fine granular, example dolomite (marble), pl. 5_1

4 **Imitative shapes.** The arrangement of masses of imperfect crystals often give rise to forms which resemble those of animate nature. The most important terms used to describe such forms are:

reniform, kidney-shaped, example hematite, pl. 5_2
botryoidal, composed of globular individuals resembling a bunch of grapes, example quartz (chalcedony), pl. 6_1

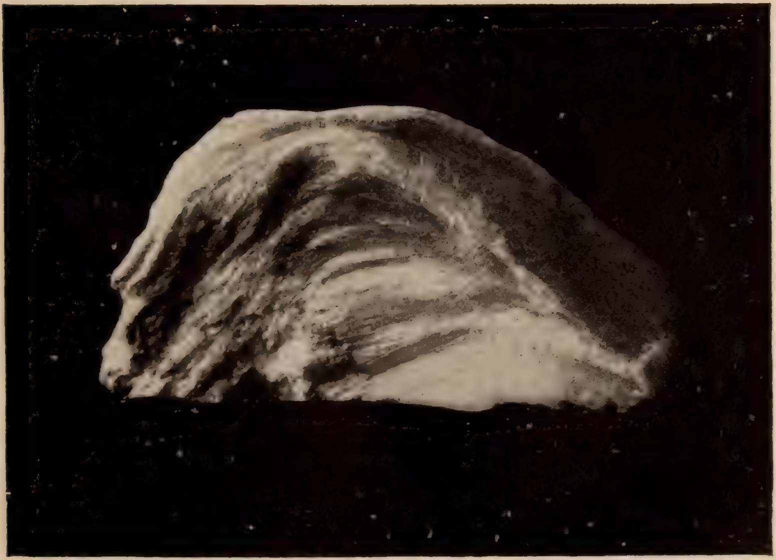


1 Beryl, Acworth N. H.



2 Cyanite, Litchfield Ct.

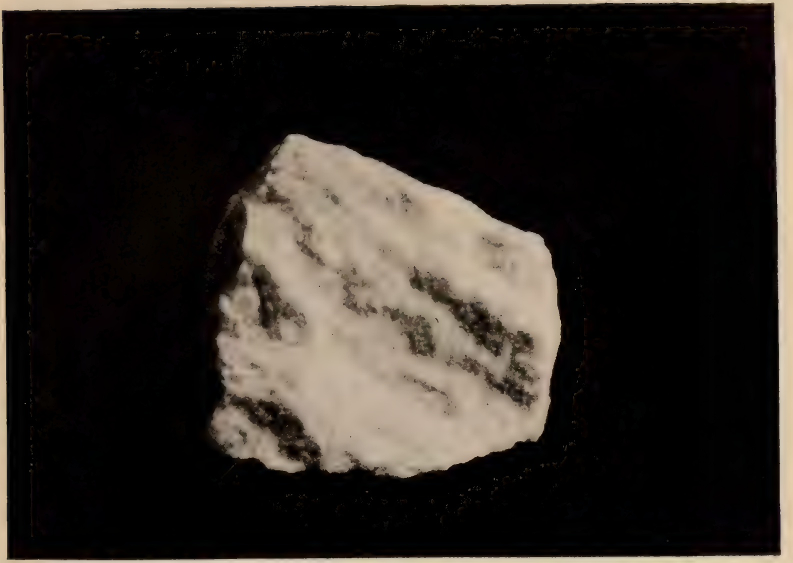
1 Serpentine (chrysotile), Danville, Quebec



2 Talc, Smithfield R. I.

1 Muscovite, Stony Point N. C.

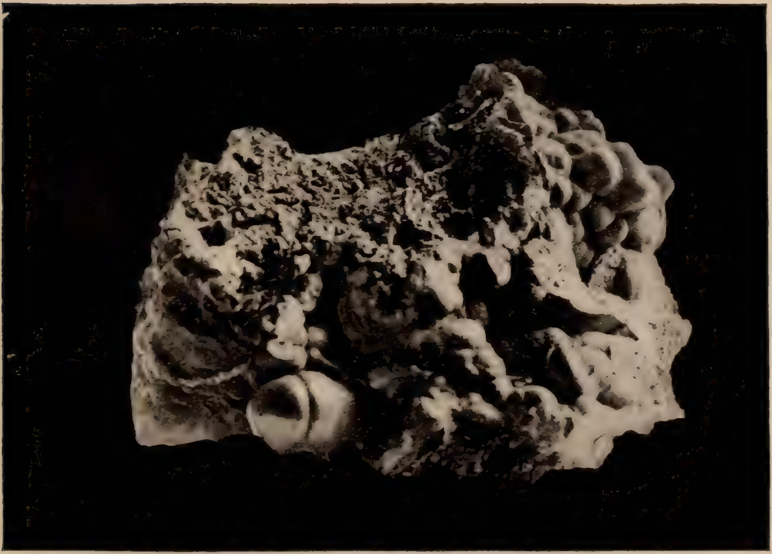
2 Magnetite, Mineville N. Y.



1 Dolomite, Dover, Dutchess co. N. Y.

2 Hematite, Cleator Moor, England

1 Quartz (chalcedony), Rocky mountains



2 Malachite, Bisbee Ariz.

1 Pectolite, West Paterson N. J.

2 Calcite (pistolite), Karlsbad, Bohemia

1 Aragonite (flos ferri), Dubuque Ia.

2 Pyrolusite (dendrite) Middle Granville N. Y.

1 Calcite (stalagmite), Howes Cave N. Y.

2 Stibnite, Felsöbânya, Hungary

1 Millerite, Antwerp N. Y.

2 Stibnite, Kremnitz, Hungary

mamillary, like the botryoidal but composed of larger and flatter protuberances, example malachite, pl. 6_2

globular, imperfect spheres of radiating fibers, examples wavellite, pectolite, pl. 7_1

oolitic, composed of small rounded grains, like the roe of fish, example calcite, pl. 7_2

coralloidal, consisting of branching forms like coral, example aragonite, pl. 8_1

dendritic, in branching treelike forms, example pyrolusite, pl. 8_2

stalactitic, in pendant columns from the roofs of caves, formed by percolation of water carrying dissolved material, example calcite, limonite, pl. 9_1

acicular, slender, needlelike forms, example stibnite, pl. 9_2

capillary, hairlike, example millerite, pl. 10_1

reticulated, interlaced fibers like a net, example stibnite, pl. 10_2.

Cleavage

Closely related to the crystalline structure of a mineral is the tendency, common in a varying degree to most mineral species, to break or split parallel to certain crystallographic planes. This tendency, which is called cleavage, takes place along the lines of minimum cohesion. Thus in a cube, the molecular arrangement of which is shown in fig. 2, it would be reasonable to expect cleavage to take place along planes parallel to the cube faces, that is, along the planes of molecular crowding. In fig. 156, assuming the dots to represent the position of molecules, the lines of least resistance to cohesion and consequently the lines of cleavage would be the vertical and horizontal rather than either of the inclined lines because the parallel lines of molecules on either side of the vertical and horizontal directions are further apart and consequently the attractive force between adjacent molecules would be least along these lines.

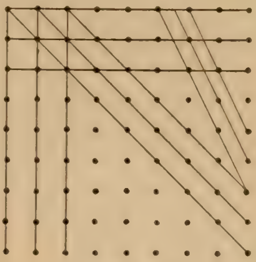


Fig. 156

In isometric minerals cleavage takes place parallel to the faces of the cube, octahedron or dodecahedron. A good example of cubic cleavage is presented by the specimen of galena shown in pl. 11_1.

Tetragonal and hexagonal minerals show basal, prismatic or more rarely pyramidal cleavage. Rhombohedral cleavage is common among minerals crystallizing in the rhombohedral division of the hexagonal system. The rhombohedral cleavage of calcite is shown in pl. 11_2.

In the orthorhombic system cleavage parallel to one or more pinacoids is common, also prismatic cleavage. Clinodiagonal cleavage, parallel to the clinopinacoid, is found in many monoclinic species; also basal and prismatic cleavages and occasionally cleavage parallel to the hemipyramids as with gypsum.

In the triclinic system it is customary to select the axes so as to make the cleavage directions parallel to the pinacoids.

The parallel planes produced by cleavage may sometimes be advantageously observed by holding the specimen so as to reflect the light from a prominent face, and noting how the cleavage faces, previously hidden by the rough surface of the specimen, catch and reflect back the light. Cleavage is also evidenced by reflections from the interior of the crystal, incipient cracks and many other traces which appeal to the eye of a trained observer.

Fracture

The fracture of a mineral is observed on a broken surface other than a cleavage plane. It may be:

1 conchoidal, with a smooth, curved surface like broken glass or porcelain;

2 even, with more or less regular depressions and elevations;

3 uneven, with a rough, irregular surface;

4 hackly, with sharp, jagged elevations like broken iron.

Hardness

The degree of resistance offered by the smooth surface of a mineral to abrasion is known as hardness. A relative scale of hardness of 10 common minerals is arranged as follows:[1]

1 talc

2 gypsum

3 calcite (crystallized)

4 fluorite

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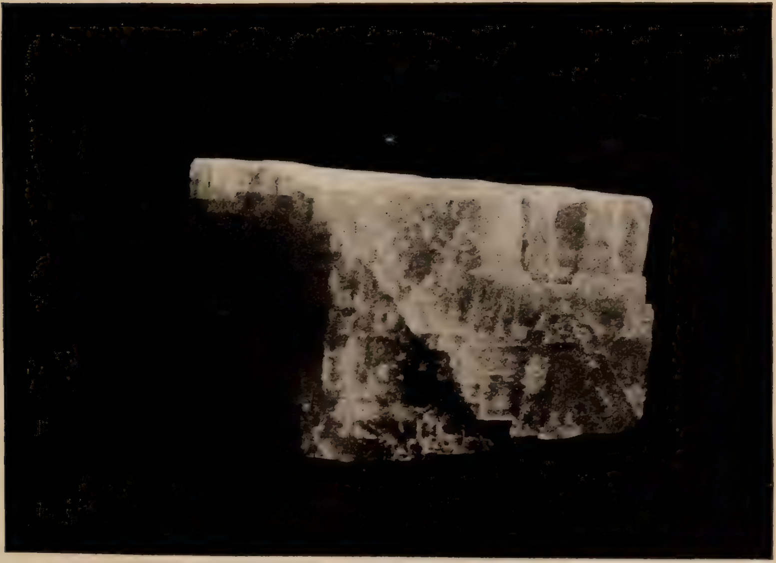
[1] This scale of hardness was introduced by Mohs and is now generally accepted.

1 Galena, Rossie N. Y.



2 Calcite, Glenville, Schenectady co. N. Y.

5 apatite
6 orthoclase
7 quartz (rock crystal)
8 topaz
9 corundum
10 diamond

A sharp corner of the mineral to be tested for hardness is rubbed across the surface of each successive member of the scale, beginning with the high members, till one is found which is distinctly scratched; the hardness thus determined lies between that of the scale mineral scratched and the next higher member; thus, a mineral which scratches calcite but does not scratch fluorite has a hardness of 3–4. A good knife will scratch 6 with difficulty.

Tenacity

A mineral may be:

1 brittle, when it falls to powder before a knife or hammer and can not be shaved in thin slices;
2 sectile, when it can be shaved in thin slices but falls to powder under the hammer;
3 ductile, when slices shaved from it may be flattened under the hammer;
4 flexible, when it will bend without breaking.

Characters depending on light

Luster

Differences in the luster of minerals are due to the light which is reflected from the surface; luster is independent of the color of the mineral. The luster of a mineral may be:

1 metallic, the luster exhibited by opaque metals, example pyrite;
2 adamantine, the oily luster of the uncut diamond, example cerussite;
3 vitreous, the luster of glass, example quartz;
4 resinous, the luster of yellow resin, example sphalerite;
5 greasy, the luster of oiled glass, example elaeolite;
6 pearly, the luster of the mother of pearl, example brucite;
7 silky, the luster of silk produced by a fibrous structure, example satin spar;
8 dull, void of luster, example kaolin.

Color

The color of a mineral is a matter of considerable variation, different specimens of the same species frequently differing through quite a wide range. This is notably so of the minerals of nonmetallic luster, as in the case of fluorite, which is found in white, yellow, green, rose-red, violet, blue, brown, wine color and greenish blue varieties. Metallic minerals are far more constant in color, a fresh fracture ordinarily giving the characteristic color of the species.

The color of the fine powder of a mineral is known as its streak and often differs from the color of the hand specimen. With soft minerals it may be readily obtained by rubbing the specimen on a piece of unglazed porcelain.

General principles of chemical classification

A substance which can not be decomposed or separated into simpler constituents is known as an element. About 70 such elements are recognized at present, less than half of which are of common occurrence. It is estimated[1] that 99% of the solid crust of the earth for a depth of 10 miles is composed of eight elements as follows:

oxygen	47.3%	calcium	3.8%
silicon	27.2	magnesium	2.7
aluminium	7.8	sodium	2.4
iron	5.4	potassium	2.4

For convenience elements are represented in chemical formulas by symbols which consist of the initial letter of the name of the element or an abbreviation composed of two letters, thus:

P=phosphorus
S=sulfur
O=oxygen

Na=sodium (natrium)
Ca=calcium
Pb=lead (plumbum) etc.

In the appendix will be found a table giving the names of the elements, their symbols and their relative atomic weight. Some elements occur native or alone in nature, such as gold, silver, copper, carbon, sulfur, etc. but the great majority of

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[1] Clarke, F. W. Relative abundance of the chemical elements. Phil. soc. of Washington. Bul. 9. 1889. p. 138.

mineral species are compounds of two or more elements united according to the laws of chemical combination.

A few predominant chemical compounds make up the greater part of the earth's crust. Of these, silica (SiO_2), a combination of silicon and oxygen, is the most important. This forms quartz and its numerous varieties, amethyst, agate, flint, etc.; and, combined with other elements, often with an extremely complicated chemical composition, silica makes the great group of silicates, which includes the larger number of the common rock forming minerals. Oxygen combined singly with an element forms another great group, the oxids to which many ores, such as those of iron, belong. Combined with aluminium oxygen forms alumina (Al_2O_3), a common mineral; and this combined with silica is the base of our clays and an important rock constituent. Oxygen with carbon and some other elements forms the carbonates to which limestone belongs; with sulfur and some other elements it forms the sulfates (gypsum, etc.); and with phosphorus and another element the phosphates. Sulfur, without oxygen, combined with an element forms a sulfid, fluorin a fluorid, chlorin a chlorid, etc.[1]

The most satisfactory classification of mineral species is that based on chemical composition. Under sections having a similar chemical composition, species are divided into groups which usually embrace minerals closely allied crystallographically. Throughout the succeeding section the chemical composition of each species is given in words and symbols, which, while appealing specially to the chemist, can be readily understood by those who bear in mind that in each mineral those elements are found whose abbreviations appear in the symbol. Numbers below the sign indicate the relative number of atoms of each element. Example, realgar is a sulfid of arsenic, and the signs of sulfur (S) and arsenic (As) appear in its symbol (AsS); or, there is one atom of sulfur and one of arsenic united, but arsenic is relatively heavier than sulfur (see table of elements in appendix) therefore the composition by weight is in percentages: sulfur, 29.9; arsenic, 70.1; 100.

Isomorphism, dimorphism, etc.

It has been found in a number of cases that mineral species so related by chemical composition as to form part of one of the

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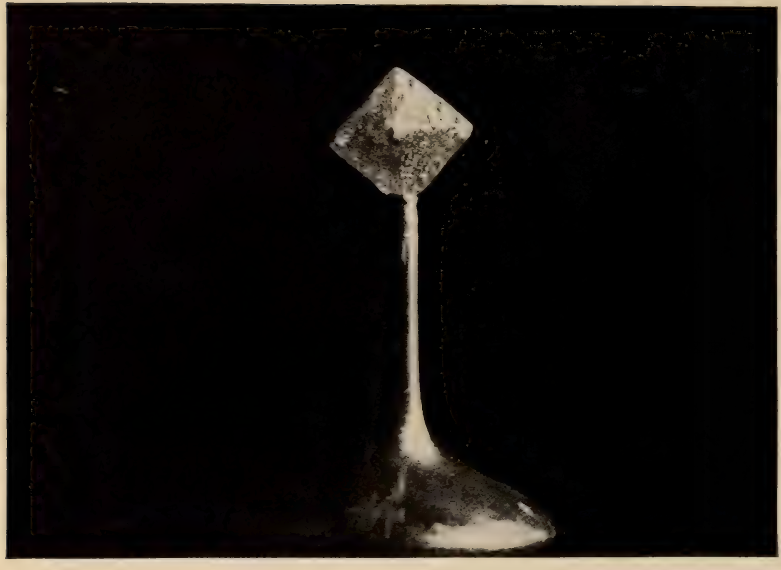
[1] Tarr, Ralph S. Economic geology of the U. S. 1894.

mineralogic divisions, such as carbonates, oxids, silicates, etc. also present a strikingly close similarity in the arrangement of their molecules as shown by their crystallization, cleavage and optical properties; minerals so related are said to form an isomorphous group.

In some instances a combination of elements occurs crystallized in two or more series of crystal forms which are notably separate and distinct and frequently present the symmetry of different systems; this gives rise to two (sometimes three) species of identical chemical composition and is known as dimorphism (or trimorphism where three species are concerned). A very good example of dimorphism is presented by the carbonate of calcium, which crystallizes in the rhombohedral group of the hexagonal system as the mineral calcite and in orthorhombic forms as the mineral aragonite. Calcite stands at the head of an isomorphous group of carbonates which all crystallize in very closely related rhombohedral forms. Similarly aragonite represents an isomorphous group of orthorhombic carbonates which agree very closely in axial ratios and crystal habit.

Pseudomorphs

Not uncommonly the composition of a crystallized mineral will undergo some change by reason of the addition, loss or replacement of one or more elements. Thus pyrite, which is a sulfid of iron, may, under certain conditions, undergo a change of composition, the sulfur being replaced by oxygen and some water and the resulting mineral will have the composition of limonite. This change is *not* accompanied by a corresponding change in external form, therefore the altered substance will present the crystallization and structure of the original mineral but the composition, color, luster and hardness of the mineral to which it has altered. Such a product of alteration is called a pseudomorph. In the above instance limonite is said to form a pseudomorph after pyrite.



1 Diamond, Kimberley, South Africa

2 Silver, Freiberg, Saxony

PART 2

DESCRIPTION OF MINERAL SPECIES

NATIVE ELEMENTS

Native elements are divided into two groups, metals and nonmetals; between these two is inserted a series of semimetals which partake, sometimes of the nature of the metals and sometimes of the nature of the nonmetals.

NONMETALS

Diamond, carbon C

Diamonds are usually found in isolated, rounded, isometric crystals, octahedrons or modified octahedrons (pl. 12_1). They are transparent, with an adamantine luster, like oiled glass, and are commonly colorless or faintly tinted.

The diamond is the hardest substance known; this, together with its high refractive power and easy octahedral cleavage, renders it particularly suited for a gem stone, while the comparative rarity of unflawed crystals and the difficulty experienced in cutting them owing to their extreme hardness, combine to make diamonds objects of considerable value. Massive and impure varieties are used for abrasive materials and in such cutting machinery and tools as require very hard edges. These massive varieties are known as bort and carbonado. Bort consists of rounded forms of confused crystalline structure. Carbonado is a black, massive form without cleavage.

Diamonds occur chiefly in alluvial deposits of gravel, sand or clay, the associated minerals being those common to granitic rocks. Diamonds were formerly extensively obtained from India, which has produced many remarkable gems; later they were discovered in Brazil, but the present great diamond producing region is South Africa.

Graphite, carbon C

Like the diamond, graphite is composed of carbon sometimes containing iron, clay, sand or other impurities. It occurs in soft black flakes or scales which are rarely hexagonal in shape.

Graphite has a basal cleavage, splitting into plates which are flexible and slightly sectile, its luster is metallic and its color black to gray.

Graphite occurs in beds and as embedded grains in granite, gneiss, mica schist and crystalline limestone. It is quite widely distributed throughout New York, appearing notably at Hague from which locality a large proportion of the American output is obtained.

Graphite is used largely in the manufacture of crucibles and other refractory vessels, in the so called "lead" pencils and for many other purposes.

Sulfur S

Sulfur is found in orthorhombic pyramids as in fig. 157, or modifications of the same, fig. 158, the crystals are often transparent and in the Sicilian variety extremely beautiful. Sulfur is also found massive, reniform, stalactitic, incrusting other minerals, as in the varieties found near hot springs and in the form of a powder. The color is commonly a lemon-yellow but not infrequently shades into yellow orange, brown or gray. The luster is resinous and the streak white. Sulfur is found notably in the regions of active or extinct volcanic action, as a deposit from hot springs and as a product of the decomposition of sulfids and sulfates. It occurs in large deposits in the island of Sicily; it is also distributed to some extent throughout the western part of the United States and has been known to occur sparingly near the sulfur springs of New York.

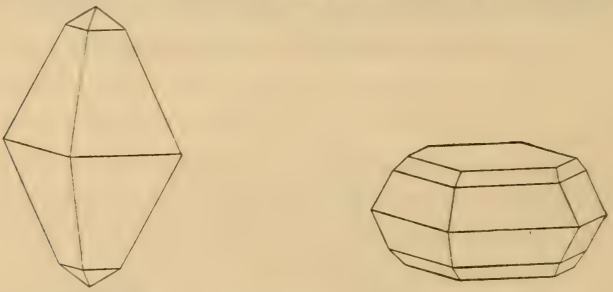


Fig. 157 Fig. 158

Sulfur

Sulfur is used in large quantities in the manufacture of sulfuric acid, gunpowder, matches etc.

SEMIMETALS

Arsenic. Arsenic is usually found in massive forms, the structure being reniform, and is composed of concentric layers which can frequently be separated with ease. Crystals are quite rare. The color is tin-white, tarnishing to black, and the luster is nearly metallic. It occurs in veins in crystalline rocks and in the older schists.

Antimony. Usually found in massive forms, lamellar or radiated, of a tin-white color and metallic luster. Rhombohedral crystals are of rare occurrence.

Bismuth. Bismuth is found in brittle, silver-white, arborescent forms which, on a fracture of the ground mass, resemble Hebrew characters; also foliated and granular. The luster is highly metallic and the color white, sometimes taking a reddish tinge. It is rarely found in distinct hexagonal crystals.

METALS

Gold Au

Gold is usually found alloyed with small amounts of silver and sometimes copper and rare metals. Distinct isometric crystals are rare though skeleton crystals and distorted octahedrons in wirelike, arborescent and reticulated shapes are quite common. Nuggets, grains and scales are also characteristic, usually disseminated through the gold-bearing rock in such small quantities as to be perceptible only by assay methods. It is of a fine yellow color, has a metallic luster and is extremely malleable and ductile.

Gold occurs in veins, usually in quartz rock, where it is associated with sulfids, specially pyrite. It is largely mined from superficial deposits of sand, gravel and boulders formed in the valleys and river bottoms from the erosion of higher rocks containing gold veins. These beds of gold-bearing material are called placers.

Gold is used chiefly for coinage, jewelry and gilding.

Silver Ag

Silver is found in nature quite pure though sometimes alloyed with gold, copper and other metals. Isometric crystals are of rather more frequent occurrence than in the case of gold; parallel groupings of cubes are quite common; these pass into distorted fernlike and wirelike forms similar to those shown in pl. 12_2. Silver is a soft, malleable metal, silver-white on the fresh fracture but tarnishing to dark gray or black.

Silver occurs in veins traversing gneiss, schist, porphyry and other rocks and is also associated with copper in calcite. It is commonly carried in small amounts by galena. Some of the more important localities where it is found are Kongsberg, Norway; Saxony; Peru; northern Mexico; also Michigan, Colorado, Idaho, Montana and Arizona. An unsuccessful attempt to mine silver in the vicinity of Ossining was made early in the last century.

Silver is used for much the same purposes as gold.

Copper Cu

Copper occurs in soft, red, malleable crystals of the isometric system, disseminated masses and sheets. The common crystal forms are the cube and tetrahexahedron alone or in combination as shown in fig. 159; distorted and twisted crystals pass from parallel groups to branching arborescent forms (pl. 13_2). Twins are quite common but are, however, almost invariably distorted. The luster is metallic and the color and streak red, the former often tarnished nearly black.

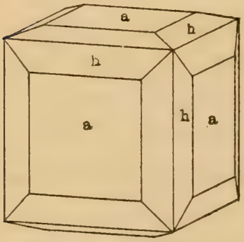


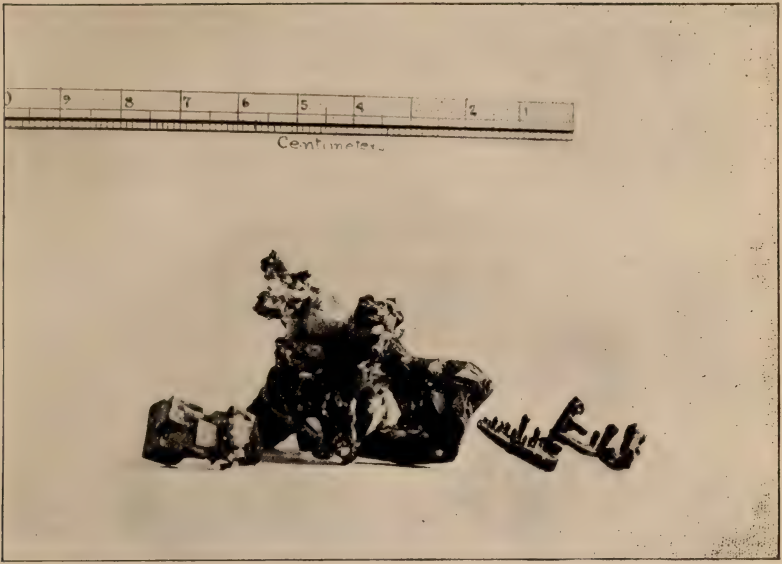
Fig. 159
Copper

Copper occurs in beds and veins with native silver and the various copper ores and is frequently found near dykes of igneous rock. In the Lake Superior region in northern Michigan it occurs in dolerite and sandstone associated with calcite, datolite, analcite, etc.

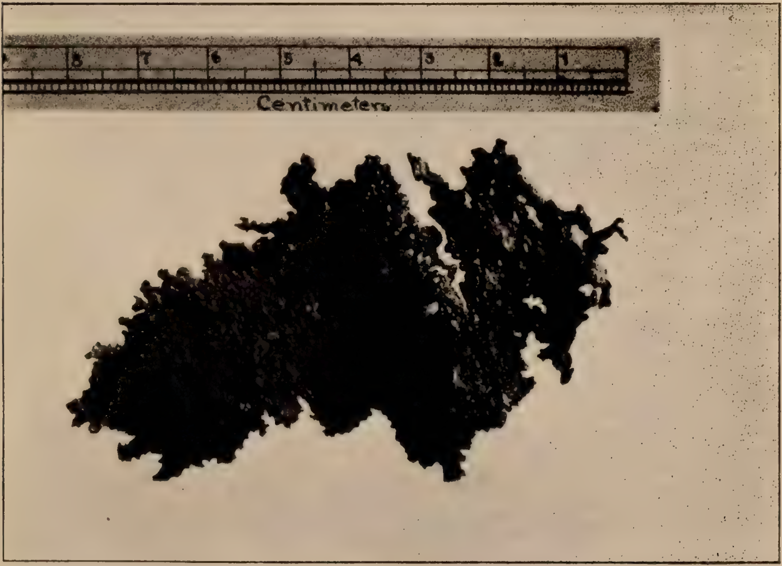
Copper is largely used in electric work and in alloys such as brass, bronze, bell metal, German silver, etc.

Plate 13

To face p. 50



1 Copper, Lake Superior, Mich.



2 Copper, Yadkin gold mine, N. C.

Mercury Hg

Mercury is remarkable as being almost the only mineral occurring in the liquid state. It is found in small white metallic globules scattered through its gangue, which is usually its own sulfid, cinnabar.

It occurs chiefly in clay shales and schists.

Platinum Pt(Fe)

Platinum as it occurs in nature is almost invariably alloyed with iron and usually with small quantities of the rarer metals. It is found in small malleable grains or nuggets of a steel-gray to white color scattered through alluvial sand and associated with gold. It is often mined with the gold from these placer deposits.

A large proportion of the production of platinum is taken from the placer deposits of the Ural mountains. It is also known to occur in Borneo, Brazil and the United States of Colombia.

Platinum is practically infusible and is consequently used to a large extent for chemical apparatus which is required to resist a high degree of heat.

Iron

See under meteorites.

SULFIDS, SELENIDS, TELLURIDS, ARSENIDS, ANTIMONIDS

SULFIDS, ETC. OF THE SEMIMETALS

Realgar AsS

Realgar is a monosulfid of arsenic. It occurs in translucent, orange-red granular masses with a resinous luster, also in transparent monoclinic crystals, which are short prismatic in habit and are striated vertically.

Realgar is found in Hungary and in the island of Borneo; it also occurs in Utah, California and Wyoming. It is used as a pigment.

Orpiment As_2S_3

Orpiment is the trisulfid of arsenic. It sometimes occurs in imperfect orthorhombic crystals but more generally in foliated or columnar masses of a brilliant lemon-yellow. When foliated it can be readily separated into thin, flexible, nonelastic scales. Orpiment is soft (H-1.5-2), slightly sectile and has a resinous or pearly luster.

It is often found associated with realgar. The principal localities are Hungary, Borneo, Turkey; also Wyoming, Utah and Nevada. It is found in the form of powder at Edenville N. Y.

Stibnite (antimony glance) Sb_2S_3

Stibnite is the trisulfid of antimony containing sulfur 28.6%, antimony 71.4%.

It is found in orthorhombic crystals of prismatic habit; a typical termination is shown in fig. 160. The crystals, which are frequently acicular, show a tendency to arrange themselves in radiating and reticulated groups (pl. 9_2, 10_2). They are grooved and striated vertically and are sometimes bent and twisted. The color and streak are lead-gray and the luster metallic with brilliant reflecting surfaces. Stibnite is quite soft, the hardness being about 2, and has an easy cleavage parallel to the vertical axis. It often occurs in massive forms coarse or fine columnar and sometimes granular.

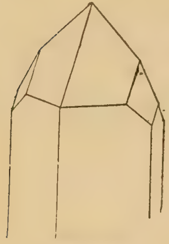


Fig. 160
Stibnite

Stibnite occurs in Hungary, Japan and New South Wales; also in Nevada, Idaho, Utah, California, Arkansas and Nova Scotia.

Stibnite is the chief source of antimony and is also used quite extensively in the production of safety matches, percussion caps, fireworks and rubber goods, and in the refining of gold.

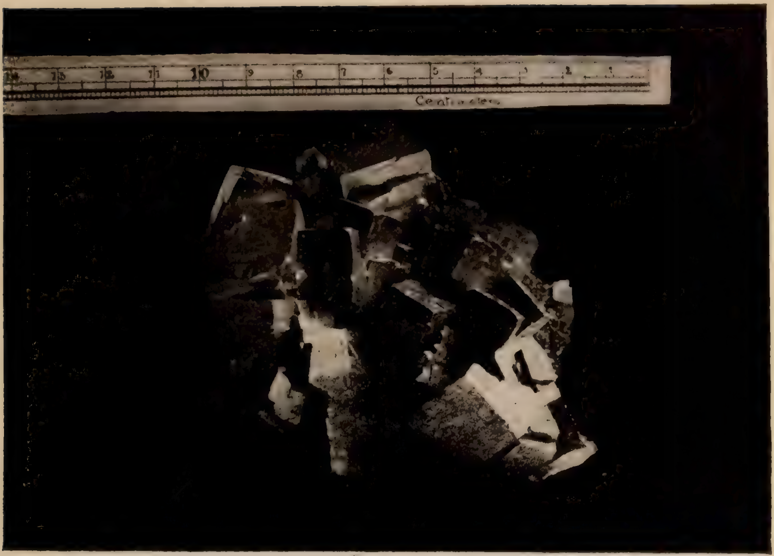
SULFIDS, ETC. OF THE METALS

Galena (galenite, lead glance) PbS

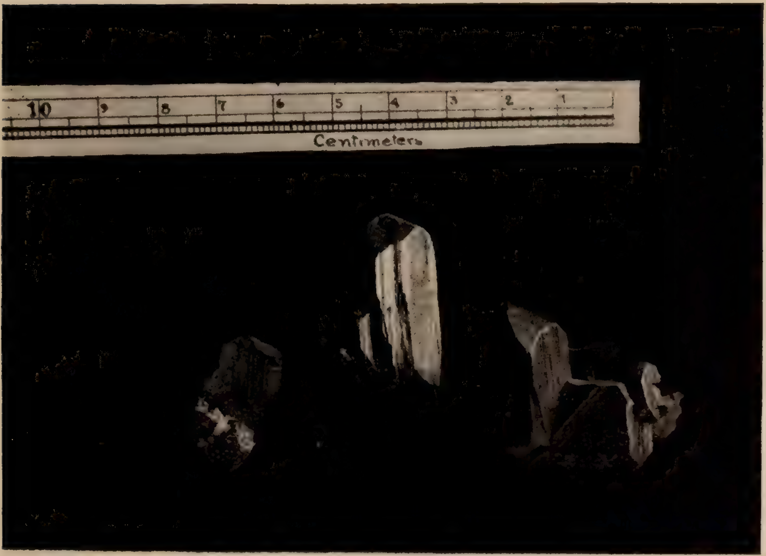
This important mineral is the sulfid of lead, containing sulfur 13.4% and lead 86.6%.

It is found crystallized and massive and is characterized by a very marked cubic cleavage (pl. 11_1). The crystals, some of which are shown in fig. 161–63 are isometric, the cube and octahedron being the prevailing forms. The crystal group shown in pl. 14_1, gives some idea of the crystal habit and irreg-

Plate 14



1 Galena, Galena Ill.



2 Chalcocite, Bristol Ct.

ular grouping. Distorted crystals are frequent, as in the specimens from Gonderbach, Nassau (N. Y. state museum collection). Twin crystals are also common. Galena is lead-gray in color and streak; it is soft (H–2.5) and very heavy. The luster is metallic and bright on a fresh fracture but apt to become dulled and oxidized on crystal faces which have been long exposed.

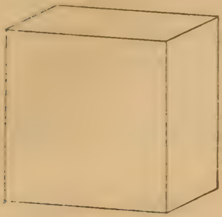


Fig. 161

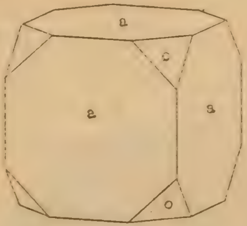


Fig. 162

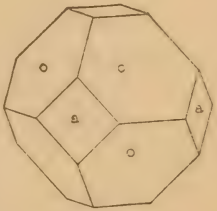


Fig. 163

Galena

Galena is very widely distributed. It occurs in veins in crystalline and noncrystalline rocks and is commonly associated with other sulfids and other salts of lead, which latter are frequently the result of its alteration. In addition to numerous and important foreign localities it occurs in the United States in extensive deposits in Missouri; also in Illinois, Iowa, Wisconsin, and in New York at Rossie, St Lawrence co., Ellenville, Ulster co. and Wurtzboro, Sullivan co.

Galena is the principal ore of lead and is extensively worked in Colorado, Idaho, Montana and other western states for the silver it usually contains.

Argentite (silver glance) AgS

The sulfid of silver contains 12.9% sulfur and 87.1% silver.

The crystals are isometric, of an octahedral habit, and are often modified by the cube; distorted forms are quite common as are parallel groupings which produce arborescent forms. It also occurs massive. Argentite is soft and sectile; it has a lead-gray color and metallic luster.

It occurs at Freiberg, Germany; in Hungary, Norway, Cornwall, Peru, Chile and Mexico. In the United States it is found in Nevada and Arizona and in the Lake Superior region of Michigan. It is mined for silver.

Chalcocite (copper glance) Cu_2S

Chalcocite is a copper sulfid containing 20.2% sulfur and 79.8% copper.

Though often occurring in orthorhombic crystals (pl. 14_2) chalcocite is more frequently met with in masses which somewhat resemble argentite but are much more brittle; it may be distinguished from bornite by the absence of the characteristic red-brown color peculiar to bornite. The luster is metallic and the streak and color lead-gray, the latter taking a dull black tarnish on exposure.

Chalcocite occurs commonly associated with other copper minerals. Beautiful specimens of this mineral are found in the Cornwall mines. It occurs also in Bohemia, Saxony, Mexico and South America. Interesting crystals are found at Bristol Ct., and massive varieties to considerable extent at Butte Mont.

Chalcocite is an ore of copper.

Sphalerite (zinc blende or blende) ZnS

The zinc sulfid known as sphalerite or blende contains 33% sulfur and 67% zinc.

Sphalerite often contains cadmium manganese and iron in small quantities. It crystallizes in the tetrahedral group of the isometric system (fig. 164, 165). In specimens from some localities the modification of the dodecahedron shown in fig. 165 has a tendency by reason of repeated twinning to form a somewhat curved face as in the specimen shown in pl. 15_1. Massive varieties are very common and show a perfect dodecahedral cleavage. Compact masses of alternating layers of sphalerite and galena also occur. The color ranges from black through red, brown, yellow, green, to white, the more frequent shades being

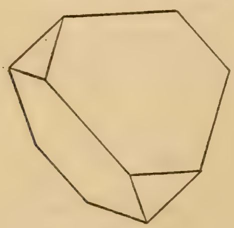


Fig. 164

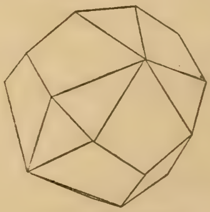


Fig. 165

Sphalerite

Plate 15

To face p. 54

1 Sphalerite, Joplin Mo.

2 Millerite, Gap mine, Lancaster co. Pa.

black, brown and yellow. The streak is yellowish brown to white and the luster resinous.

Sphalerite occurs in both crystalline and sedimentary rocks and is frequently associated with galena. Such an association is found in the extensive deposits of Missouri, Wisconsin, Iowa and Illinois. Sphalerite is found in several localities in England and Germany, also in Hungary, Sweden, Spain, etc. In New York it is found in small quantities in a number of places, notably at Wurtzboro, Sullivan co., Ellenville, Ulster co., at the Ancram lead mine in Columbia county, in the limestone of Lockport, Niagara co., and with calamin at Bethlehem Pa.

Besides being an important ore of zinc, sphalerite yields considerable cadmium.

Cinnabar HgS

The sulfid of mercury, cinnabar, contains 13.8% sulfur and 86.2% mercury.

The mineral is rarely found in hexagonal crystals of the rhombohedral-trapezohedral group; it is commonly met with in granular or earthy masses sometimes incrusting or as an earthy coating. Cinnabar is very heavy (G=8.–8.2); this and its brilliant red streak usually serve to identify it. The color is cochineal-red to reddish brown and sometimes even inclining to black; the luster is adamantine to dull.

Cinnabar occurs in a variety of rock formations, being found in slate, shale, granite and porphyry, where it is associated with other sulfids. The principal localities are Almaden, Spain, southern Russia, southern Austria, China, Peru, and Mexico. California furnishes most of the American output.

Cinnabar is a valuable ore of mercury and was formerly ground for a pigment called vermilion. The pigment is now produced artificially.

Greenockite CdS

Greenockite, the sulfid of cadmium, contains 22.3% sulfur and 77.7% cadmium.

It usually occurs as a bright yellow powder coating sphalerite and rarely in dull yellow hexagonal crystals of the hemimorphic group. The crystals are nearly transparent and of a resinous luster.

Greenockite is found crystallized in Renfrewshire, Scotland, and, associated with sphalerite, at the Bohemian locality and in Pennsylvania and Missouri.

It is mined for cadmium with the sphalerite.

Millerite (capillary pyrites) NiS

Millerite, the sulfid of nickel, contains 35.3% sulfur and 64.7% nickel.

It crystallizes in the hexagonal system but the crystals are rarely of sufficient size to make this apparent, the lengthening of the crystals producing hairlike forms which often radiate from a center or form a mat or wad of interwoven individuals. The capillary crystals are sometimes grouped in crusts of columnar or radiated aggregates as in the specimen shown in pl. 15_2. The luster is metallic, the color a brass-yellow to bronze-yellow and the streak greenish black.

Millerite occurs in cavities as at the Antwerp locality, where it is found in hematite, or incrusting as at the Pennsylvania deposit where it overlies pyrrhotite. It is found in Bohemia, Saxony and Cornwall and in the United States in Lancaster county, Pa. and at Antwerp, Jefferson co. N. Y.

It is a source of nickel.

Niccolite (copper nickel) NiAs

Niccolite is the arsenid of nickel and contains 56.1% arsenic and 43.9% nickel; of which the arsenic is sometimes replaced in part by antimony or sulfur, and the nickel by a little iron or cobalt.

Hexagonal crystals of niccolite are rare, the mineral usually occurring in pale copper-red metallic masses of smooth, impalpable structure, with an uneven fracture.

In addition to the European and South American localities, niccolite occurs in the United States at Lovelock Nev., Till Cove, Newfoundland, Silver Cliff Col., Chatham Ct. and to a very limited extent at Franklin N. J.

It is mined for nickel.

Pyrrhotite (magnetic pyrites)

Pyrrhotite is a sulfid of iron of varying percentages of sulfur and iron and often containing nickel.

It is rarely found in distinct hexagonal crystals of tabular habit, the most common form of occurrence being as a massive metallic mineral of a bronze color possessing to a varying degree the property of attracting the magnet. It differs from pyrite, bornite and niccolite in color and in the magnetic property mentioned above.

Pyrrhotite occurs in gabbro and other igneous rocks and in schists; it is also found in meteorites. It is very widely distributed. The principal American localities are Sudbury Can. and Lancaster Gap Pa. at both of which places it is mined for the nickel it contains. A deposit of pyrrhotite was formerly worked at Anthony's Nose, Westchester co. N. Y.

Bornite (purple copper ore)

Bornite is a sulfid of copper and iron of variable proportions, the massive variety being probably a mechanical mixture with chalcocite. The crystallized mineral seems to conform quite closely to the formula which gives 28.1% sulfur, 55.5% copper and 16.4% iron.

The crystallized specimens show isometric forms with a cubic habit. The massive varieties have a granular to compact structure. The mineral is characterized by a metallic luster and a dark copper-red, pinchbeck-brown or purple color which tarnishes rapidly to iridescence.

Bornite occurs associated with the other copper minerals in Cornwall (crystalline), Chile, Peru, Bolivia, Mexico and Canada and in the United States at Bristol Ct. and near Wilkesbarre Pa.

It is mined for copper.

Chalcopyrite (copper pyrites) $CuFeS_2$

Chalcopyrite is a sulfid of iron and copper in the proportions, 35% sulfur, 34.5% copper and 30.5% iron. Variations from these proportions are often due to pyrite mechanically intermixed in the massive varieties.

The tetragonal crystals of chalcopyrite belong to the sphenoidal group and when in simple, unmodified forms resemble isometric tetrahedral types. Modified crystals such as those given in fig. 166, 167, however, clearly show the true symmetry of the forms. Massive occurrences are common. Chalcopyrite has a bright metallic luster; the color is a brass-yellow, often tarnishing to colors resembling bornite.

It is widely distributed in veins and vugs in gneiss, crystalline schists and other metamorphic rocks and was probably formed in much the same way as pyrite, with which it is frequently associated. Chalcopyrite is mined in Sweden, Spain, Sudbury Can., Montana and Utah. Handsome specimens associated with quartz have been found in New York at Ellenville, Ulster co.

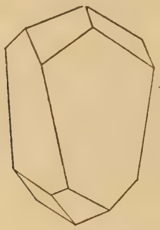


Fig. 166

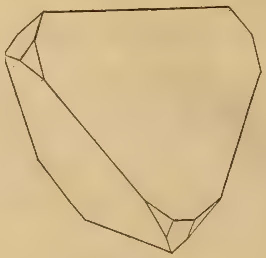


Fig. 167

Chalcopyrite

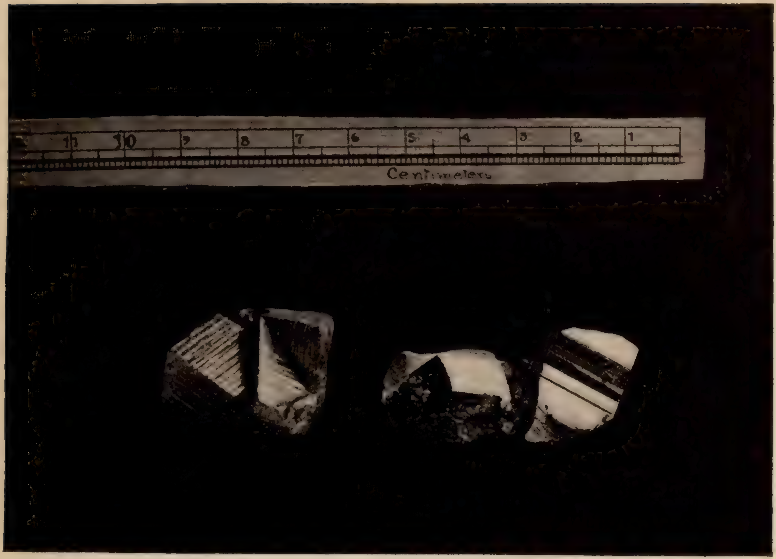
Chalcopyrite is the principal source of copper.

Pyrite (iron pyrites) FeS_2

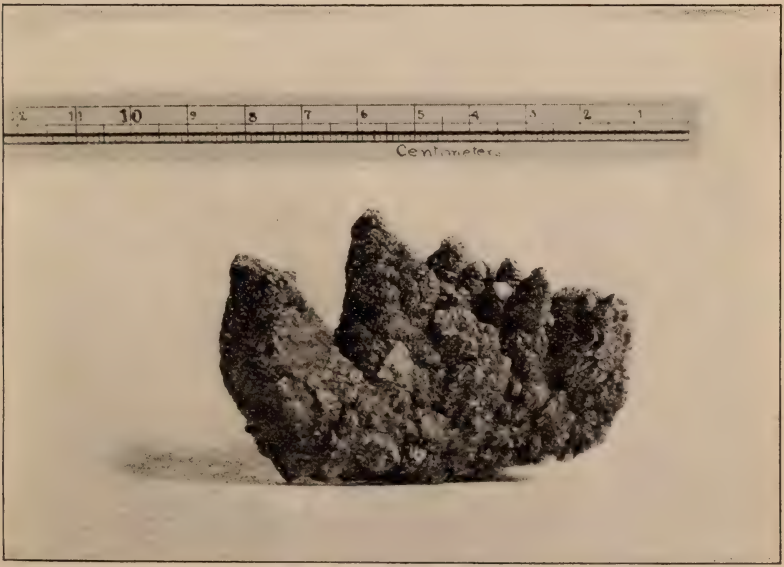
Pyrite, the isometric form of iron disulfid, contains 53.4% sulfur and 46.6% iron.

The crystals of pyrite are exceedingly interesting, showing as they do a diversity of form and a brilliancy of surface which render them objects of considerable beauty. Some of the forms of the pyritohedral group which are most frequently met with in pyrite are shown in fig. 168–72. Pl. 16_1 shows the striations so common in crystals of this species. Crystalline masses of varied form are quite frequent, producing botryoidal, globular, stalactitic and other shapes. The granular massive varieties are common. Pyrite has a brilliant metallic luster; its color is a pale brass-yellow somewhat lighter than that of chalcopyrite. Pyrite occurs in almost every variety of rock; the deposits in sedimentary rocks were probably formed by the precipitation of the included ferruginous matter from a hot aqueous solution in the presence of decaying vegetable and animal matter.

Plate 16



1 Pyrite, Gilpin county, Col.



2 Marcasite, Galena Ill.

Pyrite deposits are worked for the production of sulfuric acid in Louisa county, Va., in the Rio Tinto region of Spain and in various other localities including one at Hermon, St Lawrence co. N. Y. Sometimes gold and copper contained in small quantities in pyrite are recovered.

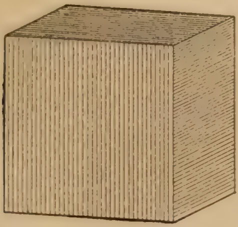


Fig. 168

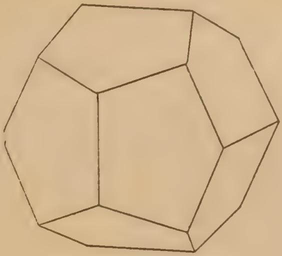


Fig. 169

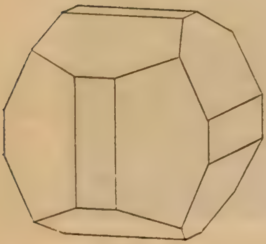


Fig. 170

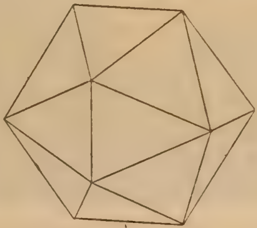


Fig. 171

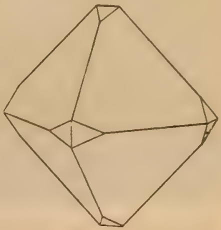


Fig. 172

Pyrite

Smaltite, chloanthite $(CoNi)As_2$

The minerals of this group pass from one to the other by such insensible gradations that it is often impossible to separate them. Smaltite is essentially cobalt diarsenid containing 71.8% arsenic and 28.2% cobalt. Chloanthite is essentially nickel diarsenid and contains 71.9% arsenic and 28.1% nickel.

The crystals are similar to those of pyrite. The mineral usually occurs in tin-white to steel-gray metallic masses.

It occurs in veins with other ores of cobalt, nickel, copper and silver, notably in the Saxon and Bohemian localities. It is also found at Chatham Ct., Franklin N. J. and in California.

It is the main source of the cobalt products.

Cobaltite (cobalt glance) CoAsS

Cobaltite, the sulfarsenid of cobalt, contains 19.3% sulfur, 45.2% arsenic and 35.5% cobalt.

It resembles pyrite in crystallization and luster and is silver-white to gray in color.

Like smaltite it is a source of cobalt compounds.

Marcasite (white iron pyrites) FeS_2

Marcasite is the orthorhombic iron disulfid, and has the same composition as pyrite.

The dimorphism of iron disulfid is all the more interesting because pyrite represents an isomorphous group of sulfids and arsenids which crystallize in similar forms of the isometric system, and marcasite heads a similar isomorphous group crystallizing in closely related forms of the orthorhombic system.

Twins and crystalline aggregates are common, resembling spearheads, cockscombs, etc. often with radiated, stalactitic structure as in pl. 16_2. The color of marcasite is somewhat whiter than that of pyrite, which it closely resembles.

Marcasite occurs in Saxony, Bohemia and England, and in the United States, associated with sphalerite, at the zinc mines of Missouri, in Wisconsin and at Warwick, Orange co. N. Y.

It is used in the manufacture of sulfuric acid. It is also found in nodular concretions in the Tertiary and Cretaceous clays of Long Island and Staten Island.

Arsenopyrite (mispickel) FeAsS

Arsenopyrite is the sulfarsenid of iron and contains 46% arsenic, 34.3% iron and 19.7% sulfur.

Arsenopyrite crystallizes in the orthorhombic system in forms resembling marcasite. A common type of crystal is represented in fig. 173 and a characteristic grouping in pl. 17_1. Arsenopyrite commonly occurs in coarse to fine granular masses or disseminated grains. It is silver-white to gray, with a metallic luster.

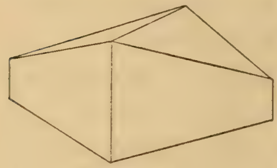


Fig. 173
Arsenopyrite

Arsenopyrite is found principally in veins in crystalline rocks associated with other metallic sulfids and arsenids. The deposits of New South Wales, California and Alaska occasionally carry some gold. It is found in many European localities,

Plate 17

To face p. 60

1 Arsenopyrite and dolomite, Freiberg, Saxony

2 Halite, Great Salt lake, Utah

in Canada, in parts of New England and in Orange and Putnam counties, N. Y.

Arsenopyrite is an ore of arsenic.

Sylvanite (graphic tellurium) (AuAg) Te_2

Sylvanite represents a group of gold and silver tellurids which has recently developed to considerable importance in the Cripple Creek district of Colorado. Sylvanite contains 62.1% tellurium, 24.5% gold and 13.4% silver.

It occurs in flat monoclinic crystals usually grouped in branching forms resembling written characters, it is silver-white to steel-gray in color, inclining to yellow, and has a brilliant metallic luster.

Sylvanite occurs in Transylvania, California and Boulder county, Col. where it is mined for gold.

SULFO-SALTS

SULFARSENITES, SULFANTIMONITES, ETC.

Bournonite (wheel ore) $PbCuSbS_3$

Bournonite is a sulfantimonite of lead and copper and contains 42.5% lead, 13% copper, 24.7% antimony and 19.8% sulfur.

The orthorhombic crystals are frequently twinned, producing the "cogwheel" forms from which the species derives its common name. It frequently occurs massive, granular or compact. The color is steel-gray to dark gray and the luster metallic.

Bournonite is found in Germany, Bohemia, Hungary, Cornwall, Mexico, Chile; also in Canada, Arizona, Arkansas and Colorado.

Pyrargyrite (dark ruby silver ore) Ag_3SbS_3

Pyrargyrite is a sulfantimonite of silver and contains 17.8% sulfur, 22.3% antimony and 59.9% silver.

Pyrargyrite crystallizes in the rhombohedral-hemimorphic group of the hexagonal system. The crystals are prismatic with rather flat terminations and are frequently twinned. It is translucent to opaque, of a deep red color by transmitted light and gives a purplish red streak. The luster is metallic to adamantine.

Pyrargyrite is found in several German localities, in Mexico and Chile; also in Idaho, Nevada, Colorado and other silver bearing regions of the western states.

It is mined for silver.

Proustite (light ruby silver ore) Ag_3AsS_3

Proustite is a sulfarsenite of silver and contains 19.4% sulfur, 15.2% arsenic and 65.4% silver.

Proustite closely resembles pyrargyrite in crystallization as well as in translucency. Its luster is adamantine rather than metallic and it differs from pyrargyrite in the color, which shades more toward scarlet. The streak is scarlet.

Proustite is found associated with pyrargyrite, the localities being essentially the same as for that species.

It is a source of silver.

Tetrahedrite (gray copper ore) $Cu_8Sb_2S_7$

Tetrahedrite is a sulfantimonite of copper and contains 23.1% sulfur, 24.8% antimony and 52.1% copper. Some of the antimony is usually replaced by arsenic, which causes it to merge gradually into tennantite, the sulfarsenite of silver.

Tetrahedrite crystallizes in the tetrahedral group of the isometric system. The crystals, two of the commonest types of which are shown in fig. 174, 175, are tetrahedral in habit. Massive forms are frequent. The color varies from a light steel-gray to an iron-black; the luster is metallic.

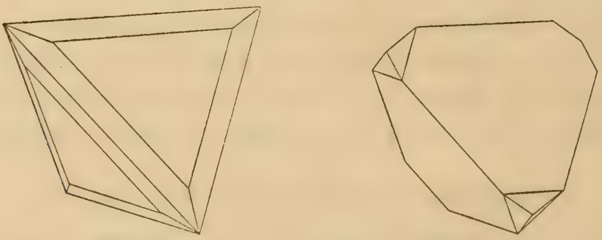


Fig. 174 Fig. 175

Tetrahedrite

Tetrahedrite is commonly associated with chalcopyrite, massive varieties frequently forming intimate mechanical mixtures; crystals of tetrahedrite are often incrusted with chalcopyrite. It is also associated with several other metallic sulfids. It is found in Europe, South America, Mexico, Nevada and Colorado.

Stephanite (brittle silver ore) Ag_5SbS_4

Stephanite is a sulfantimonite of silver containing 16.3% sulfur, 15.2% antimony and 68.5% silver.

Orthorhombic crystals in short prismatic and tabular forms are frequently found. The mineral usually occurs in fine grained masses of an iron-black color and metallic luster. Also in disseminated grains.

Stephanite occurs in veins with other silver ores, the principal localities being those mentioned under argentite, pyrargyrite, etc.

Enargite Cu_3AsS_4

Enargite is a sulfarsenite of copper containing 32.6% sulfur, 19.1% arsenic and 48.3% copper.

Orthorhombic crystals are sometimes met with; these are prismatic in habit and striated parallel to the vertical axis. Enargite commonly occurs in columnar or granular masses. It is black in color and has a metallic luster.

Enargite is found associated with other copper minerals in Chile, Peru and Mexico; also in South Carolina, Colorado, Utah, California and in the Tintic district of Montana.

It is an ore of copper.

HALOIDS

CHLORIDS, BROMIDS, IODIDS, FLUORIDS

Halite (rock salt) NaCl

Halite or common salt is the chlorid of sodium and contains 39.4% chlorin and 60.6% sodium. It seldom occurs perfectly pure but is commonly mixed with calcium sulfate, calcium chlorid, magnesium chlorid and magnesium sulfate.

Halite is isometric and usually crystallizes in cubes (pl. 17_2), which often show distortion and cavernous faces, as in fig. 176. Masses with perfect cubic cleavage are common as well as a fibrous variety which is said to be pseudomorphous after fibrous gypsum. Halite has a vitreous luster and when pure is colorless and transparent; yellow, red, brown, blue and purple shades are due to impurities, as is also the translucency accompanying these variations in color. It has a characteristic saline taste.

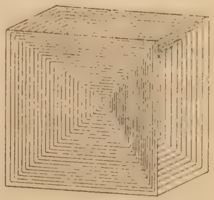


Fig. 176
Halite

Salt is of wide distribution and frequently occurs in beds of sufficient size to constitute a true rock mass. These deposits, which are found interstratified with rocks of all geologic horizons, have been formed by gradual evaporation from bodies of water which have been cut off from the main body of the ocean, or which, as in the case of Great Salt lake and the Dead sea, have been concentrated through lack of an outlet. The mineral matter is crystallized out in inverse ratio to its solubility, the less soluble minerals, such as gypsum, forming prior to the more soluble ones such as salt. This process is still taking place in many parts of the world.

Halite is of of such universal occurrence that a list of its localities would include almost every civilized country. In the United States extensive and valuable deposits of salt are found in central and western New York, in Ohio, Michigan, West Virginia, Kansas, Louisiana, Nevada, Utah, Arizona and California. Salt springs and wells abound in the neighborhood of the salt deposits and these as well as the waters of salt lakes and sea waters are used as sources of the commercial product.

Halite is used to form a glaze on pottery and in many chemical and metallurgic industries as well as for the familiar culinary and preservative purposes.

Cerargyrite (horn silver) AgCl

Cerargyrite, the chlorid of silver, is composed of 24.7% chlorin and 75.3% silver.

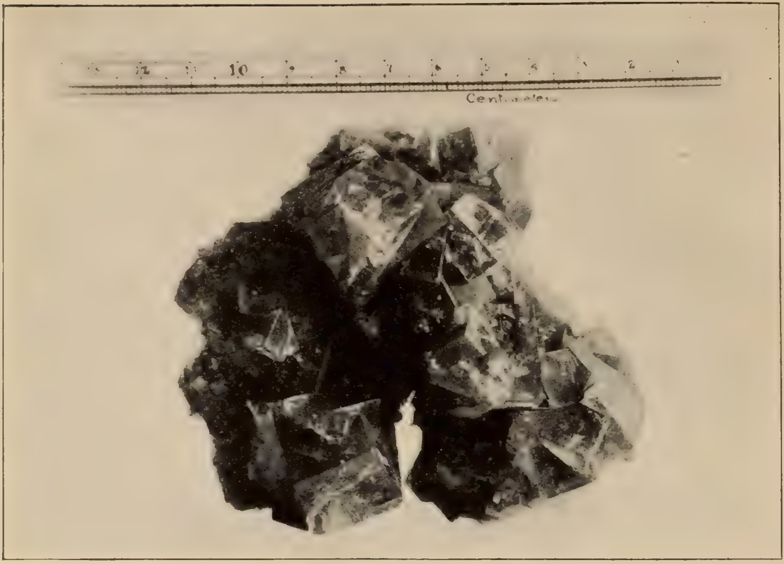
Isometric crystals of a cubic habit are quite rare, the mineral usually occurring in massive crusts or coatings of a grayish green to violet color and waxy or resinous luster resembling horn or wax. It is extremely sectile and turns violet-brown on being exposed to the light.

Cerargyrite probably results from precipitation from silver charged solutions in contact with the chlorids contained in surface waters. It usually occurs near the top of veins in clay slate, associated with other ores of silver. Cerargyrite is found extensively in Peru, Chile and Mexico; it also forms part of the mineral wealth of Colorado, Nevada, Idaho and Utah.

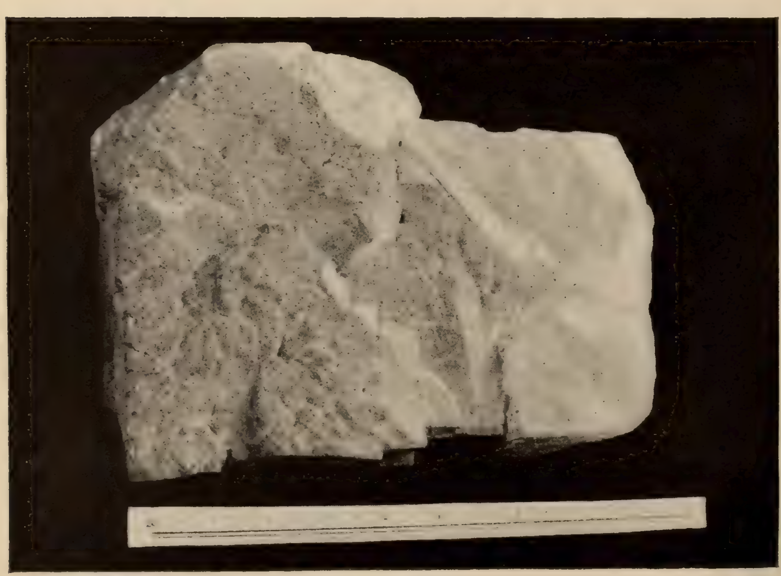
It is mined for silver.

Plate 18

To face p. 65



1 Fluorite, Cumberland, England



2 Fluorite, Macomb N. Y.

Fluorite (fluor spar) CaF_2

Fluorite is the fluorid of calcium and contains 48.9% fluorin and 51.1% calcium.

The isometric crystals of fluorite exhibit many interesting forms, some of which are shown in fig. 177–79. Penetration twins are quite common (pl. 18_1). The crystals are vitreous, transparent and of a great variety of colors, white, yellow, greenish blue, purple and green being most common; white, pink, red, sky-blue and other colored varieties are often found. Massive varieties sometimes show irregular banding of different colors. Granular and fibrous occurrences are less frequent. All varieties are characterized by perfect cleavage parallel to the octahedron, which can be frequently traced in the crystallized specimens, as in pl. 18_2.

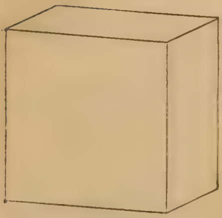


Fig. 177

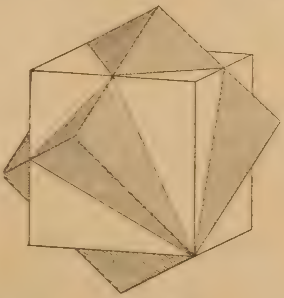


Fig. 178

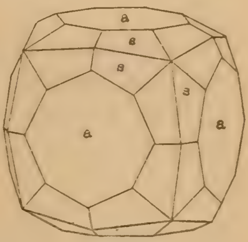


Fig. 179

Fluorite

Fluorite is found in beds, or more often in veins, in gneiss, slate, limestone and sandstone; it frequently occurs as the gangue of metallic minerals, notably lead ores. Fluorite occurs in many parts of England and Saxony; also in Rosiclare Ill. where it is mined in large quantities, in Jefferson and St Lawrence counties, N. Y. and in several other states.

Fluorite is used as a flux in some metallurgic processes, also in the production of opalescent glass, enameled cooking ware and hydrofluoric acid.

Cryolite Na_3AlF_6

Cryolite is a fluorid of sodium and aluminium, containing 54.4% fluorin, 12.8% aluminium and 32.8% sodium.

The monoclinic crystals of cryolite frequently present a cubic aspect due to the fact that the β angle is nearly 90° and the *a* and *b* axes almost equal. Parallel groupings are common as well as massive and columnar forms. The cleavage is nearly cubic in angle. Cryolite is transparent to translucent; colorless or white, often reddish, brownish or black owing to small amounts of iron, and has a vitreous to greasy luster. The German name *Eisstein* (ice-stone) suggests its resemblance to ice. It is quite soft (H=2.5) and is readily melted in the flame of a candle.

The principal locality for cryolite is Ivigtut in west Greenland, where it is found in a vein in gray gneiss.

It is used in several chemical processes, notably in the manufacture of aluminium.

Atacamite $Cu_2ClH_3O_3$

Atacamite is a hydrated oxychlorid of copper containing 16.6% chlorin, 14.9% copper, 55.8% copper oxid and 12.7% water.

Atacamite occurs in orthorhombic prismatic crystals, vertically striated. It is more commonly found in confused crystalline aggregates and fibrous or granular massive forms. The luster is adamantine to vitreous and the color bright to dark green.

Atacamite takes its name from the Atacama desert in northern Chile where it is found associated with other copper ores; it is also found in Bolivia, South Australia, Cornwall and Arizona.

It is an ore of copper.

OXIDS

OXID OF SILICON

Quartz SiO_2

Quartz is pure silica or silicon dioxid (53.3% oxygen and 46.7% silicon). It is often colored by small amounts of iron oxid, manganese, titanium, carbon, etc.

Quartz crystallizes in the rhombohedral-trapezohedral group of the hexagonal system; the crystals are commonly prismatic with the prism faces striated parallel to the basal plane and are terminated by one or both rhombohedrons together with other modifications characteristic of the group. Distortion gives rise to flat and unequally developed forms of great variety as well as acicular, tapering and twisted individuals. Grouping of crystals in parallel position, "scepter," "phantom," and capped

Plate 19

To face p. 67

1 Quartz, Crystal mountain, Ark.

2 Quartz (smoky), St Gothard, Switzerland

forms are of particular interest from a crystallographic point of view. Twinning occurs quite frequently. Massive forms occur in great variety with granular mammillary stalactite and concretionary structure, plane or banded.

Quartz has a vitreous luster in the crystallized varieties which passes, in the massive forms, to greasy, splendent or dull. When pure, quartz is transparent and colorless with a white streak; various shades of yellow, red, brown, green, amethyst and black are due to slight impurities.

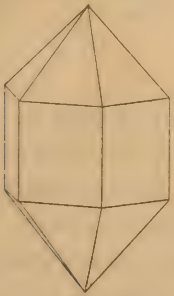


Fig. 180

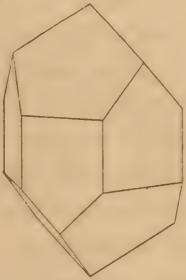


Fig. 181

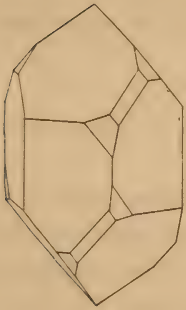


Fig. 182

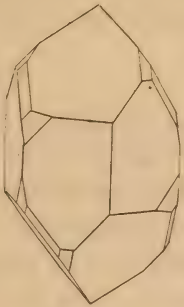


Fig. 183

Quartz

A—CRYSTALLINE VARIETIES

Rock crystal. Pure, colorless

Amethyst. Purple to violet. Color probably due to manganese

Rose quartz. Pink to rose. Colored by titanium

Smoky quartz. Smoky brown to black. Color probably due to carbon

Milky quartz. Translucent white. Usually massive

Ferruginous quartz. Opaque brown to red. Colored by iron

Aventurin. Spangled with scales of mica, hematite etc.

B—CRYPTOCRYSTALLINE VARIETIES

Chalcedony. Mammillary. Uniform in tint

Carnelian. A clear, red chalcedony

Chrysoprase. Apple green. Color due to nickel

Prase. Dull, leek-green

Agate. A variegated chalcedony. Colors are banded, irregularly clouded or in mosslike dendritic forms

Onyx. Parallel layers light and dark

Jasper. Impure, opaque.

Quartz occurs as a constituent of many rocks such as granite, gneiss, quartz porphyry, syenite, sandstone, etc. and as a vein mineral in rocks of all geologic horizons. Its distribution is so extensive as to preclude its limitation to any given area. Quartz rocks are extensively used for building stone; chalcedonic varieties are often polished for ornamental objects and massive varieties are ground and used in the manufacture of sandpaper, glass and porcelain and as an acid flux in some metallurgic processes.

Opal $SiO_2.nH_2O$

Like quartz, opal is composed of silica or silicon dioxid, but contains from 5% to 12% water.

Opal shows no evidences of crystallization and is therefore considered amorphous. It occurs in transparent to translucent milky white or red masses and veins, often characterized by internal reflections and rich play of colors; in waxy masses yellow, red, brown, green, gray or blue in color; in opaque, porous, brittle stalactitic masses deposited by geysers and hot springs and in earthy varieties.

VARIETIES

Precious opal. Exhibits play of color. Used as a gem

Fire opal. Red, firelike reflections

Common or semiopal. In part translucent with greasy luster

Wood opal. Pseudomorphous after wood

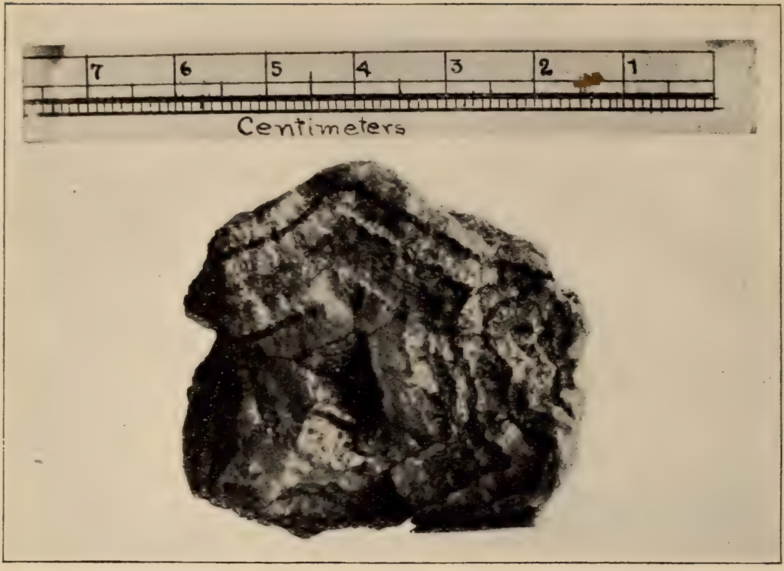
Hyalite. Colorless, transparent, droplike masses

Geyserite. Porous opal, deposited from hot water carrying silica

Tripolite. Massive, chalklike silica composed of the remains of diotomes.

Plate 20

To face p. 69



1 Quartz (agate), Wyoming

2 Cuprite (chalcotrichite), Morenci Ariz.

Opal occurs in cavities and fissures in igneous rocks, as concretions in limestones, as sinter in the vicinity of geysers, hot springs, etc. The precious variety is found in Hungary, Australia, Mexico and in Washington and Idaho.

Precious opal is highly valued as a gem. The chalky variety is used for polishing and washing purposes, in the manufacture of dynamite and in the preparation of a soluble glass.

OXIDS OF METALS

Cuprite (red copper ore) Cu_2O

Cuprite is the oxid of copper and contains 11.2% oxygen and 88.8% copper.

Crystals of cuprite (fig. 184, 185) are isometric, the prevailing forms being the cube, octahedron and dodecahedron, often highly modified; in the variety chalcotrichite the cube crystals are distorted to such an extent as to produce hairlike forms (pl. 20_2). Massive, granular and earthy forms are common. The luster of cuprite is submetallic or adamantine to earthy and the color varies from a dark red which is nearly black to a vermilion or scarlet, seen in some of the massive varieties. It is transparent to opaque.

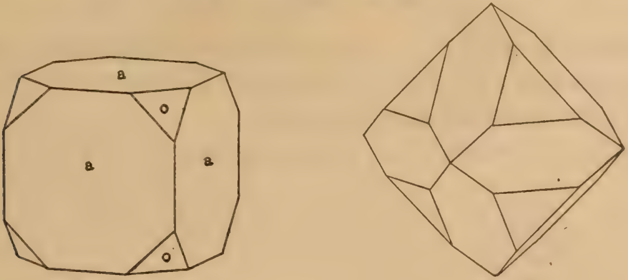


Fig. 184 Fig. 185

Cuprite

Cuprite results from the oxidation of the sulfids of copper and is found associated with other copper minerals and with limonite. It occurs in fine crystals in the Cornwall mines and is found in considerable deposits in Chile, Bolivia, Peru, the Lake Superior region and Arizona.

It is a useful copper ore.

Zincite (red zinc ore) ZnO

This oxid of zinc contains 19.7% oxygen and 80.3% zinc; it usually carries some manganese.

The natural crystals, which are rare, have been referred to the hemimorphic group of the hexagonal system. Zincite ordinarily occurs in deep red to brick-red adamantine masses with a foliated or granular structure or as coarse grains disseminated through the matrix. It has a subadamantine luster and is translucent.

Zincite occurs in the vicinity of Franklin N. J. associated with the minerals characteristic of that locality and is mined with the associate minerals for the zinc which it contains.

Corundum (emery) Al_2O_3

Corundum is alumina, or sesquioxid of aluminium, and contains 47.1% oxygen and 52.9% aluminium; massive emery contains more or less iron oxid as an impurity.

Crystals of corundum are rhombohedral (fig. 186, 187); rough and rounded forms are characteristic, as well as twinning, which is indicated by laminated structure and intersecting striations. With the exception of the diamond, corundum is the hardest substance known.

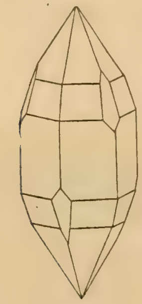


Fig. 186

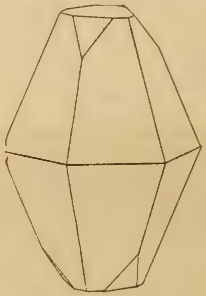


Fig. 187

Corundum

The precious varieties known as sapphire and ruby are transparent or translucent, with vitreous to adamantine luster, and abound in fine colors.

The gems cut from these varieties are:

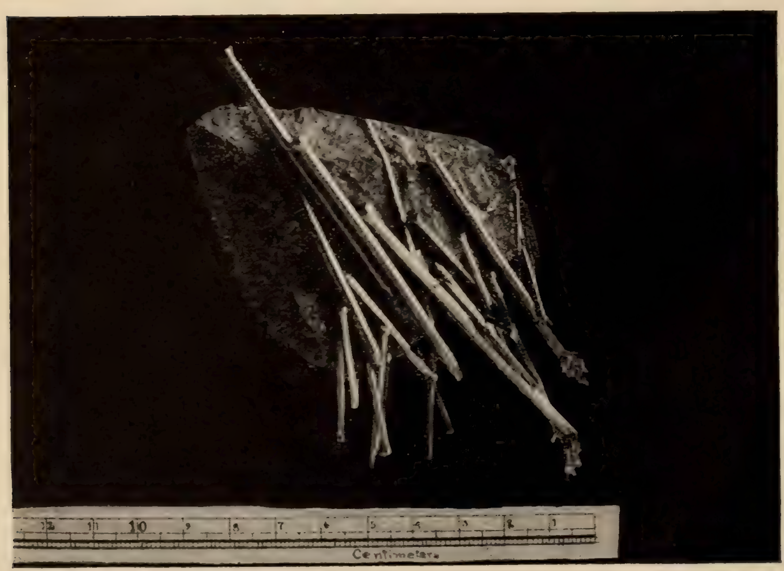
Sapphire. Blue in color

Oriental ruby. A rich red

Plate 21

To face p. 71

1 Hematite (Eisenrosen), St Gothard, Switzerland



2 Magnetite (lodestone), Magnet Cove Ark.

Oriental topaz. Yellow

Oriental emerald. Green

Oriental amethyst. Purple

An opaque variety of corundum occurs in coarse nodular crystals with a marked rhombohedral parting and of a dull blue, gray, brown or black color.

The variety known as emery is granular in texture, of great toughness and black or grayish black in color. It is commonly intermingled with hematite or magnetite. This variety, which is of great value as an abrasive, is found in a number of grades, classed on the relative coarseness of the corundum crystals or grains.

The gem varieties of corundum are found in the gravel of river beds in Upper Burma and Ceylon; some handsome gems have been obtained from Montana and North Carolina.

Corundum occurs in many crystalline rocks associated with minerals of the chlorite group, tourmalin, spinel, cyanite, etc. and has been observed in some of the younger volcanic rocks. It is mined for emery in the island of Naxos, in Asia Minor, and in the United States at Chester Mass., in Westchester county, N. Y. and elsewhere.

Hematite (specular iron) Fe_2O_3

Hematite is the sesquioxid of iron and contains 30% oxygen and 70% iron.

Hematite crystallizes in the rhombohedral group of the hexagonal system. The crystals are commonly thick or tabular in habit (fig. 188) as distinct from the tapering forms of corundum, and are often reduced to thin plates which in some varieties group themselves in rosettes (eisenrosen pl. 21_1). Massive forms in compact columnar, radiated and kidney-shaped masses pass into loose earthy varieties, containing more or less clay. The luster of hematite varies with its form from a splendent metallic, in the crystallized varieties, to dull in the ocherous and argillaceous hematite; the color also varies from iron-black to red. The streak is red in all varieties.

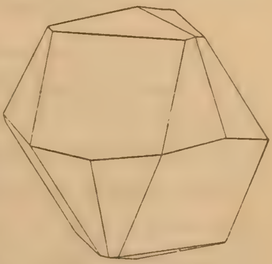


Fig. 188
Hematite

Hematite occurs in rocks of all geologic horizons. It is widely distributed and the numerous foreign localities afford beautifully crystallized specimens. In the United States vast beds of hematite are found in the Archaean rocks of northern Michigan, northern Wisconsin, Minnesota, Missouri, and in Jefferson and St Lawrence counties of northern New York; also in the Clinton group of the Upper Silurian in New York and Pennsylvania.[1]

Hematite constitutes the chief source of iron; the earthy variety is ground for paint.

Ilmenite or menaccanite (titanic iron ore) $(Fe,Ti)_2O_3$

Ilmenite is an oxid of iron and titanium containing 31.6% oxygen, 31.6% titanium and 36.8% iron. The crystals, which are trirhombohedral, somewhat resembles those of hematite in habit (fig. 189). Ilmenite commonly occurs in iron-black plates and masses of submetallic luster, also in embedded grains or as loose sand.

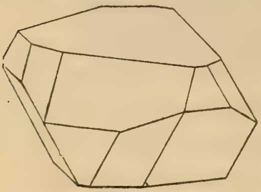


Fig. 189
Ilmenite

Ilmenite is found in many igneous rocks notably in gabbros and diorites; it is sometimes altered to limonite and titanite. In addition to several European localities ilmenite is found in the town of Warwick, Orange co. N. Y. and at Litchfield Ct.

The large amount of fuel required to reduce this mineral renders it, in most cases, undesirable as an ore of iron. It is, however, used as a lining in furnaces.

Spinel $MgO.Al_2O_3$

Spinel, the magnesium aluminate, contains 71.8% alumina and 28.2% magnesia. These two components may be replaced in part by ferrous and ferric iron, manganese and chromium.

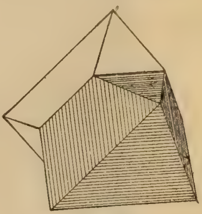


Fig. 190
Spinel

The crystals of spinel are isometric, usually the octahedron or the octahedron modified, and are frequently twinned (fig. 190). The luster is vitreous to dull and the color varies from red to blue, green, yellow and black. A transparent variety called ruby spinel is transparent to translucent and often of a rich red color. This constitutes the gem known as

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[1] N. Y. state mus. Bul. 7. 1889.

spinel ruby or balas ruby, which often rivals the oriental ruby in color and fire.

Spinel occurs in limestone, gneiss, serpentine and other metamorphic rocks. Spinel ruby is abundant in Ceylon and Burma and has been obtained from Hamburg N. J. and Orange county, N. Y. Crystals of spinel are found in many parts of North Carolina and Massachusetts and near the boundary line between New York and New Jersey.

Magnetite (magnetic iron ore) $FeO.Fe_2O_3$

Magnetite is composed of iron sesquioxid and iron protoxid and contains 72.4% iron and 27.6% oxygen.

Magnetite crystallizes in isometric forms closely resembling those of spinel. Parting parallel to the octahedron is often developed (*see* specimen from Mineville N. Y. in N. Y. state mus. collection). Massive varieties have laminated, coarse or fine granular and compact structure (pl. 4_2). Magnetite has a metallic or submetallic luster, is black in color and is strongly magnetic. A variety known as lodestone is a natural magnet (pl. 21_2).

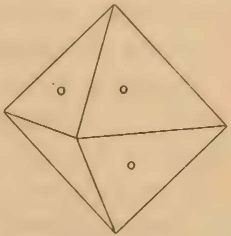

Fig. 191
Magnetite

Magnetite occurs mostly in crystalline rocks and is of universal distribution. Extensive beds are found in the Archaean formation of northern New York and in the Adirondack region, as well as in Saratoga, Herkimer, Orange and Putnam counties of the same state,[1] the former deposits being to a considerable extent titaniferous.

Magnetite is extensively mined for iron.

Franklinite (FeMnZn)O.(FeMn)$_2$O$_3$

Franklinite is an iron, zinc and manganese ferrate and manganate of rather complicated formula and varying relative quantities.

The isometric crystals of franklinite are octahedral in habit and are generally characterized by rounded edges, otherwise they resemble those of magnetite. Franklinite also occurs in rounded grains and in compact masses. In color and luster it

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[1] N. Y. state mus. Bul. 7. 1889.

closely resembles magnetite and is chiefly distinguished by its slight tendency to attract the magnet and by its characteristic association with zincite and willemite at Franklin and Ogdensburg N. J. its most notable localities.

It is used at Franklin with other ores for the production of zinc and of an alloy of iron and manganese known as spiegeleisen.

Chromite (chromic iron) $FeO.Cr_2O_3$

Chromite, the iron chromate, contains 68% chromium sesquioxid and 32% iron protoxid.

Chromite is rarely found in small octahedral crystals. It commonly occurs as a black massive mineral resembling massive magnetite, sometimes in disseminated grains and sand. It is, in some instances, feebly magnetic.

It occurs in veins or embedded masses in serpentine and may often be recognized by its association with that mineral.

Turkey and New Caledonia furnish much of the chromite now used. A somewhat lower grade ore is found in extensive deposits in California.

Chromium extracted from chromite is used in the production of several pigments, in the manufacture of bichromate of potash for calico printing and for chrome steel.

Chrysoberyl $BeO.Al_2O_3$

Chrysoberyl is the aluminate of beryllium and contains 80.2% alumina and 19.8% glucina.

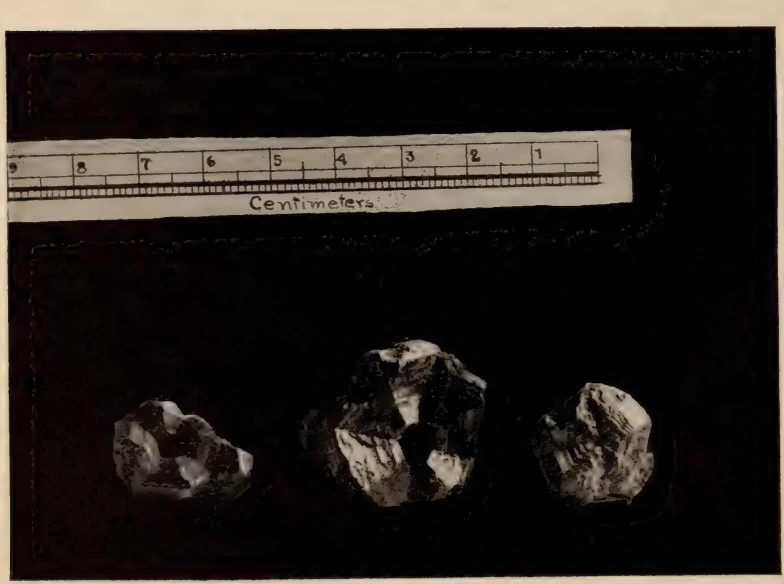
The crystals of chrysoberyl, which are orthorhombic, are commonly twinned producing pseudohexagonal shapes which sometimes show reentrant angles. The crystals are generally tabular in habit with intersecting, featherlike striation due to repeated twinning. Chrysoberyl is transparent to translucent, of a vitreous luster and of various colors from a pale yellowish green to emerald-green. The variety alexandrite is of an emerald-green color by reflected light which, however, changes to a columbine-red by transmitted light.

Brazil, Ceylon, Moravia and the Ural mountains of Russia produce chrysoberyl. It has been found at Haddam Ct. and at Greenfield N. Y.

Chrysoberyl is used as a gem, the varieties alexandrite and cat's eye being specially prized.

Plate 22

1 Cassiterite, Schlaggenwald, Bohemia



2 Rutile, Magnet Cove Ark.

Cassiterite (stream tin) SnO_2

Cassiterite is the dioxid of tin containing 21.4% oxygen and 78.6% tin.

Tetragonal crystals of the general type shown in fig. 192 are terminated with a low pyramid. Forms of prismatic habit with steeper and more complicated terminations are also characteristic, and twins similar to the form shown in pl. 22_1 are quite common. Reniform masses and rounded pebbles with fibrous radiated structure (stream tin) are of common occurrence. The luster of cassiterite is adamantine and in the case of crystallized varieties is usually splendent; the color is brown or black, sometimes red, grey or yellow, and the streak is brown.

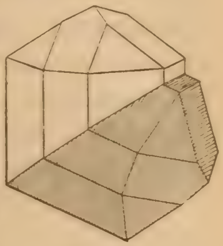


Fig. 192
Cassiterite

Cassiterite occurs in veins traversing granite, gneiss and other igneous and metamorphic rocks. It is found abundantly in Cornwall and other parts of England, in Bohemia, Saxony, East Indies, Australia, Bolivia and Mexico; also in the United States in South Dakota, California and other states.

Cassiterite is the sole source of tin.

Rutile (nigrin) TiO_2

Rutile is the dioxid of titanium and contains 40% oxygen and 60% titanium.

In crystallization rutile closely resembles cassiterite (fig. 193). The crystals are prismatic in habit, often passing into acicular and hairlike forms which are vertically striated and are sometimes included in quartz and other minerals. Twinning, resulting in knee-jointed crystals and rosettes (pl. 22_2), is quite common. Rutile is occasionally found in compact masses which carry some iron. The luster of rutile is rather more brilliant and metallic than cassiterite and may be described as metallic-adamantine; in color it varies from brownish red to nearly black and when seen by transmitted light in transparent varieties it is deep red.

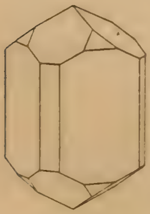


Fig. 193

Rutile occurs in granite, gneiss, syenite, mica, slate and sometimes in the limestones; it is frequently embedded in other minerals and is of common occurrence as grains or fragments in many gold-bearing sands. It is found in many parts of Europe and also in Maine and Georgia, at Magnet Cove Ark. and in Orange county, N. Y.

Rutile is chiefly used to color porcelain and may serve as a source of titanium.

Octahedrite. Octahedrite is a tetragonal mineral of the same composition as rutile but differs slightly from it in crystallization.

Brookite. Brookite is an orthorhombic form of titanium dioxid closely related to the two foregoing minerals.

Pyrolusite MnO_2

Pyrolusite is the dioxid of manganese and contains 36.8% oxygen and 63.2% manganese.

Pyrolusite commonly occurs in columnar masses which frequently radiate from a center; also in fine grained massive stalactitic and dendritic forms (pl. 8_2), in layers interposed with psilomelane and in velvety, reniform crusts. It is black in color and so soft (H–1–2.5) that it leaves a black mark on paper. The luster is metallic or dull.

Pyrolusite occurs associated with psilomelane, hematite, limonite and manganite. It is found in central Europe, India, Australia and Cuba; deposits occur in the United States in Virginia, Georgia, Arkansas, California, Vermont and North Carolina; New Brunswick and Nova Scotia furnish a high grade material.

Pyrolusite is used in the manufacture of various useful alloys, as an oxidizing agent in the manufacture of chlorin, bromin and disinfectants and in calico printing, glass coloring, etc.

Göthite $Fe_2O_3.H_2O$

Göthite is a hydrated sesquioxid of iron and contains 27% oxygen, 62.9% iron and 10.1% water.

The orthorhombic crystals of göthite are prismatic in habit, striated in the direction of the vertical axis and often flattened in the direction of the brachyaxis into scales. Needlelike crystals grouped in radiating or parallel position pass into massive featherlike structure and reniform and stalactitic forms.

Plate 23

1 Manganite, Ilefeld, Hartz, Germany

2 Limonite, Richmond Mass.

The luster is adamantine and the color yellowish, reddish and blackish brown.

Göthite occurs with other oxids of iron specially hematite and limonite and is classed commercially with limonite under the name of "brown hematite." It is an ore of iron.

Manganite $Mn_20_3.H_20$

Manganite is a hydrated sesquioxid of manganese containing 27.3% oxygen, 62.4% manganese and 10.3% water.

Manganite occurs in orthorhombic crystals usually prismatic with deeply striated or grooved surfaces; these are frequently grouped in bundles giving the appearance of sheaves of rods (pl. 23_1). It is rarely found in massive granular or stalactitic forms. The luster of manganite is submetallic and the color gray to black.

Manganite occurs associated with other manganese minerals which commonly result from its alteration.

For uses see Pyrolusite.

Limonite (brown hematite) $2Fe_20_3.3H_20$

Limonite is a hydrated sesquioxid of iron differing from göthite in the relative amount of iron sesquioxid and water; it contains 25.7% oxygen, 59.8% iron and 14.5% water. The ocherous varieties often contain clay or sand.

Limonite does not occur crystallized. It is commonly found in mammillary, botryoidal or stalactitic masses grading into loose and porous bog ore and earthy and concretionary masses.

The compact variety has a black varnishlike surface and fibrous radiated structure (pl. 23_2). The forms of looser structure are characterized by a dull luster and range in color from brown to yellow. The streak of limonite is brown.

Limonite is formed from the decomposition or alteration of other minerals containing iron; thus the bog ore is deposited in a marshy place by streams carrying iron in solution which is oxidized, sinks to the bottom, and in time by the combined action of heat and pressure is transformed into a bed of limonite.

Limonite is found in Bavaria and other parts of Germany, in Scotland, Sweden, etc. It is mined from large deposits in Virginia, Alabama, Pennsylvania, Michigan, Tennessee and

Georgia and in Dutchess and Columbia counties, N. Y.[1] It is also found in Richmond co. N. Y.

Limonite is an abundant but low grade ore of iron; the ocherous varieties are ground for paint.

Bauxite $Al_20_3.2H_20$

Bauxite is a hydrous aluminium sesquioxid containing 73.9% alumina and 26.1% water. The aluminium is often replaced in part by iron. Bauxite occurs in disseminated, rounded grains and in oolitic, spongy or claylike masses; sometimes fine grained compact. The luster is dull and the color varies from white when pure to red, yellow, and brown for the iron-bearing varieties.

Bauxite is found at Baux and elsewhere in France; also in Arkansas, Alabama and Georgia. It is the chief source of aluminium and is used in the manufacture of alum.

Brucite $Mg0.H_20$

Brucite is the magnesium hydrate and contains 69% magnesia and 31% water.

The crystals are rhombohedral and tabular in habit. The mineral is of more frequent occurrence in translucent foliated masses and in fibrous forms. The luster is pearly or waxy to vitreous and the color white, gray, bluish or green.

Brucite occurs in serpentine and limestone associated with other magnesium minerals. It is found at Hoboken N. J., at Brewster, Putnam co. and in Richmond and Westchester counties N. Y.; also at Texas Pa.

Gibbsite $Al_20_3.\ 3H_20$

Gibbsite is an aluminium hydrate containing 65.4% alumina and 34.6% water.

It is rarely found in six sided monoclinic crystals, but usually occurs in mammillary crusts and stalactitic shapes (pl. 24_1) which sometimes show an ill defined, fibrous, internal structure. The color is commonly white or nearly white but may be grayish, greenish, reddish or yellow; the luster is subvitreous. The mineral is found in small deposits, often associated with limon-

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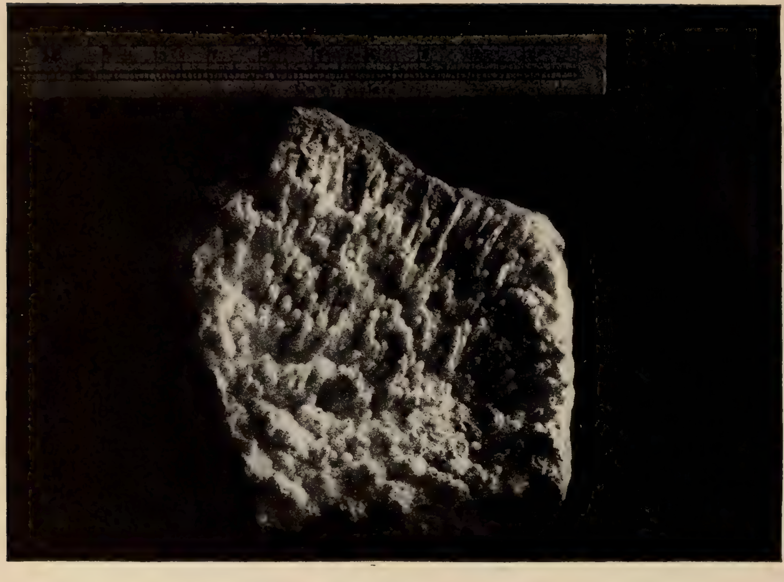
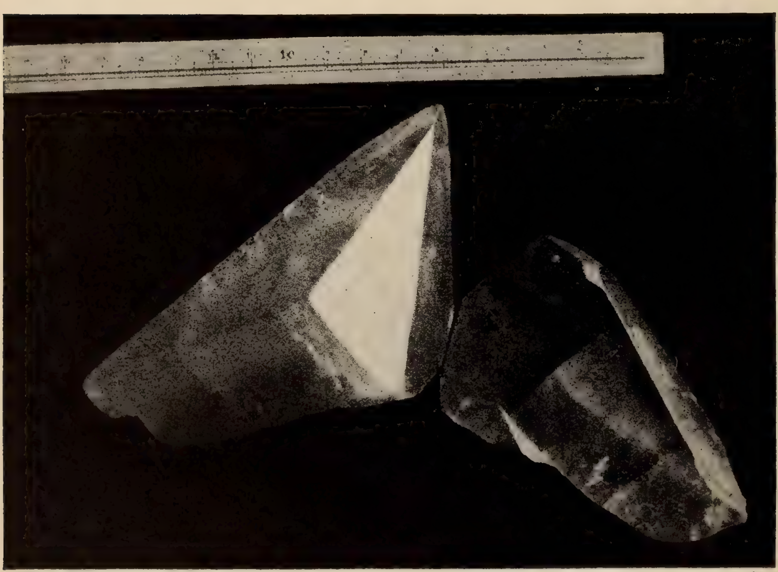
[1] N. Y. state mus. Bul. 7. 1889.

Plate 24

To face p. 79



1 Gibbsite, Richmond Mass.



2 Calcite, Joplin Mo.

ite, at Richmond Mass., with the bauxite of Georgia and Alabama, and in Dutchess and Orange counties, N. Y.

It is an ore of aluminium but has not been found in sufficient quantities to render it of much importance.

Psilomelane (black hematite)

Psilomelane is a hydrous manganese manganate of somewhat doubtful composition and usually very impure.

Psilomelane does not occur crystallized. It is found in black or dark gray, botryoidal, reniform or stalactitic masses with a submetallic or dull luster.

It is commonly associated with pyrolusite in alternate layers and is found in many localities given for the latter mineral. It is applied to the same uses as pyrolusite.

OXYGEN SALTS

CARBONATES

The anhydrous carbonates form two distinct isomorphous groups, one of which is distinguished by rhombohedral crystalline forms of singularly close relation in the various species which form the group; this is named from its most prominent member the calcite group. Similarly the orthorhombic forms of aragonite are closely related crystallographically to those of the other carbonates in the aragonite group.

Calcite (calcareous spar, limestone) $CaCo_3$

Calcite is the carbonate of calcium and contains 44% carbon dioxid and 56% lime.

Calcite crystallizes in the rhombohedral class of the hexagonal system, the great variety and beauty of its crystals making it an object of interesting study to the novice as well as to the trained mineralogist. The unit rhombohedron shown in fig. 194 is an important form both because it is prominent in many varieties and because the perfect and strongly marked cleavage of calcite takes place in planes parallel to the faces of the unit rhombohedron. Many varieties are scalenohedral in habit, crystallizing in forms similar to those shown in fig. 195–97. The name "dog tooth spar" is given to this type, a specimen of which is shown in pl. 24_2. A flat rhombohedron (fig. 198) is prominent in the variety known as "nail head spar."

A steep rhombohedron also occurs modified in many ways, also crystals of prismatic habit (pl. 25_1). Twins are of common occurrence and are of several forms one of which is shown in fig. 199. Calcite also occurs massive with easy rhombohedral cleavage, fibrous (satin spar), coarse and fine granular (crystalline limestone and marble), pulverulent (chalk), stalactitic, etc.

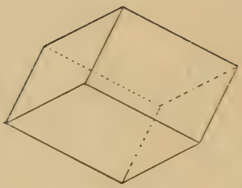


Fig. 194

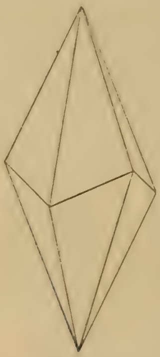


Fig. 195

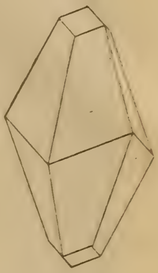


Fig. 196

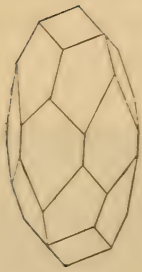


Fig. 197

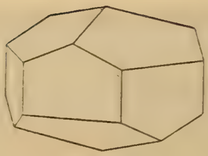


Fig. 198

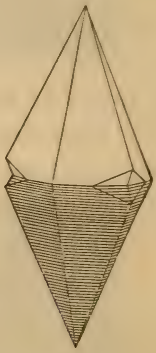


Fig. 199

Calcite

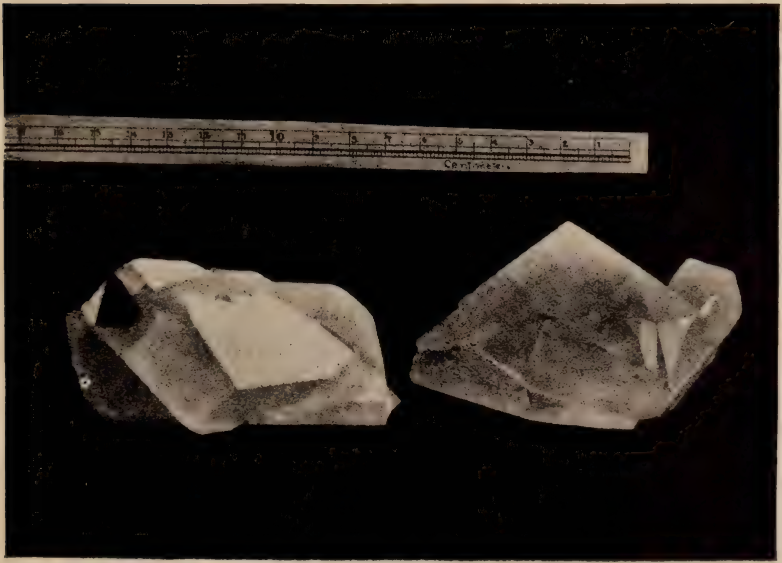
The luster of calcite ranges from vitreous in the crystallized varieties to dull in the limestones and chalk. It is normally colorless or white but often red, green, blue, violet, yellow, brown or black from impurities.

Calcite is readily distinguished by its characteristic rhombic cleavage in three directions as well as by the fact that it is easily scratched by a knife (H. 3) and that a drop of dilute hydrochloric acid will cause it to effervesce violently.

Plate 25

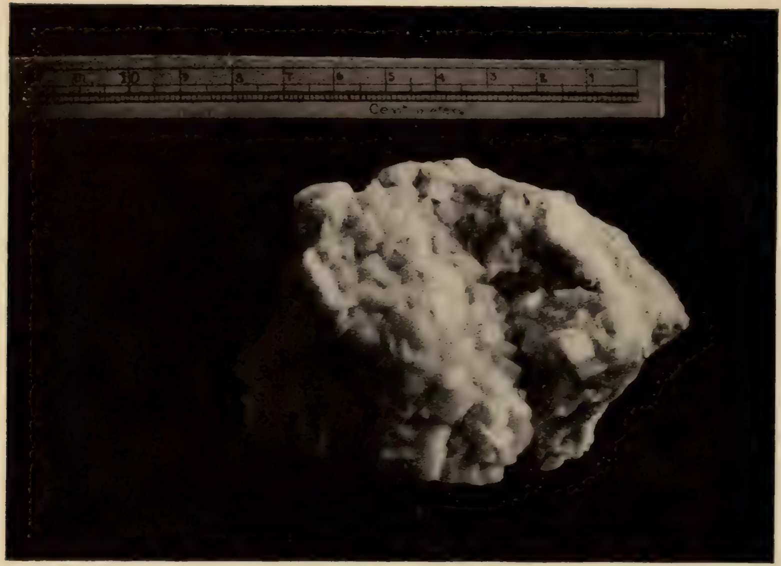
To face p. 80

1 Calcite, Egremont, England

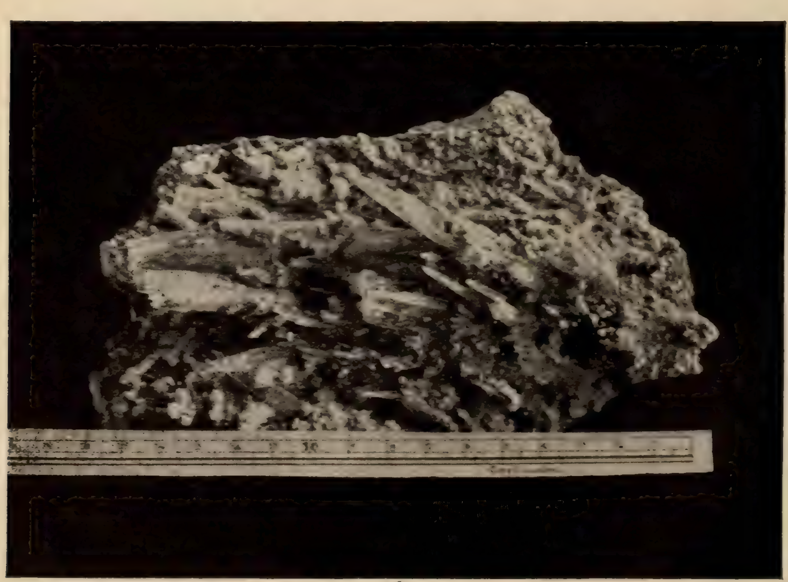


2 Calcite, Rossie N. Y.

Plate 26 To face p. 81



1 Dolomite, Lockport N. Y.



2 Aragonite, Banat, Hungary

Calcite is probably the most widely distributed mineral. Great beds of limestone are found among the rocks of nearly every geologic horizon. Calcite also occurs as a vein mineral, in the form of stalactites and stalagmites in caves, and as a frequently associated mineral with metallic ores.

As limestone and marble, calcite is quarried to a considerable extent in Vermont, Georgia, Tennessee, Alabama, California, New York,[1] Pennsylvania and Massachusetts. Calcite in the form of limestone and marble is extensively used as a building stone; it is also burnt for quick lime, Portland and other cements and is of value as a flux for certain silicious ores. Certain varieties are used for lithographic stone, and the colorless, transparent variety is employed in optical apparatus for polarizing light.

Dolomite (pearl spar) $(CaMg)CO_3$

Dolomite is the carbonate of calcium and magnesium containing 47.9% carbon dioxid, 30.4% lime and 21.7% magnesia.

In crystallization dolomite closely resembles the rhombohedral forms of calcite. It may, however, be readily distinguished from the latter by the marked curvature of the rhombohedral faces (pl. 26_1). Massive coarse or fine granular varieties are distinguished with difficulty from the corresponding forms of calcite.

The luster of dolomite is vitreous to pearly; the color is commonly white, pink or gray and less frequently rose-red, green, brown or black.

Dolomite in the form of dolomitic limestone constitutes extensive strata in many geologic formations and forms a series from pure limestone to pure dolomite. Compact and crystalline varieties frequently occur with serpentine and other magnesium minerals.

In New York dolomite is found at Lockport and Niagara Falls, Niagara co.; at Brewster, Putnam co.; Union Springs, Cayuga co., and in many other localities.[1]

It is used for much the same purposes as calcite.

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[1] N. Y. state mus. Bul. 15. 1896.

Magnesite $MgCO_3$

Magnesite, the carbonate of magnesium, contains 52.4% carbon dioxid and 47.6% magnesia.

Rhombohedral crystals of magnesite are rare. It occurs commonly in granular, cleavable or compact earthy masses and as veins in serpentine. The luster is dull, sometimes vitreous or silky, and the color white, yellowish or grayish white and sometimes brown.

Magnesite is commonly associated with serpentine, talc, brucite and other magnesium minerals. Much of the marble known as verd antique is composed of serpentine veined with magnesite. It is found in Quebec, Pennsylvania, Maryland and in several places in California and Massachusetts. It has been found in the serpentine rocks of Westchester county, N. Y.

Magnesite is used as a refractory material for the lining of converters, etc.; also in the manufacture of epsom salts and carbon dioxid for soda water.

Siderite (spathic iron ore) $FeCO_3$

Siderite is the iron protocarbonate and contains 37.9% carbon dioxid and 62.1% iron protoxid (a composition equivalent to 48.2% iron). Manganese, magnesium or calcium may also be present in small quantities.

Siderite is rhombohedral in crystallization, the crystals being commonly rhombohedral in habit with curved faces resembling those of dolomite. It is characterized in massive varieties by the oblique rhombohedral cleavage common to this group of carbonates. In color siderite is mostly grayish yellow or brown, ranging from pale buff shades to dark brown or black. The luster is vitreous to pearly and the mineral in general resembles dolomite but is somewhat heavier and in most instances is distinguished by its brown color.

Massive siderite is often formed by the action of decaying vegetable matter on limonite. It occurs in gneiss, mica and clay slate and as clay iron stone in coal formations. It is found abundantly in Cornwall and other English localities; also in the coal formations of Pennsylvania, Ohio, Virginia and Tennessee, at Hudson and Burden, Columbia co. and at Antwerp, Jefferson co. N.Y.[1] Siderite supplies a little over 1% of American iron ore.

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[1] N. Y. state mus. Bul. 7. 1889.

Rhodochrosite $MnCO_3$

Rhodochrosite is a manganese carbonate containing 38.3% carbon dioxid and 61.7% manganese protoxid.

It occurs occasionally in rhombohedral crystals similar in shape to those of dolomite but more frequently in vitreous or pearly masses of pink to brown color with a marked rhombohedral cleavage; less frequently in globular and botryoidal forms with columnar structure or incrusting; granular or compact masses are common.

Rhodochrosite is often found associated with gold and silver ores notably at Butte Mont., in Nevada, Colorado and elsewhere. As yet it has no commercial value.

Smithsonite (dry bone ore) $ZnCO_3$

Smithsonite is a carbonate of zinc containing 35.2% carbon dioxid and 64.8% zinc protoxid. Small amounts of copper, cadmium, etc. frequently produce marked differences in the color.

Distinct crystals of smithsonite of rhombohedral form are of quite rare occurrence. It is commonly found in reniform, botryoidal or stalactitic masses, often with a drusy surface. It occurs also in spongy, granular and earthy forms. The luster is vitreous to dull and the color normally white or light in shade but often highly colored by impurities. The common variety of smithsonite resembles calcined bones, as indicated by the name given to it by miners.

Smithsonite is essentially a secondary product formed from other zinc ores by the action of carbonated waters. It is found in veins and beds associated with other ores of zinc as well as those of lead, copper and iron. It is found abundantly in this country in the zinc regions of Missouri, Virginia and Wisconsin.

As an ore of zinc smithsonite is highly valued on account of the ease with which it is reduced. The deposits are now nearly exhausted.

Aragonite $CaCO_3$

Aragonite, which is a calcium carbonate, has the same composition as calcite but differs from the latter in crystallization.

The crystals of aragonite are orthorhombic, sometimes prismatic in habit (fig. 200) with acute terminations (domes and pyramids) which merge into radiating needlelike forms (pl. 26_2). A twinning, which is characteristic of this group of carbonates, produces prismatic forms which somewhat resemble hexagonal prisms (fig. 201, pl. 27_1). Stalactitic incrusting, columnar and corallike forms (pl. 8_1) also occur. The prevailing color is white, which shades to violet, yellow and pale green in some varieties; the luster is vitreous.

Fig. 200

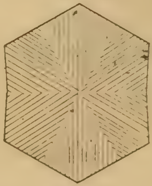


Fig. 201

Aragonite

Crystallized varieties may be distinguished from calcite by the difference in form but massive specimens can only be determined by cleavage and optical tests. Aragonite is formed in much the same way as calcite, but is of far less common occurrence. It is often found associated with gypsum and serpentine and with iron ore as flos ferri (pl. 8_1). In the United States aragonite is found in several localities in California, in Connecticut, Illinois, Missouri, New Mexico and Pennsylvania and in Niagara, Orange and Madison counties, N. Y.

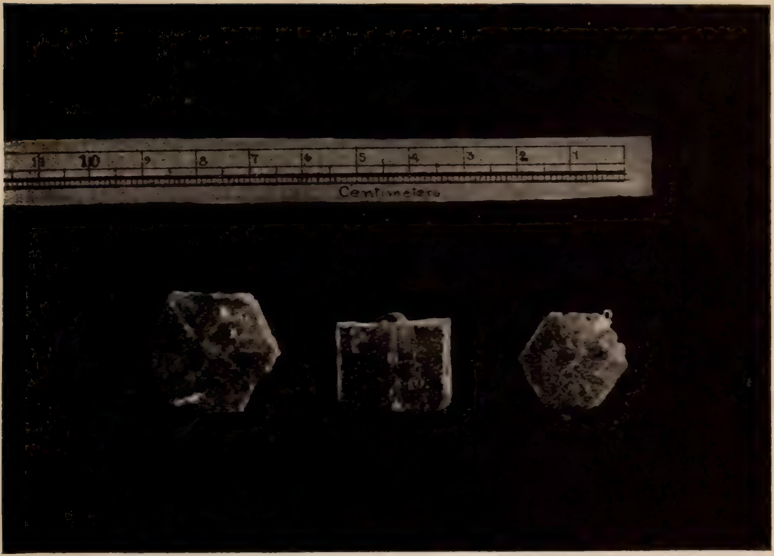
Witherite $BaCO_3$

Witherite is a barium carbonate containing 22.3% carbon dioxid and 77.7% baryta.

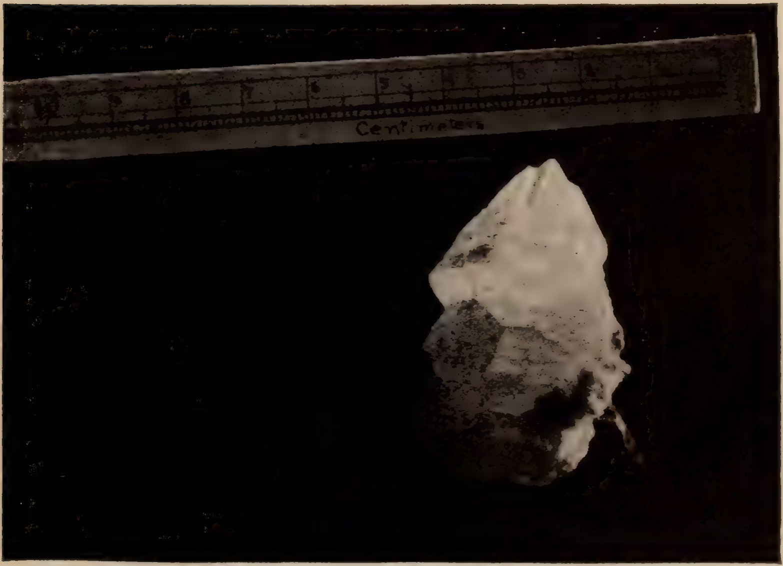
Though witherite is orthorhombic in crystallization single crystals are practically unknown; twinned forms resembling a series of hexagonal pyramids superposed are characteristic (pl. 27_2). It also occurs massive in columnar or granular structure. The luster is vitreous and the color white, gray or yellowish.

Plate 27

To face p. 84



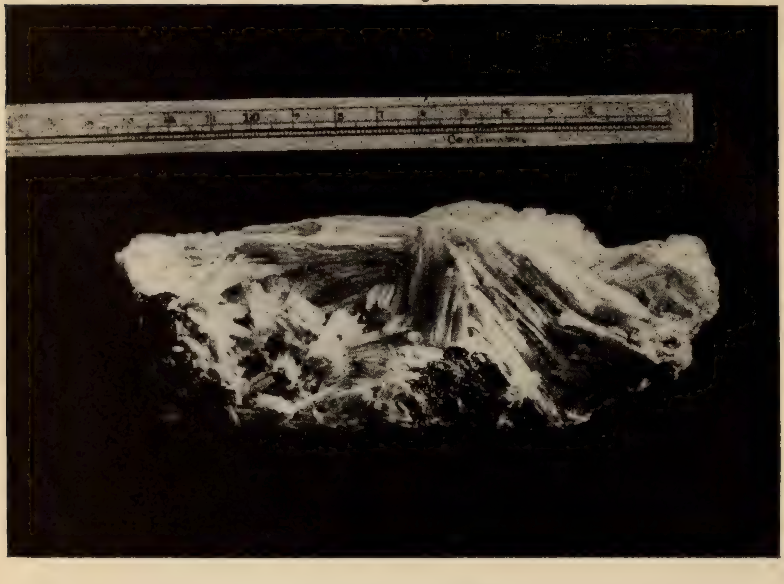
1 Aragonite, Bastenes, France



2 Witherite, Fallowfield, England

Plate 28

To face p. 85



1 Cerussite, Arizona

2 Albite, Branchville Ct.

Witherite is mined at Fallowfield Eng. Small deposits of the mineral occur near Lexington Ky. and at Thunder bay, Lake Superior.

It is used as an adulterant of white lead and in the refining of beet sugar molasses.

Strontianite $SrCO_3$

Strontianite, the carbonate of strontium, contains 29.9% carbon dioxid and 70.1% strontia.

Distinct orthorhombic crystals are quite rare. Radiated, spear-shaped or acicular crystalline aggregates are common; also columnar, fibrous and granular masses. The luster of strontianite is vitreous and the color is white, pinkish or greenish.

Strontianite is found in New York at or near Schoharie, Schoharie co., Clinton, Oneida co. and in several localities in Jefferson county.

It is an important source of strontium compounds used in the manufacture of fireworks.

Cerussite (white lead ore) $PbCO_3$

Cerussite, the carbonate of lead, contains 16.5% carbon dioxid and 83.5% lead oxid. It sometimes carries a little silver.

The crystals of cerussite are orthorhombic, often of tabular habit, flattened parallel to the *a* and *c* axes as in fig. 202; the repeated twinning of this type yields six rayed forms as shown in fig. 203. Crystals of prismatic and pyramidal habit are also frequent. Clusters of interlaced fibrous crystals pass into silky aggregates and masses (pl. 28_1). Granular, compact or earthy

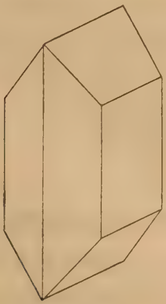


Fig. 202

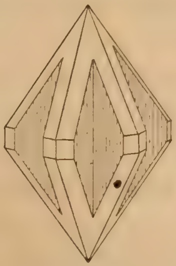


Fig. 203

Cerussite

masses are common. Distinct individual crystals are commonly transparent with an adamantine luster and are colorless or white. Massive varieties are translucent to opaque and have a silky luster which in the earthy forms is nearly dull. The color is white, gray or grayish black.

Cerussite occurs with other lead minerals and results from the alteration of galena by the action of water charged with carbon dioxid. It is found in many parts of England and in central Europe; also in Pennsylvania, Virginia, North Carolina and in Wisconsin and other lead regions of the northwestern states and in Colorado and Arizona.

It is mined for lead and silver and is used in a direct process for the production of white lead.

Malachite (green carbonate of copper) $CuCO_3. Cu(OH)_2$

Malachite is a basic carbonate of copper and contains 19.9% carbon dioxid, 71.9% copper oxid and 8.2% water.

Distinct monoclinic crystals are rare. The mineral commonly occurs in bright green masses and crusts of botryoidal surface and radiating, silky fibrous structure, showing a banding of light and dark green. It is also found in stalactitic forms and earthy masses. The luster is adamantine, silky to dull, and the color bright to dark green.

Malachite is formed by the action of water charged with carbon dioxid on other copper minerals. Large deposits are found at Bisbee Ariz. and adjacent regions. It is also found to a considerable extent in Siberia, Chile and Australia and is of frequent occurrence in all deposits of copper ore.

It is a source of copper and is frequently polished for ornamental objects.

Azurite (blue copper ore) $2CuCO_3. Cu(OH)_2$

Azurite is a basic copper carbonate differing slightly from malachite in composition. It contains 25.6% carbon dioxid, 69.2% copper oxid and 5.2% water.

Azurite occurs in monoclinic crystals of varied habit and often highly modified. Massive forms sometimes show columnar structure. As an incrustation it often has a velvety luster. It has a vitreous luster and is distinguished by its characteristic blue color.

It is formed in the same way as malachite and occurs associated with it at the localities named under the latter mineral.

Azurite is an ore of copper.

SILICATES

The members of this division are mainly important as rock-forming minerals. They are oxygen salts in which silicon is present as the acid element and are classed according as they are salts of disilicic acid ($H_2Si_2O_5$), polysilicic acid ($H_4Si_3O_8$), metasilicic acid (H_2SiO_3) or orthosilicic acid (H_4SiO_4) into disilicates, polysilicates, metasilicates, orthosilicates.

Subsilicates represent a group of basic silicates having a lower oxygen ratio than the foregoing.

Disilicates, polysilicates

Feldspar group

For many reasons the feldspars are considered the most important group of minerals in the large division of the silicates. They form an essential constituent in a number of rocks such as granite, syenite, gneiss, etc. which are of primary importance as building materials and are largely quarried in all parts of the world. As a group of minerals the feldspars present several general characteristics which unite them in close relation to each other.

1 Crystallizing in the monoclinic and triclinic systems, the feldspars agree closely in crystal habit, prism angle and methods of twinning.

2 They are characterized by two easy cleavages inclined to one another at an angle which is close to 90°, the cleavage surfaces being smooth and of high polish.

3 In hardness they vary between the comparatively close limits of 6 and 6.5.

4 They range in color from clear and colorless through white, pale shades of yellow, pink or green, to less common dark gray tints.

5 The feldspars are silicates of aluminium and some other base, commonly potassium, sodium or calcium, less frequently barium.

Orthoclase (potash feldspar) $KAlSi_3O_8$

Orthoclase is a silicate of aluminium and potassium. Part of the potassium is often replaced by sodium giving rise to a variety known as soda-orthoclase.

The crystals of orthoclase are monoclinic, a type of frequent occurrence being that shown in fig. 204. Types of prismatic habit, often orthorhombic in aspect from the equal development of the basal pinacoid and positive hemiorthodome (fig. 205), are often found in the transparent variety called adularia.

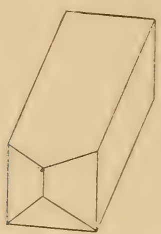


Fig. 204

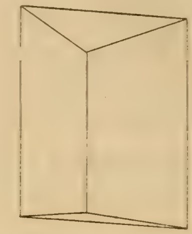


Fig. 205

Orthoclase

Twin crystals occur quite frequently and are ordinarily of three types, the Carlsbad, the Baveno and the Manebach type.[1] The cleavage of orthoclase takes place in two directions parallel to the basal and clinopinacoid and at an angle which is close to 90°. Cleavable masses are quite common. Also compact non-cleavable masses resembling flint.

The luster of orthoclase is vitreous or pearly and the color is commonly flesh-red, yellowish, white or colorless; more rarely gray or green.

Orthoclase abounds in igneous rocks and constitutes an important element in granite, gneiss and syenite and in the form of sanidine is common in the volcanic rocks rhyolite, trachyte and phonolite. It is quarried in Maine, Connecticut, Massachusetts and Pennsylvania and at Bedford and Fort Ann N. Y.

Orthoclase is used in the manufacture of porcelain and china, as a constituent of the body of the ware and also to produce the glaze.

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[1] These forms of twinning are illustrated by specimens and models in the collection of the New York state museum.

Microcline $KAlSi_3O_8$

Microcline is a triclinic feldspar having the same composition as orthoclase and was formerly grouped under that species. The crystals are so close to those of orthoclase in angle and habit that the unassisted eye is unable to distinguish between the two species. Under the polarizing microscope a characteristic gridiron structure is observable in a thin section of microcline. A characteristic variety called Amazon stone has a beautiful green color. In other respects the characteristics are essentially the same as for orthoclase.

Plagioclase feldspars

The triclinic group of minerals known as the plagioclase feldspars constitute a practically continuous series from pure soda alumina silicate in albite ($NaAlSi_3O_8$) to pure lime alumina silicate, in anorthite ($CaAl_2Si_2O_8$). The intermediate species now to be discussed are mixtures of these two molecules and of necessity grade into one another, so that in many cases no marked division line can be drawn. If the albite molecule, $NaAlSi_3O_8$, be represented by Ab, and the anorthite molecule, $CaAl_2Si_2O_8$, be represented by An, the albite-anorthite series or, as they are usually called, the plagioclase feldspars, may be represented in composition as follows:

Albite	Ab — $Ab_6\ An_1$
Oligoclase	$Ab_6\ An_1$ — $Ab_3\ An_1$
Andesin	$Ab_3\ An_1$ — $Ab_1\ An_1$
Labradorite	$Ab_1\ An_1$ — $Ab_1\ An_3$
Bytownite (rare)	$Ab_1\ An_3$ — $Ab_1\ An_6$
Anorthite	$Ab_1\ An_6$ — An

The plagioclase feldspars are characterized in general by a repeated twinning parallel to the brachypinacoid which results in a series of striations on the basal cleavage surface. They form an important constituent of the igneous rocks, dacite, andesite, diorite and diabase.

Albite (soda feldspar)

Albite is a silicate of aluminium and sodium.

It occurs in triclinic crystals (fig. 206) often tabular parallel to the brachypinacoid and usually twinned parallel to the same plane (albite law) or with the macro axis as the twinning axis (pericline law). It is common in pure white granular masses or in aggregations of straight or curved laminae. The luster is vitreous or pearly and the prevailing color white or less commonly bluish, gray, red or green of light tints; an opalescence or play of color is not uncommon on the cleavage surface.

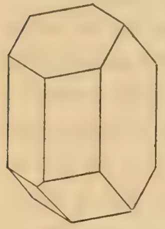


Fig. 206
Albite

Albite is frequently found in cavities and seams in acidic rocks and is frequently a matrix for such minerals as tourmalin, beryl, chrysoberyl, topaz etc. Interesting crystals of albite are found at Moriah, Essex co. N. Y.

Oligoclase (soda lime feldspar)

Oligoclase is a silicate of aluminium, sodium and calcium.

It does not often occur crystallized. Cleavable masses are characterized by the fine striations, common to the plagioclases, but particularly well developed in this species. The luster is vitreous to pearly and the color whitish with faint tints of gray, green, red or yellow.

It occurs with orthoclase and albite in granitoid rocks and in rocks of volcanic origin. Interesting crystals are found in St Lawrence county, N. Y.

Labradorite (lime soda feldspar)

Labradorite is a silicate of aluminium, sodium and calcium. It is rarely found in small triclinic crystals but is commonly met with in dark gray cleavable masses which often display a remarkable change of color as the light is reflected from a cleavage surface. The luster is vitreous to pearly and the color in general darker than that of the other plagioclases.

Labradorite is usually associated with pyroxene and amphibole in many basic rocks. It is the chief feldspar found in the Adirondack region of New York.

Anorthite (lime feldspar)

Anorthite is a silicate of aluminium and calcium. The triclinic crystals of anorthite are usually prismatic in habit, twinned, as with albite, and colorless, white or reddish yellow.

The cleavable masses are pink or gray. Granular masses of a white or reddish color are common.

Anorthite occurs in many volcanic rocks.

Metasilicates

Leucite $KAl(SiO_3)_2$

Leucite is a silicate of potassium and aluminium. It crystallizes in trapezohedrons (fig. 207) and is often found in irregular grains disseminated through lava and volcanic rock. The luster is vitreous and the color light gray or white.

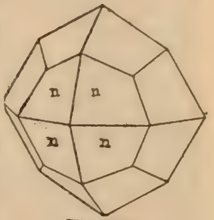


Fig. 207
Leucite

Pyroxene group

The following species though falling in the orthorhombic, monoclinic and triclinic systems, exhibit a marked similarity in crystal habit and in the angle of the fundamental prism, which varies but slightly from 87°. This relation is emphasized by the fact that a more or less pronounced cleavage takes place parallel to this fundamental prism in all species referred to this group.

Enstatite (bronzite) $(MgFe)SiO_3$

Enstatite is essentially a silicate of magnesium but often contains some iron replacing the magnesium. The iron-bearing variety is known as bronzite and grades into hypersthene with increased percentage of iron.

Enstatite rarely occurs in orthorhombic crystals of columnar habit. It is usually found in lamellar or fibrous masses, brown, gray or green in color and in the variety bronzite with a submetallic or bronzelike luster.

It is frequently found in basaltic and granular eruptive rocks and is quite common in stony meteorites. It occurs at Tilly Foster, Putnam co. and at Edwards, St Lawrence co. N. Y.

Hypersthene $(MgFe)SiO_3$

Hypersthene is a silicate of magnesium and iron. With a decreasing proportion of iron hypersthene grades into enstatite. Orthorhombic crystals are rare. The mineral is usually found in dark green to black foliated masses, frequently showing a metalloidal luster somewhat similar to that of bronzite. Hypersthene is found in norites and other granular eruptive rocks, a series of which may be found in the vicinity of Peekskill, Westchester co. N. Y.

Pyroxene (augite)

Pyroxene is essentially a normal metasilicate of calcium and magnesium, also containing iron, manganese or zinc and sometimes small percentages of potassium and sodium. The many varieties are usually classified as nonaluminous and aluminous.

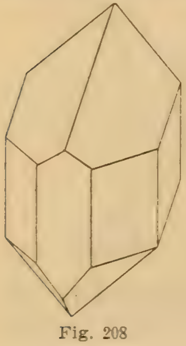


Fig. 208

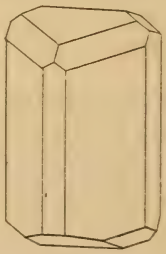


Fig. 209

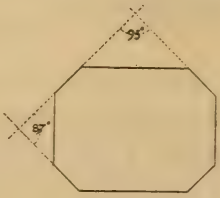


Fig. 210

Pyroxene

Pyroxene occurs in monoclinic crystals of prismatic habit with well developed terminations (fig. 208, 209); these crystals have a nearly square or octagonal cross section composed of the faces of the unit prism which has an angle of 93° (nearly 90°) and the faces of the ortho and clino pinacoid (fig. 210). A strongly marked parting parallel to the basal pinacoid is very characteristic, and is well shown in the specimen reproduced in pl. 29_1. The crystals are often thick and short. Massive forms are granular, foliated or columnar in structure but rarely fibrous. The luster is vitreous, resinous to dull and the color usually some shade of green, but also white, brown, or black.

VARIETIES

Diopsid or malacolite $CaMg(SiO_3)_2$. Usually white or pale green in color.

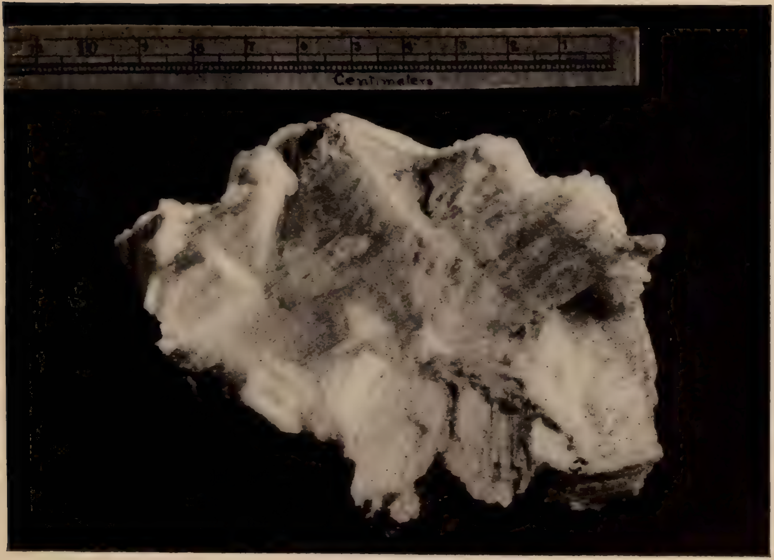
Hedenbergite $(CaFe)(SiO_3)_2$. Color grayish green to black.

Augite. An aluminous pyroxene chiefly $CaMg(SiO_3)_2$ but containing aluminium and iron. Color dark green, brownish green to black.

Plate 29

To face p. 92

1 Pyroxene, East Russell N. Y.



2 Wollastonite, near Gouverneur N. Y.

Diallage. A foliated variety, green or brown in color.

Pyroxene is an essential constituent of many basic eruptive rocks notably the diabases and gabbros. It occurs associated with amphibole, wernerite and the feldspars. In New York pyroxene occurs in handsome specimens in Orange, Westchester, Essex and Lewis counties and specially in St Lawrence county.

Spodumene $LiAl(SiO_3)_2$

Spodumene is a silicate of lithium and aluminium.

It occurs in monoclinic crystals sometimes of considerable size which are characterized by a lamellar structure parallel to the orthopinacoid causing them to split into broad smooth plates. In the variety hiddenite the crystals are small, transparent and of a yellow-green or emerald-green color. It is also found in cleavable masses. The luster is vitreous and sometimes pearly on the cleavage surfaces, and the color white or various shades of green, pink and purple.

Spodumene occurs in granite rocks and is readily altered. Immense crystals are found at Branchville Ct. The variety hiddenite occurs at Stony Point N. C.

The emerald-green hiddenite is used as a gem.

Jadeite (jade) $NaAl(SiO_3)_2$

This is a tough translucent mineral of closely compact structure and of a general green color. It is chiefly notable as the material from which many of the prehistoric implements were made and is still used in the East, specially in China, for ornaments and utensils.

Wollastonite (tabular spar) $CaSiO_3$

Wollastonite is a silicate of calcium, sometimes occurring in tabular monoclinic crystals, but usually in cleavable to fibrous white or gray masses. When fibrous the fibers lie in parallel position or are arranged in reticulated bundles of parallel fibers (pl. 29_2). The luster is vitreous to silky and the color white or faint tints of gray, yellow, red or brown.

Wollastonite is found in granular limestone and as a contact mineral.

Pectolite $HNaCa_2(SiO_3)_3$

Pectolite is a silicate of sodium and calcium, and contains water.

It usually occurs in radiated aggregates of needlelike crystals which are rarely terminated (pl. 7_1). Monoclinic crystals are rare. The luster is vitreous to silky and the color white or gray.

Pectolite is found associated with the zeolites and prehnite in cavities and seams of basic eruptive rocks.

Rhodonite $MnSiO_3$

Rhodonite is a silicate of manganese with part of the manganese replaced by iron, calcium or zinc.

The crystals of rhodonite are triclinic, tabular parallel to the basal pinacoid, or in forms resembling pyroxene in habit but with rounded edges and angles. It also occurs in cleavable to compact masses and in embedded grains. The luster is vitreous and the color commonly brownish red, flesh-red or pink, less frequently greenish or yellowish.

Rhodonite occurs in the United States in Maine and Massachusetts and abundantly in the vicinity of Franklin N. J.

Amphibole group

This group of minerals is closely allied to the pyroxenes, forming as it does a series whose members are chemically analagous to the corresponding members of a parallel series in the pyroxene group. The two groups are also closely related crystallographically; thus a comparison of the axial ratios of pyroxene and amphibole brings out the fact that if the *a* and *c* unit intercepts for amphibole be multiplied by 2 the result will approximate very closely the actual values of the corresponding intercepts for pyroxene:

PYROXENE			AMPHIBOLE			AMPHIBOLE		
a:	b:	c	a:	b:	c	2a:	b:	2c
1.092:	1:	0.589	0.551:	1:	1 0.294	1.102:	1:	0.588

Amphibole (hornblende)

Amphibole is essentially a metasilicate of calcium and magnesium usually containing iron and manganese and also sodium and potassium to some extent. As in the case of the pyroxenes the varieties are divided into nonaluminous and aluminous.

Amphibole occurs in monoclinic crystals of prismatic habit, usually with an acute rhombic section and striated vertically; a typical section is shown in fig. 211. Some of the common types are given in fig. 212, 213. Columnar and fibrous masses are common, often radiated; also coarse or fine granular masses. The luster is vitreous to pearly and often silky. The color varies with different varieties but is mainly white, shades of green, brown or black.

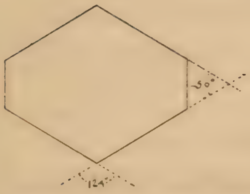


Fig. 211

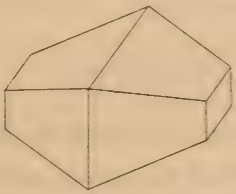


Fig. 212

Fig. 213

Amphibole

VARIETIES

Tremolite $\mathbf{CaMg_3(SiO_3)_4}$. White or dark gray in color, sometimes transparent and colorless. Luster silky.

Actinolite $\mathbf{Ca(MgFe)_3SiO_3)_4}$. Bright green to grayish green in color.

Nephrite (jade). A compact tough variety similar to the jadeite described under pyroxene.

Asbestos. A fine fibrous material white, gray, or greenish in color, easily separated into threadlike fibers.

Hornblende. An aluminous variety. Green, grayish green or black in color.

Amphibole occurs in crystalline limestone and in granitoid and schistose rocks. It is an important constituent of many granites, syenites and diorites. Good specimens have been obtained in Orange, St Lawrence and Lewis counties, N. Y.

Amphibole asbestos, which must not be confounded with the fibrous serpentine passing commercially under the same name, is mined in California, Wyoming and Oregon. Large deposits also occur in North Carolina, Georgia, Pennsylvania and other states but these deposits are not at present worked with profit.

Asbestos is extensively used for incombustible appliances and fabrics.

Crocidolite (blue asbestos)

This is a blue to green fibrous amphibole resembling asbestos. An altered form from South Africa has the interstices between the fibers filled with silica and under the name of "tiger's eye" is sometimes cut for a cheap gem.

Beryl (emerald) $Be_3Al_2(SiO_3)_6$

Beryl is a silicate of beryllium and aluminium. It occurs in hexagonal crystals of prismatic habit which are often striated vertically and are seldom terminated (fig. 214, 215). It is also found in columnar or granular masses. The luster is vitreous and the color emerald-green, pale green, light blue, yellowish white, white to colorless.

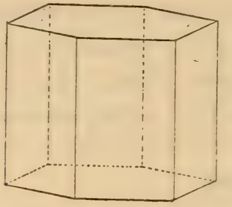


Fig. 214

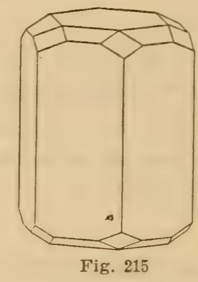


Fig. 215

Beryl

Beryl is common as an accessory mineral in granite veins. It is also found in mica schist, clay slate, etc. Beryl occurs in Maine, Massachusetts, New Hampshire, Connecticut, North Carolina, South Dakota and other states. The finest emeralds come from United States of Colombia, Brazil, India, Siberia and Australia. A few emeralds have been found at Stony Point S. C.

Emerald and a sky-blue to greenish blue variety called aquamarine are cut as gems.

Iolite (cordierite)

Iolite is a metasilicate of magnesium, aluminium and iron of somewhat complicated formula.

It occurs in short orthorhombic prisms and glassy quartzlike masses of a prevailing blue color which is deeper in one direction and more grayish or yellowish in a direction at right angles to the first.

It occurs in gneiss or granite but rarely in volcanic rocks.

Orthosilicates

Nephelite (nephelin) $K_2Na_6Al_8Si_9O_{34}$

Nephelite is an orthosilicate of sodium, potassium and aluminium.

The crystals are hexagonal-hemimorphic, prismatic in habit, terminated with a basal pinacoid sometimes slightly modified by a low pyramid. The crystals are small, sometimes transparent, with a vitreous luster, and are colorless, white or faintly yellow. Colorless or white glassy grains are found in some eruptive rocks. A common variety, called elaeolite, occurs in indistinct crystals or masses of a peculiar greasy luster and reddish brown or greenish in color.

Nephelite occurs in the more basic igneous rocks as the product of a magma rich in soda. The crystallized variety is found associated with epidote and vesuvianite in lavas and other eruptive rocks, notably in the lavas of Vesuvius. Elaeolite occurs in granular crystalline rocks and is found in Maine, Arkansas, Texas and elsewhere.

Cancrinite

An orthosilicate of sodium, calcium and aluminium generally found in yellow to white masses associated with elaeolite and blue sodalite.

It is found in the Urals, in Norway and at Litchfield and Gardiner Me.

Sodalite $Na_4(AlCl)Al_2(SiO_4)_3$

Sodalite is a chlorosilicate of sodium and aluminium. It is found in bright blue to gray masses of a vitreous to greasy luster, in concentric nodules resembling chalcedony and rarely in isometric dodecahedral crystals.

It is formed from elaeolite and its mode of occurrence is similar to that mineral.

Haüynite $Na_2Ca(NaSo_4.Al)Al_2(SiO_4)_3$

Haüynite is a sodium, calcium and aluminium orthosilicate with some sodium sulfate.

Haüynite occurs in glassy rounded isometric crystals and grains of a blue to green color in igneous rocks and lavas.

Lazurite (lapis lazuli) $Na_4(NaS_3.Al)Al_2(SiO_4)_3$

Lazurite is an orthosilicate of sodium and aluminium with sodium sulfid.

It occurs in deep blue masses and rarely in isometric crystals. Lazurite was formerly used as a natural pigment, producing the deep blue color known as ultramarine; it has now been almost entirely superseded by the artificial product of that name.

Garnet $R^{II}_3R^{III}_2(SiO_4)_3$

Garnet is an orthosilicate of the general formula $R^{II}_3R^{III}_2(SiO_4)_3$ in which R^{II} may be calcium, magnesium, ferrous iron, or manganese and R^{III} aluminium, ferric iron or chromium, rarely titanium. The varying proportions of these elements give rise to numerous varieties, the principal types of which will be discussed under "Varieties."

Garnet crystallizes in the normal group of the isometric system. Fig. 216-18 show the common types of crystals. It occurs in isolated, embedded crystals, in drusy incrustations and in granular, lamellar and compact masses, also as rounded grains and in sand.

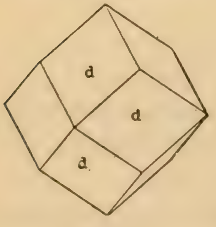


Fig. 216

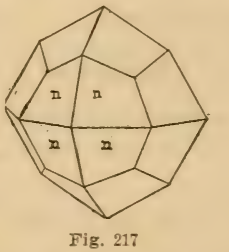


Fig. 217

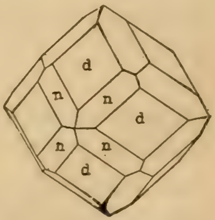


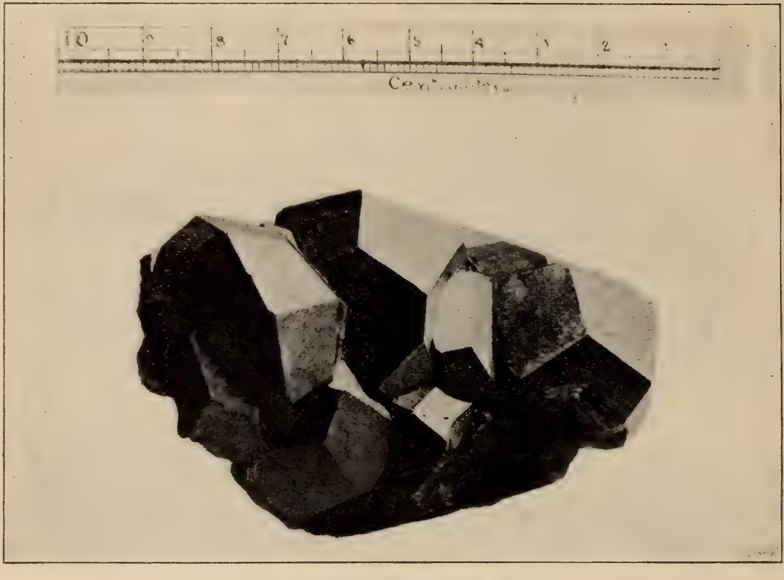
Fig. 218

Garnet

The luster is vitreous to resinous and the color commonly brown, red or black but also yellow, pink, white, green and violet. In hardness garnet ranks between quartz and corundum.

Plate 30

To face p. 99



1 Garnet, Russell Mass.

2 Andalusite (chiastolite), Lancaster Mass.

VARIETIES

1 Aluminium garnet. Grossularite $Ca_3Al_2(SiO_4)_3$. White, pale yellow, pale green, reddish, brown or rose-red in color, rarely emerald-green from the presence of chromium.

Pyrope $Mg_3Al_2(SiO_4)_3$. Deep red to nearly black in color. Transparent specimens are cut for gems.

Almandite $Fe_3Al_2(SiO_4)_3$. Deep red to black in color. This variety includes many of the common garnets and when transparent is cut for gems.

Spessartite $Mn_3Al_2(SiO_4)_3$. Dark hyacinth-red, violet-red to brownish red.

2 Iron garnet. Andradite $Ca_3Fe_2(SiO_4)_3$. Various shades of yellow, green, red, brown and black in color. This variety is quite common.

3 Chromium garnet. Uvarovite $Ca_3Cr_2(SiO_4)_3$. In minute crystals of an emerald-green color.

Garnet, particularly the variety almandite, occurs abundantly in gneiss and the crystalline schists. Grossularite is characteristic of the contact zones of intruded igneous rock in the crystalline schists. Pyrope is found in many basic igneous rocks, and spessartite in granite rocks, quartzites and whetstone schists, also in rhyolite. Uvarovite is found with chromite in serpentine and in granular limestone. Pink garnets embedded in marble are found at Mordos Mex. In New York garnet is found in Essex, Warren, Orange, Westchester and New York counties.

Garnet is extensively used as abrasive material. The Mexican marble mentioned above is polished for ornamental purposes and transparent red and green varieties are cut for gems.

Chrysolite (olivin, peridot) $(Mg.Fe)_2SiO_4$

Chrysolite is an orthosilicate of magnesium and iron. It rarely occurs in orthorhombic crystals but is usually found in transparent to translucent granular masses, disseminated grains or as sand. The luster of chrysolite is vitreous and the color a yellowish green, olive-green, or bottle-green to brownish red.

Chrysolite occurs as an essential constituent of peridotite and of some gabbros. It is found in eruptive rocks such as trap, basalt, etc. and as a product of the metamorphism of certain sedimentary rocks containing magnesia and silica.

As a rock constituent chrysolite occurs in the rocks of the Cortlandt series in the vicinity of Peekskill, Westchester co. and Stony Point, Rockland co. N. Y.

Transparent varieties of olivin are cut as gems and are known to jewelers as olivins or peridots.

Willemite Zn_2SiO_4

Willemite is an orthosilicate of zinc containing 72.9% zinc oxid and 27.1% silica. A considerable part of the zinc is replaced by manganese in the variety troostite.

Willemite occurs in hexagonal crystals of the trirhombohedral class prismatic in habit. It is more commonly found in granular masses and disseminated grains. The luster is resinous and the color greenish yellow to apple-green when pure but flesh-red in the manganese bearing variety.

Willemite is chiefly found associated with franklinite and zincite in the vicinity of Franklin N.J. where it is mined for zinc.

Phenacite Be_2SiO_4

Phenacite is the orthosilicate of beryllium. It occurs in transparent hexagonal crystals, trirhombohedral, which are commonly small, lens-shaped and transparent and white or yellowish in color.

It occurs with microcline, beryl, quartz and topaz and is found in the Urals, in Mexico and at Pike's peak Col. It is sometimes cut for an imitation gem.

Dioptase H_2CuSiO_4

Dioptase is a basic copper orthosilicate occurring in rhombohedral crystals and crystalline aggregates of a vitreous luster and emerald-green in color; also massive.

Wernerite (scapolite)

Wernerite is an aluminium, sodium and calcium chlorosilicate of variable composition, usually containing some soda.

The crystals of wernerite are tetragonal, of the general type shown in fig. 219, and are characterized by the low pyramidal termination. They are commonly coarse and thick, often with rounded edges and angles and with a characteristic fibrous appearance on the cleavage surfaces. Wernerite also occurs in columnar and granular masses. The luster is vitreous to dull, and the color is usually gray, dull green or white, sometimes bluish or reddish.

Wernerite occurs in metamorphic rocks and is abundant in granular limestone near the contact with granite or other igneous rocks. It is associated with pyroxene, amphibole, apatite, etc. In New York wernerite is found in Orange, Essex and Lewis counties and abundantly in Jefferson and St Lawrence counties.

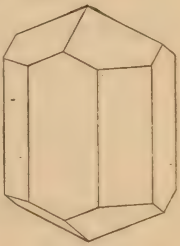


Fig. 219
Wernerite

Vesuvianite (idocrase)

Vesuvianite is a basic calcium-aluminium silicate of uncertain formula with some of the calcium replaced by manganese and some of the aluminium by iron. Fluorin and titanium may be present.

The crystals are tetragonal, prismatic or pyramidal in habit, the prismatic crystals often exhibiting the general type shown in fig. 220. Columnar masses occur straight, radiated or irregular, often producing characteristic striations parallel to the vertical axis. The luster is vitreous to resinous and the color commonly brown, green or some intermediate shade, rarely yellow or blue.

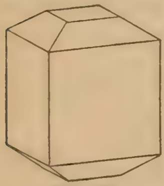


Fig. 220
Vesuvianite

Vesuvianite commonly occurs as a contact mineral from the alteration of impure limestone; also in serpentine, chlorite schist, gneiss and other metamorphic rocks; in the former case it is usually associated with garnet, phlogopite, pyroxene, wollastonite, etc. It is found in Canada, Maine, New Hampshire and New Jersey and in Orange county and other localities in New York.

Zircon (hyacinth) $ZrSiO_4$

Zircon is a silicate of zirconium usually containing a little iron sesquioxid.

It occurs in tetragonal crystals, prismatic in habit, of the general types shown in fig. 221–23, but sometimes pyramidal with the prism only slightly developed. Twins similar to those of cassiterite and rutile occur. Zircon is also found in irregular lumps and grains. The luster is adamantine and the color usually brown, reddish or gray but also colorless, green or yellow. Zircon is somewhat harder than quartz.

Zircon occurs chiefly in granite, gneiss, crystalline limestone and other crystalline rocks and in alluvial deposits; often in auriferous sands; sometimes also in volcanic rocks. Interesting specimens of zircon have been found in Orange, Essex and St Lawrence counties, N. Y. It is mined in North Carolina.

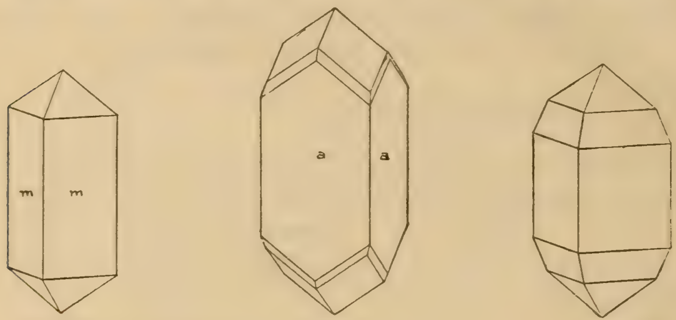


Fig. 221 Fig. 222 Fig. 223

Zircon

Zircon is the chief source of zirconium oxid used in certain incandescent light mantles. Transparent red and brown varieties are cut as gems and are known to jewelers as hyacinth, a term also used in connection with garnet.

Topaz $Al_{12}Si_6O_{25}F_{10}$

Topaz is an aluminium fluosilicate.

The crystals are orthorhombic, prismatic in habit, frequently with complicated terminations (fig. 224, 225) and often striated

Fig. 224 Fig. 225

Topaz

vertically on the prismatic faces. They show perfect cleavage parallel to the base, the cleavage surfaces presenting beautifully polished reflecting planes. They are usually attached and are consequently rarely terminated at both ends. Topaz occurs also in columnar masses and rolled fragments.

The luster is vitreous and resembles that of quartz; the crystals are colorless, yellow, reddish, bluish, faintly green or pink; massive varieties are often white. The hardness exceeds that of quartz but is not as high as corundum.

Topaz occurs in veins and cavities in the highly acid igneous rocks such as granite, rhyolite, etc. and sometimes in gneiss and schists. It is often found in alluvial deposits with stream tin. It is commonly associated with fluorite, cassiterite and tourmalin.

It is found in Saxony, the Urals, Japan, Brazil, Mexico; and in Maine, Colorado and Utah.

Transparent varieties are cut for gems.

Andalusite Al_2SiO_5

Andalusite is an orthosilicate of aluminium.

It occurs in coarse orthorhombic crystals nearly square in cross section or in tough columnar or granular masses. The variety chiastolite occurs in rounded prisms which are characterized by carbonaceous inclusions symmetrically arranged with respect to the vertical axis; these show on a fracture, a cross or tesselated figure as in pl. 30_2. The luster is vitreous inclining to pearly; the color varies from white or light gray through light green or violet to rose-red or flesh-red.

Andalusite occurs in imperfectly crystalline schist, in gneiss, mica schist and other metamorphic rocks. Chiastolite is commonly a contact mineral in clay slates adjoining granite dikes. It is found in Andalusia, Spain; Brazil and in many localities in the New England states, Pennsylvania and California.

Sillimanite (fibrolite) Al_2SiO_5

An orthosilicate of aluminium with the same composition as andalusite. It occurs in long slender orthorhombic crystals, in parallel groups passing into fibrous or columnar masses, brown or gray in color and extremely tough in tenacity. Its mode of occurrence is similar to that of andalusite.

Cyanite (disthene) Al_2SiO_5

Cyanite is probably a basic metasilicate of aluminium with the formula $(AlO)_2 SiO_3$. Dana, however, places it for convenience in the group with sillimanite, to which mineral it bears a close relation.

Cyanite is found in long bladelike, triclinic crystals which are rarely terminated and in coarsely bladed columnar masses usually of a grayish blue color (pl. 2_2). It cleaves easily parallel to the three pinacoids. The luster is vitreous to pearly and the color commonly blue along the center of the blades, shading to white on the edges; also gray, green to nearly black.

It occurs in gneiss and mica schist with garnet and staurolite and is often associated with corundum. It is found in the corundum regions of Massachusetts, Pennsylvania, North Carolina and Georgia; it has been noted in the rocks of New York island.

Cyanite is sometimes used as a gem.

Datolite $Ca(BOH)SiO_4$

Datolite is a basic calcium and boron orthosilicate.

It crystallizes in monoclinic forms of varied habit but usually short prismatic (fig. 226) and often highly modified. The crystals are glassy, transparent or translucent and colorless, white or pale green. A massive compact variety has a dull luster resembling unglazed porcelain and is gray or pinkish in color.

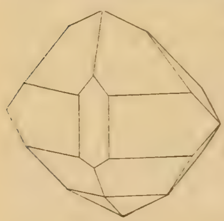


Fig. 226
Datolite

Datolite occurs as a secondary mineral in veins and cavities in basic eruptive rocks associated with calcite, prehnite and the zeolites; also in metallic veins as in the Lake Superior copper region where the massive variety is quite common. It is also found in the vicinity of Bergen Hill and Paterson N. J. and in other localities throughout New York[1] and New England.

Epidote $HCa_2(Al,Fe)_3Si_3O_{13}$

Epidote is a basic calcium, aluminium and iron silicate.

It occurs in monoclinic crystals which are commonly elongated

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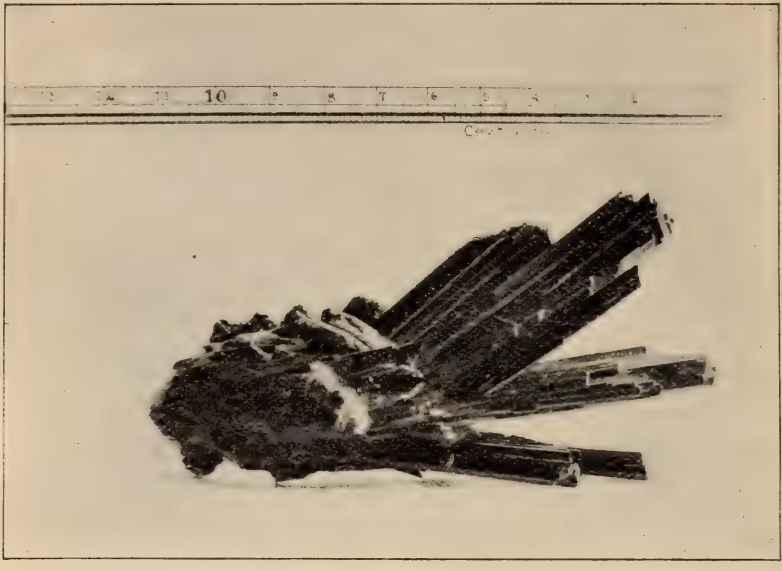
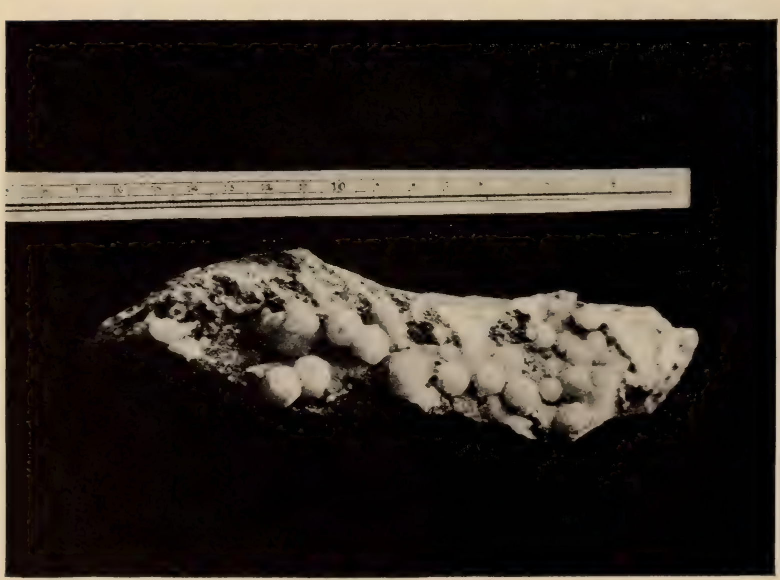
[1] A few rare occurrences are noted in St Lawrence county. *See* Dana, J. D. System of mineralogy. 1892.

Plate 31

To face p. 105



1 Epidote, Sulzbach, Tyrol



2 Prehnite, West Paterson N. J.

in the direction of the orthoaxis producing forms of horizontal prismatic habit (fig. 227). These pass into acicular forms, striated in the direction of elongation, columnar, parallel or divergent, and fibrous masses (pl. 31_1). It also occurs coarse to fine granular. The luster is vitreous, the crystals sharp and with brilliantly reflecting faces; the color is commonly some shade of pistachio-green, often nearly black, also yellowish green, gray or brown.

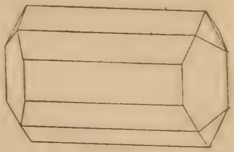


Fig. 227
Epidote

Epidote occurs in metamorphic rocks of the older formations, in gneiss, mica and hornblende schists. It is found associated with quartz, the feldspars, actinolite and minerals of the chlorite group. It is common in New England and in many of the western states. Handsome specimens have been found in Orange and Putnam counties, N. Y.

Axinite $H_2Ca_4(BO)Al_3(SiO_4)_5(?)$

Axinite is an aluminium and calcium borosilicate with some of the calcium replaced by iron and manganese. It occurs in sharp triclinic crystals with acute edges (fig. 228), clove-brown, bluish or yellow in color and in lamellar and curved lamellar masses. The luster is highly vitreous.

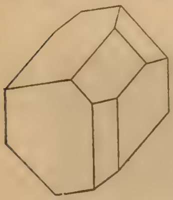


Fig. 228
Axinite

Prehnite $H_2Ca_2Al_2(SiO_4)_3$

Prehnite is an acid calcium and aluminium orthosilicate.

It is rarely found in isolated orthorhombic crystals of tabular habit but usually occurs in aggregates of such crystals united by their basal planes and producing barrellike, sheaflike and botryoidal shapes (pl. 31_2) with crystalline surfaces. The luster is vitreous, faint pearly on the basal planes; the color is light green to oil green, yellowish green, gray to white.

Prehnite occurs as a secondary mineral in veins and cavities in basic eruptive rocks, basalt, diabase, etc. also in gneiss and granite associated with calcite, pectolite, datolite and the zeolites. It is sometimes associated with the copper of the Lake Superior region. Beautiful specimens are found in the neighborhood of Bergen Hill and Paterson N. J.

It is occasionally cut as a gem.

Subsilicates

The minerals here included are probably either metasilicates or orthosilicates, which, for lack of definite knowledge regarding their constitution, have been classed by Dana under this head.

Humite group

This group includes the species chondrodite, humite and clinohumite. They are basic fluosilicates of magnesium and are closely related chemically. They occur in crystals which are extremely complicated (chondrodite and clinohumite are monoclinic, and humite is orthorhombic). Clinohumite and chondrodite occur in compact masses and disseminated grains. A vitreous to resinous luster is common to the group and the general color is red, brownish red, brown to yellow.

The humite group occur mainly in ejected masses of limestone and are associated with chrysolite, biotite, pyroxene, magnetite, spinel, etc. The minerals of the humite group are all found at the Tilly Foster mine, Putnam co. N. Y.

Calamin H_2ZnSiO_5

Calamin is a basic zinc silicate containing 67.5% zinc oxid, 25% silica and 7.5% water.

The crystals are orthorhombic-hemimorphic, usually tabular parallel to the brachypinacoid (fig. 229) and are frequently joined in radiated groups forming a rounded notched ridge or cockscomb (pl. 32_1). Granular, stalactitic and botryoidal masses are also found. The luster is vitreous to pearly. Isolated crystals are occasionally colorless and transparent; in general the color is white, more rarely delicate shades of blue or green and yellow to brown in the massive varieties.

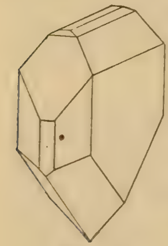
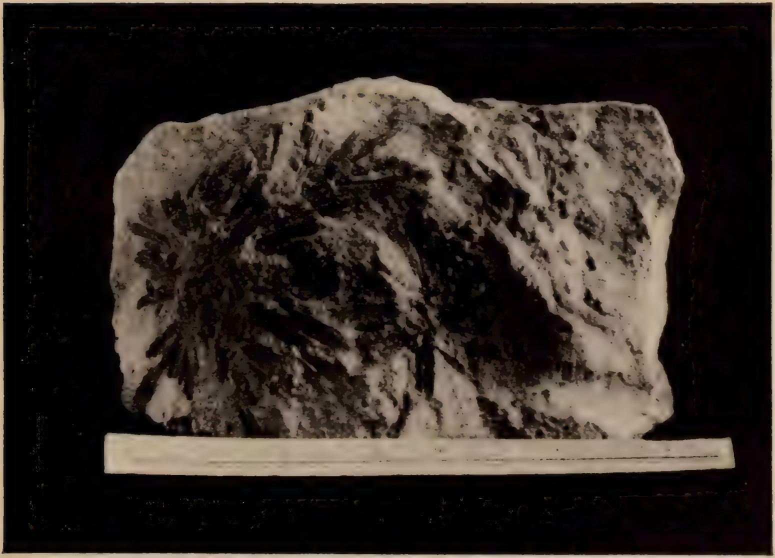


Fig. 229
Calamin

Calamin usually accompanies smithsonite in veins and cavities in stratified calcareous rocks associated with the sulfids of zinc, iron and lead. It is mined in considerable amounts in Silesia and Rhenish Germany. In the United States it occurs extensively at Granby Mo.; also at Sterling Hill N. J., Bethlehem Pa. and in Virginia, Pennsylvania, Utah and Montana.

As an ore of zinc it is valued as being comparatively free from volatile impurities.

1 Calamin, Franklin N. J.



2 Tourmalin (rubellite) on lepidolite, San Diego county, Cal.

Tourmalin (schorl)

Tourmalin is a complex silicate of boron and aluminium with appreciable amounts of either magnesium, iron or the alkali metals.

It crystallizes in the rhombohedral-hemimorphic class of the hexagonal system in prismatic crystals, sometimes short and thick as in fig. 230 or elongated with vertical striations, but always presenting a somewhat triangular cross section (fig. 231). Where doubly terminated the crystals show different modifications on the two extremities. Parallel or radiated crystal aggregates are common as well as columnar and compact masses (pl. 32_2). The luster is vitreous to resinous; the color is commonly black, brown or bluish, also blue, green, pink, or red, rarely colorless or white. Some varieties are composed of an internal core of red surrounded by a layer of green, others are differently colored at the opposite extremities.

Fig. 230 Fig. 231

Tourmalin

Tourmalin occurs in crystalline rocks such as granite, gneiss, mica schist, crystalline limestone, etc. The brown variety is generally found in granular limestone and dolomite; a bluish black kind is often associated with the tin ores; black tourmalins are common in quartz, granite, gneiss and mica schist; rubellite, a pink to red variety, is found in lepidolite. In New York tourmalin is found in handsome specimens in St Lawrence county; at Gouverneur and Pierrepont; also in Essex, Orange and New York counties.

Transparent varieties are sometimes cut as gems or for use in certain optical apparatus.

Staurolite $HFeAl_5Si_2O_{13}$

Staurolite is a basic iron and aluminium silicate with magnesium (and sometimes manganese) replacing part of the ferrous iron.

It occurs in orthorhombic crystals of prismatic habit which are often twinned, producing crosslike forms (pl. 33_1). The luster is resinous to vitreous and the color varies from a blackish brown to dark brown or gray.

Staurolite is usually found in metamorphic rocks such as gneiss, mica schist and argillaceous schists as a result of regional metamorphism and is frequently associated with garnet, sillimanite, cyanite and tourmalin. It occurs throughout the mica schists of New England, in North Carolina and Georgia. A few occurrences are noted in the mica schists of New York as the result of contact metamorphism, as at Peekskill, Westchester co.[1]

Hydrous silicates

The species here included contain water of crystallization, as is the case with the zeolites, or yield, on ignition, water which is present as a base; in the latter category belong the micas and talc. In a third type of silicates referred to this division the relation of the water contained to the general composition is still in doubt.

Zeolite division

Apophyllite $H_7KCa_4(SiO_3)_8+4\frac{1}{2}H_2O$

Apophyllite is a hydrous potassium and calcium silicate.

It occurs in tetragonal crystals, mostly of square cross section, sometimes flattened in the direction of the vertical axis into plates; and in rectangular forms, somewhat isometric in aspect but striated on the prismatic faces and giving pearly reflections from the basal plane (pl. 33_2); it is often found with steep pyramidal terminations (fig. 232). It is also found occasionally in lamellar masses. The luster is vitreous except on the basal pinacoid which face has a pearly luster with internal opalescence often likened to the eye of a fish; it is colorless, white, pink or greenish.

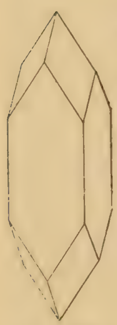


Fig. 232
Apophyllite

Apophyllite occurs as a secondary mineral in basalt and other volcanic rocks associated with the zeolites, datolite, prehnite, and calcite; also in cavities in granite and gneiss. Nova Scotia, the Lake Superior copper region and Bergen Hill N. J. afford many good specimens.

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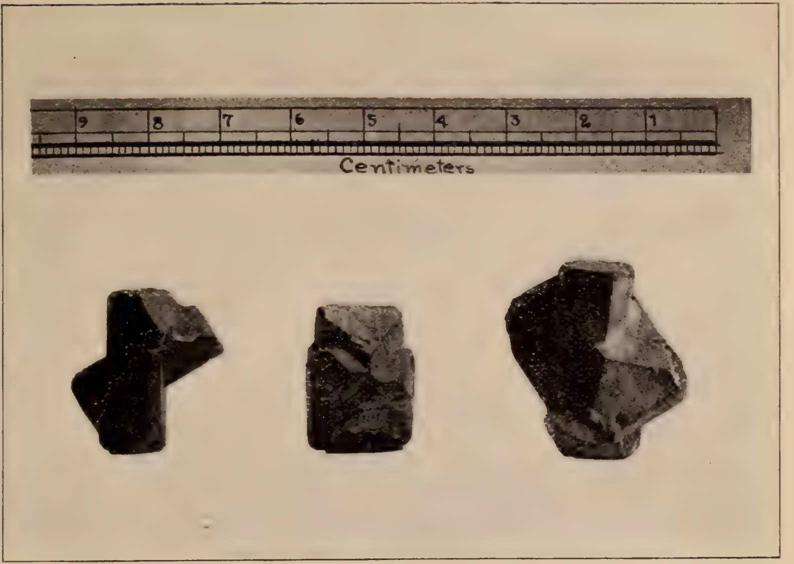
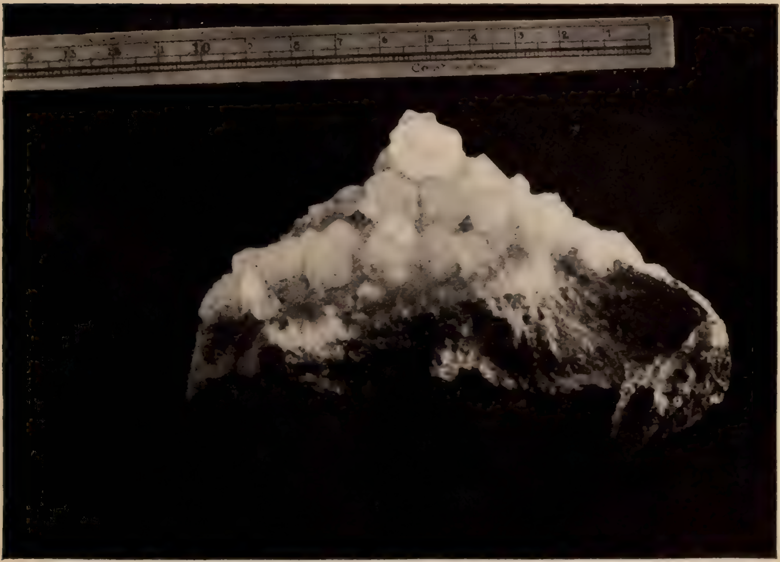
[1] Williams, G. H. Contact metamorphism near Peekskill N. Y. Am. jour. sci. 1888. 36: 254.

Plate 33

To face p. 108

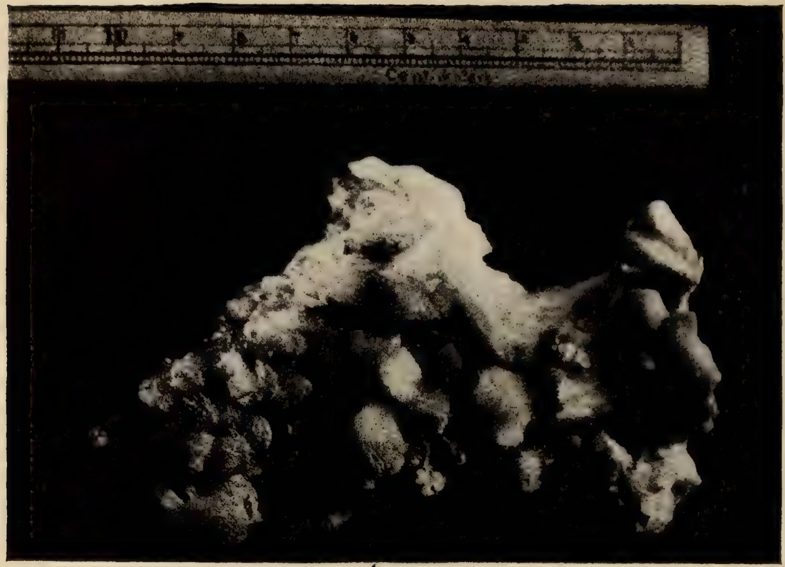


1 Staurolite, Fanning county, Ga.

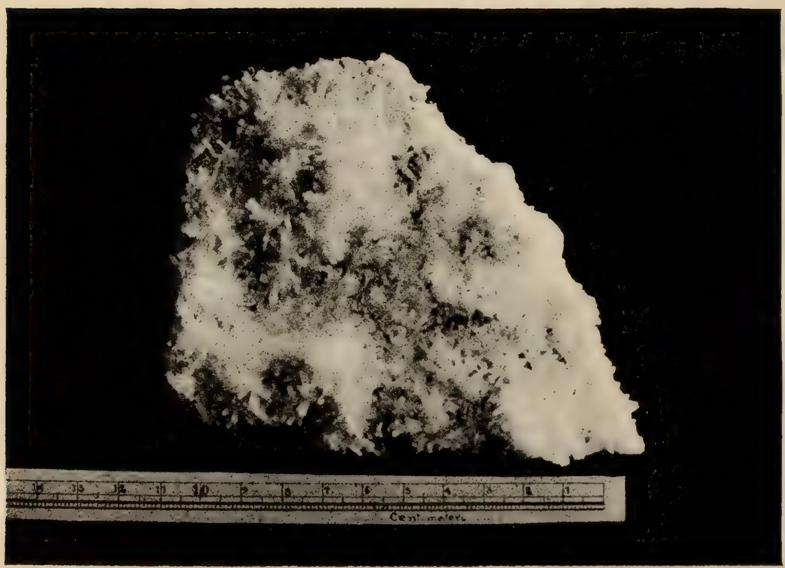


2 Apophyllite, West Paterson N. J.

Plate 34



1 Stilbite, Partridge Island N. S.



2 Natrolite, Weehawken N. J.

Heulandite $H_2CaAl_2(SiO_3)_6+3H_2O$

Heulandite is a hydrous calcium and aluminum silicate.

It occurs in monoclinic crystals, somewhat coffinlike in shape with marked cleavage parallel to the clinopinacoid and a pearly luster on the clinopinacoid and cleavage surfaces. The crystals are sometimes joined in parallel position, giving ridgelike forms of the general coffinlike section. The luster is pearly to vitreous and the color white, red or brown.

Heulandite occurs with the other zeolites in basaltic rocks and gneiss. For localities see apophyllite.

Stilbite (desmine) $H_4(Na_2.Ca)Al_2(SiO_3)_6+4H_2O$

Stilbite is a hydrous sodium, calcium and aluminium silicate.

It occurs in monoclinic crystals resembling those of heulandite but usually more tabular parallel to the clinopinacoid and with a more strongly marked tendency to form aggregates which are sheaflike (pl. 34_1), globular or radiated in form. The broad faces of the tabular crystals show a pearly luster, otherwise the luster is vitreous; the color is white, red, brown or yellow.

Stilbite occurs in the formations and localities common to the zeolites, for which see apophyllite.

Chabazite $(Ca,Na_2)Al_2(SiO_3)_4+6H_2O$

Chabazite is a hydrous calcium, sodium and aluminium silicate.

It occurs in rhombohedral crystals with nearly square faces, which give them somewhat the aspect of cubes. These faces, however, are commonly striated parallel to the edges and are often broken by the protuberance of an angle of the twinned negative rhombohedron. The luster is vitreous and the color white or flesh-red.

Chabazite like the other zeolites is found generally in basaltic rocks. It is abundant in several localities in Nova Scotia.

Analcite $NaAl(SiO_3)_2+H_2O$

Analcite is a hydrous sodium and aluminium silicate.

It occurs in isometric crystals, usually trapezohedrons (fig. 233). A variety from the Cyclopean islands near Sicily is cubic in habit with small trapezohedral modifications. It is sometimes found in concentric groups about a single crystal as a nucleus and more rarely in granular or compact masses with concentric structure. The luster is vitreous and the crystals are colorless or white, greenish or faintly red in color.

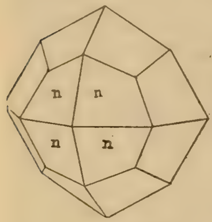


Fig. 233
Analcite

Analcite is a secondary mineral occurring with other zeolites in the basalt or gneiss at the prominent zeolite localities previously given under apophyllite.

Natrolite $Na_2Al_2Si_3O_{10}+2H_2O$

Natrolite is a hydrous sodium and aluminium silicate.

It occurs in slender, orthorhombic prisms of nearly square cross section often terminated by a flat pyramid (fig. 234); these are commonly grouped in radiating and interlacing aggregates (pl. 34_2). It also occurs in radiating fibrous forms and granular to compact masses. The luster is vitreous; the color is white, greenish or reddish, the crystals are frequently colorless.

The manner of occurrence, association and localities are the same as for the other zeolites.

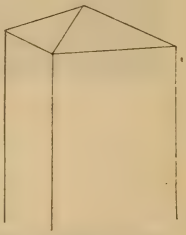


Fig. 234
Natrolite

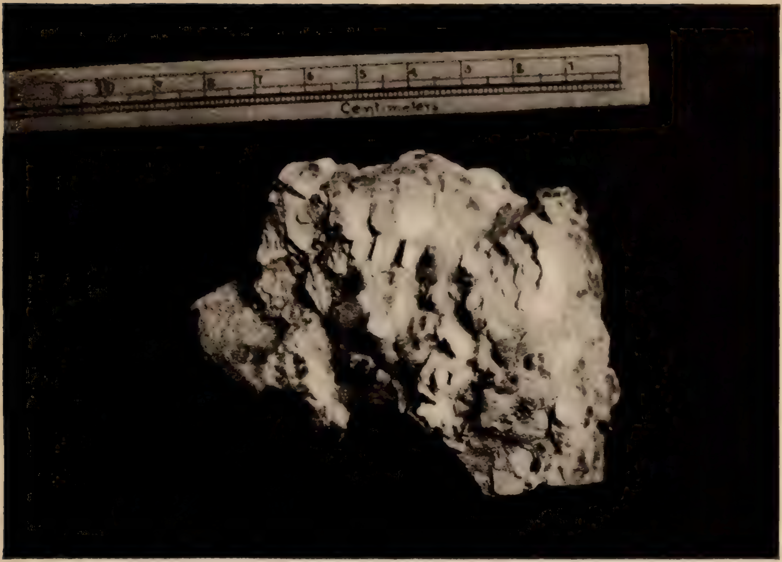
Mica division

Muscovite (common mica, isinglass) $H_2KAl_3(SiO_4)_3$

Muscovite is a hydrous potassium and aluminium orthosilicate.

The crystals of muscovite are monoclinic, prismatic and tabular in habit, with a rhombic or hexagonal section and cleave with great ease parallel to the base into extremely thin elastic plates. It also occurs in disseminated scales, often grouped in globular (pl. 35_1) or plumose (pl. 35_2) forms. The luster of muscovite is vitreous, pearly on the cleavage planes; the color is commonly gray, brown, green or yellow, sometimes violet or black.

Muscovite is the most common of the micas and is very widely distributed. It is an essential constituent of mica schist and, to a less degree, of some granite and gneiss. The best developed crystals occur in pegmatite dikes and veins. It is also found in fragmental rocks and limestones but rarely as a secondary mineral in volcanic rocks.



1 Muscovite, Stowe Me.

2 Muscovite (plumose), Minot Me.

Muscovite is mined in South Carolina and New Hampshire. Deposits of good quality also exist in Pennsylvania, Colorado, Nevada, New Mexico, South Dakota, Washington and California. Muscovite has been found in Westchester, Orange, Jefferson and St Lawrence counties, N. Y.

Muscovite, known commercially as mica and colloquially as isinglass, is much used for the doors of furnaces and stoves, also as an insulating material in dynamos and other electric appliances and for many less important purposes.

Lepidolite (lithia mica)

Lepidolite is a basic fluosilicate of potassium lithium and aluminium. It occurs in crystalline plates resembling those of muscovite but of a pinkish or violet-gray color often nearly white. More frequently it is found in massive granular aggregates of coarse or fine scales. It cleaves easily parallel to the base into elastic plates. It is distinguished from muscovite mainly by the color.

It is found in granite and gneiss particularly in pegmatite veins.

Biotite (black mica) $(H,K)_2(Mg,Fe^{II})_2(Al,Fe^{III})_2(SiO_4)_3$

Biotite is a potassium, magnesium, aluminium, ferrous and ferric iron orthosilicate.

It occurs in monoclinic crystals, tabular or short prismatic in habit, similar to those of muscovite. These show the basal cleavage characteristic of the micas, separating into thin elastic plates. It is often found in disseminated scales or in massive aggregates of cleavable scales. The luster is vitreous, pearly, or, in the dark colored varieties, submetallic; the color is commonly dark green to black.

Biotite occurs as an important constituent in many igneous rocks and is common in most granites, and in many syenites and diorites; also in such eruptive rocks as rhyolite, trachyte and andesite. In small flakes biotite is present in many common rocks and soils.

Orange, Essex and St Lawrence counties, N. Y. furnish good specimens.

Phlogopite (amber mica) $(H,K,MgF)_3Mg_3Al(SiO_4)_3$

Phlogopite is a potassium, magnesium and aluminium fluosilicate.

The crystals of phlogopite are similar to those of muscovite and biotite but are often developed into rather longer prismatic forms usually tapering slightly at either end. The color is commonly yellowish brown to brownish red, frequently a metallic copper-red on the cleavage surfaces.

It is specially characteristic of crystalline limestone and is also found in serpentine. Localities are numerous throughout New York, particularly in Jefferson and St Lawrence counties, and in New Jersey.

Phlogopite is used largely as an insulating material in electric work.

Clinochlore (ripidolite) $H_8Mg_5Al_2Si_3O_{18}$

Clinochlore is a basic magnesium and aluminium silicate.

It occurs in monoclinic crystals closely approximating hexagonal forms in prism angle. The crystals cleave easily into thin, inelastic plates resembling those of the micas. It is also found in masses of coarse or fine scales and in an earthy variety. In color clinochlore is commonly some shade of green, more rarely yellowish, white or rose-red.

It is frequently found in chlorite and talcose rocks and in serpentine. Clinochlore partly altered to serpentine occurs with magnetite at Brewster, Putnam co. N. Y.

Prochlorite $H_{40}(FeMg)_{23}Al_{14}Si_{13}O_{90}$

Prochlorite is a basic magnesium and aluminium silicate with some iron and a lower percentage of silica than clinochlore.

It is monoclinic, the crystals are commonly small with strongly furrowed prismatic faces and often curiously twisted into wormlike shapes. It is also found in foliated and granular masses. The color varies from grass-green to blackish green and the luster from feebly pearly to dull.

It frequently results from the decomposition of mica, amphibole, garnet, pyroxene, etc. Its association and occurrence are similar to clinochlore.

Serpentine and talc division

Serpentine $H_4Mg_3Si_20_9$

Serpentine is a hydrous magnesium silicate with some of the magnesium replaced by iron.

Serpentine occurs only in massive forms and in pseudomorphs after crystals of chrysolite, amphibole, pyroxene, enstatite, etc. It is sometimes foliated but also occurs in delicate silky fibers (pl. 3_1) and in fine granular to impalpable masses. It is characterized by a greasy feel. The color is green of various shades, yellow, brown, red, black and nearly white, often gray on exposure and frequently variegated. The luster is greasy, silky or waxy.

Serpentine is a secondary mineral resulting from the alteration of certain magnesium silicates and frequently forms large rock masses. When formed from the alteration of basic igneous rocks it is associated with spinel, garnet, chromite and sometimes ores of nickel. The variety derived from the decomposition of metamorphic rocks is commonly accompanied by dolomite, magnesite and other carbonates. A variegated rock of the latter type is polished for ornamental purposes and goes by the name of verd antique marble; this is quarried at Milford Ct. A fibrous variety known as chrysotile is mined in Quebec and is used as asbestos. Outcrops of serpentine are found in Westchester county at New Rochelle, Rye and Port Chester, and in Putnam, Orange, Richmond, Jefferson and St Lawrence counties, N. Y.

Talc (steatite, soapstone) $H_2Mg_3(Si0_3)_4$

Talc is an acid metasilicate of magnesium.

Owing to the extreme rarity of crystallized specimens its system of crystallization is still in doubt. It commonly occurs in foliated or fibrous masses (pl. 3_2), sometimes with a stellated structure, and in coarse or fine granular to compact masses. These vary in hardness (H1–1.5) but are in general very soft with a soapy feel. The color is ordinarily white, greenish or gray and the luster pearly or waxy.

VARIETIES

Foliated talc. A light green to white foliated variety which may be separated into thin, inelastic plates.

Soapstone or steatite. A coarse to fine granular talc of a gray or green color; used extensively for making sinks and as a refractory material for hearths, stove linings, etc.

French chalk. A soft compact material used by tailors for marking cloth.

Agolite. A fibrous variety of talc somewhat above the average hardness and used when mixed with wood pulp in the manufacture of paper.

Rensselaerite. A name given to the pseudomorphs of talc after pyroxene.

Talc in the form of soapstone is very common, and in some regions constitutes quite extensive beds. It is often associated with serpentine, chlorite schist and dolomite and frequently forms pseudomorphs after other minerals. An extensive deposit at Talcville, St Lawrence co. N. Y. is mined for the manufacture of paper and for a fireproof fiber which is mixed with serpentine asbestos.[1]

Besides the uses above mentioned talc is used in making soap, as a dressing for skins and as a lubricant.

Sepiolite (meerschaum) $H_4Mg_2Si_3O_{10}$

Sepiolite is a silicate of magnesium containing water. It occurs in soft, compact, white, amorphous masses of an earthy texture and with a dull luster. It is rarely fibrous.

Sepiolite is found in Asia Minor, Greece, Morocco, Moravia and in Spain where it is used as a building stone. The material from Asia Minor is used for making meerschaum pipes.

Kaolin division

Kaolinite (kaolin) $H_4Al_2Si_2O_9$

Kaolinite is a basic aluminium silicate with some iron and organic matter.

It occurs in small scalelike pearly monoclinic crystals, more commonly in compact or loose masses of a claylike nature. The color is white, grayish, yellowish and sometimes brownish, bluish or reddish. The common massive material is plastic and unctuous to the touch.

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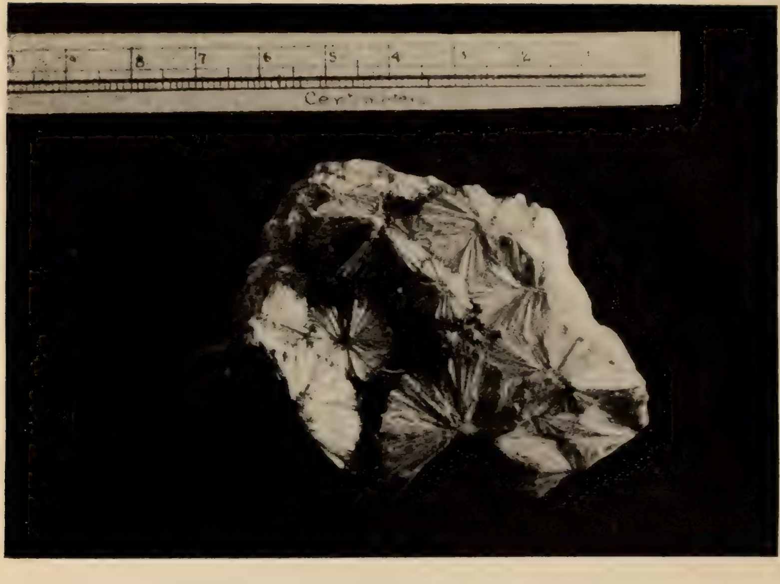
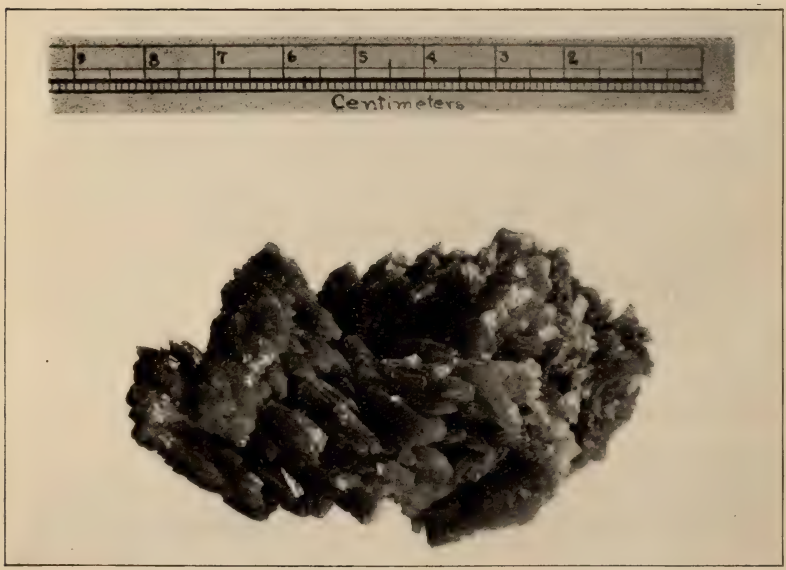
[1] Nevius, J. N. Talc industry of St Lawrence county, N. Y. N. Y. state mus. 51st an. rep't. 1897. 1:119-27.

Plate 36

To face p. 115



1 Pyrophyllite, Lincoln county, Ga.



2 Pyromorphite, Ems, Germany

Kaolin is of secondary origin resulting from a decomposition of the feldspars and other silicates. It occurs associated with the feldspars, corundum, topaz, etc. Notable deposits occur in China, Belgium, France, Bavaria and Cornwall. In the United States kaolin is mined in Florida, North Carolina, Delaware, Pennsylvania, and in somewhat poorer quality in Ohio, New Jersey, New York and other states.

As a constituent of porcelain, chinaware, tiling and similar products its importance is constantly increasing.[1]

Pyrophyllite (pencil stone) $H_2Al_2(SiO_3)_4$

Pyrophyllite is a basic aluminium silicate.

It occurs in radiated, lamellar or fibrous masses, sometimes compact and smooth, soft and soapy like talc (pl. 36_1). The luster is pearly to dull and the color white, greenish, brownish or yellow.

The compact variety is present in some schistose rocks and the foliated form often occurs associated with cyanite. Pyrophyllite is found in North Carolina, South Carolina and Georgia.

It is extensively used for slate pencils.

Chrysocolla $CuSiO_3+2H_2O$

Chrysocolla is a hydrous copper silicate containing 34.3% silica, 45.2% copper oxid and 20.5% water. It is often very impure.

Chrysocolla is found in green to blue masses with an enamel-like texture; sometimes botryoidal; incrusting or filling seams. Impure varieties often occur in earthy masses, green or dull brown in color.

It occurs associated with other copper minerals specially in the upper parts of veins and is to be found in most of the copper producing regions.

It is an ore of copper and is also used for imitation turquoise.

Titano-silicates, Titanates

Titanite (sphene) $CaTiSiO_5$

Titanite is a calcium titano-silicate often carrying iron in varying amounts and sometimes manganese and yttrium.

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[1] For an exhaustive treatise on this subject *see* N. Y. state mus. Bul. 35. 1900.

The crystals of titanite are monoclinic and very varied in form; commonly of a wedge-shaped or tabular type (fig. 235) but often prismatic in habit. Compact massive forms also occur but lamellar varieties are rare. The luster is adamantine or resinous and the color usually brown to black, yellow or green, rarely rose-red.

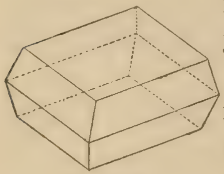


Fig. 235
Titanite

Titanite occurs as an accessory rock-forming mineral in many igneous rocks, mostly of the acidic feldspathic type and is more common in plutonic granular than in the volcanic forms. It is found in basic hornblende granites, syenites and diorites and is very characteristic of the nephelin schists, gneisses, etc.; also in granular limestone and in beds of iron ore. It is commonly associated with pyroxene, amphibole, wernerite, zircon, apatite, etc. and when found in cavities in granite and gneiss often accompanies orthoclase and quartz.

Handsome specimens are to be found in Ottawa and Renfrew counties, Canada, and in New York in the Lake George region of Essex county and in St Lawrence, Lewis, Orange and Putnam counties. Transparent varieties are cut for gems.

NIOBATES, TANTALATES

Columbite, tantalite

The species columbite, an iron and manganese niobate, and tantalite, an iron tantalate, grade into each other chemically to such an extent that it is impossible to definitely separate the two species. The normal formula for columbite is (Fe, Mn) Nb_2O_6 and that for normal tantalite is $FeTa_2O_6$. The iron and manganese vary widely and tin and wolfram are also often present in small amounts.

The crystals which are orthorhombic are of varied habit, sometimes occurring in short prismatic forms or in tabular prismatic crystals flattened parallel to the macropinacoid. Heart-shaped twins are quite common. It also occurs massive. The luster is submetallic, often very brilliant, and the color black in opaque varieties or brown in the more translucent occurrences. It is frequently iridescent, particularly on the surfaces produced by cleavage, which occurs in two directions at right angles.

Columbite often occurs in granite and pegmatite veins, in mica, and, in the Greenland locality, in cryolite; it has been found in gold washings in the Urals. In the United States it is found in Maine, New Hampshire, Massachusetts, Connecticut, New York, Pennsylvania, Virginia, North Carolina, Colorado, South Dakota and California.

PHOSPHATES, ARSENATES, VANADATES, ANTIMONATES

Monazite $(Ce,La,Di)PO_4$

Monazite is a phosphate of the cerium metals, with some thorium and silicon possibly present as mechanical impurities.

It occurs in small monoclinic crystals (fig. 236) often flattened parallel to the orthopinacoid; also in disseminated grains or as sand and sometimes in angular masses. The luster is resinous and the color hyacinth-red, brown to yellow.

Monazite in the form of sand is quite abundant in certain parts of Brazil; it also occurs as a constituent of the gneiss rock of North Carolina and South Carolina.

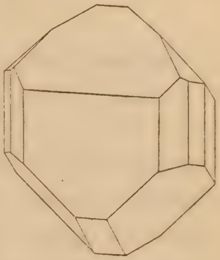


Fig. 236
Monazite

It is the chief source of the thorium which is now extensively used in the manufacture of mantles for incandescent gas fixtures.

Apatite group

Apatite (phosphate rock) $Ca_5(Cl,F)(PO_4)_3$

Under this head are included the subdivisions fluor-apatite and chlor-apatite. The former is a calcium phosphate with calcium fluorid and the latter a calcium phosphate with calcium chlorid. Intermediate compounds contain both fluorin and chlorin in varying amounts.


Fig. 237
Apatite

Apatite crystallizes in the pyramidal group of the hexagonal system. The crystals are prismatic in habit commonly terminated by the unit pyramid (fig. 237) and sometimes with the additional modification of the base; occasionally the prismatic crystals are short or tabular and show the modification of the third order pyramid (as in specimens from Knappenwand in the Tyrol). Compact massive varieties have a globular or reniform structure and are often found in rocklike masses or nodules not unlike common limestone. The luster is vitreous to resinous and the color varies widely from sea-green, bluish green, brown or flesh-red, in the commoner occurrences, to transparent violet, yellow or colorless and opaque white or gray in the less common forms.

VARIETIES

Ordinary. Crystallized or granular massive material as described above.

Phosphorite. Fibrous concretionary and partly scaly masses.

Osteolite. Mostly altered and impure apatite of a compact earthly nature and white or gray in color.

RELATED

Phosphate rock. A massive impure phosphatic material chiefly of organic origin, and granular, spongelike or nodular in structure. Here are included the phosphatic limestones, guano deposits and bone beds from which is extracted material of considerable importance in the manufacture of fertilizers.

Apatite occurs in a great variety of formations but is most common in metamorphic crystalline rocks particularly in granular limestone, in gneiss, syenite, mica schist and in beds of iron ore. As an accessory rock mineral it has a wide distribution. It is found in many igneous rocks, the larger crystals being characteristic of granite and pegmatite, where it is associated with quartz, feldspar, tourmalin, muscovite, beryl, etc.

Besides many foreign localities apatite occurs in extensive deposits in the Laurentian gneiss of Canada associated with calcite, pyroxene, amphibole, titanite, etc. It is found in Maine, New Hampshire, Massachusetts, Connecticut, and in New York, in St Lawrence, Jefferson, Essex and Orange counties; also in Pennsylvania and North Carolina. Extensive deposits of phosphate rock occur in eastern South Carolina and Florida.

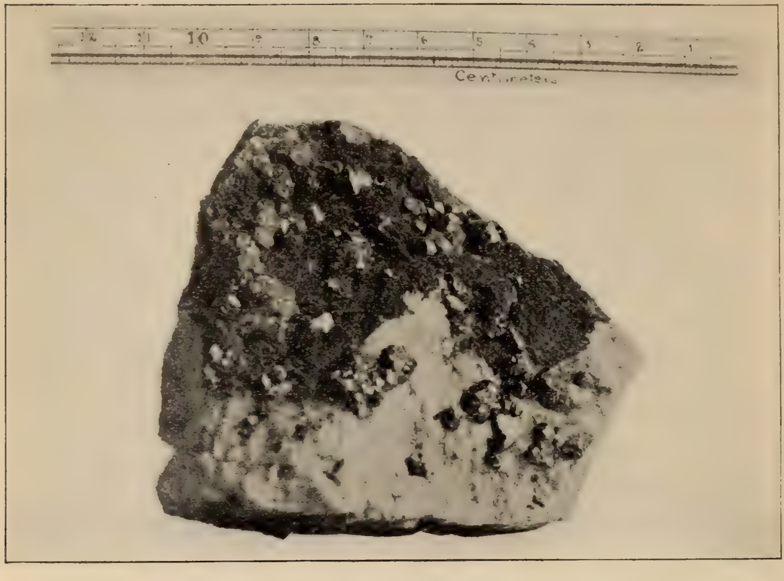
Apatite in the form of phosphate rock is largely used for fertilizers. The purer material is employed in the manufacture of phosphorus.

Pyromorphite (green lead ore) $(PbCl)Pb_4(PO_4)_3$

Pyromorphite is a phosphate of lead with lead chlorid, often with some arsenic, iron or calcium. With a larger proportion of arsenic it passes into mimetite.

Plate 37

To face p. 119



1 Mimetite, Cornwall, England

2 Wavellite, Garland county, Ga.

It occurs in hexagonal crystals of the pyramidal group, prismatic in habit, often in rounded or barrel-shaped forms or in parallel and branching groups (pl. 36_2), less frequently in globular and reniform masses with a subcolumnar structure. The luster is resinous and the color usually some shade of green, yellow or brown, also grayish white or milk-white.

Pyromorphite occurs principally in veins with galena and other lead minerals. It is found in Saxony, Bohemia and Nassau and in several places in England and Scotland. In the United States it occurs in Maine, Pennsylvania, North Carolina and at Ossining N. Y.

Mimetite $(PlCl)Pb_4(AsO_4)_3$

Mimetite is an arsenate of lead with lead chlorid. With the replacement of arsenic by phosphorus it grades into pyromorphite; calcium also frequently replaces part of the lead.

The crystals of mimetite are hexagonal-pyramidal and resemble those of pyromorphite; they show, however, a marked tendency toward the production of rounded, globular aggregates (pl. 37_1). The mineral also occurs in mammillary crusts. The luster is resinous and the color yellow to brown or white. Its occurrence is similar to that of pyromorphite.

Vanadinite $(PbCl)Pb_4(VO_4)_3$

Vanadinite is a vanadinate of lead with lead chlorid. Phosphorus is also often present in small amounts; also arsenic, both of which replace some of the vanadium.

The crystals are like those of pyromorphite and mimetite, often with hollow or cavernous faces on the basal plane, and sometimes showing the modification of the third order pyramid (fig. 238). The luster is resinous and the color deep red, brown to yellow.

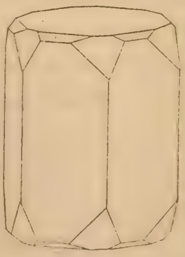


Fig. 238
Vanadinite

Vanadinite abounds in the mining regions of Arizona and New Mexico where it is associated with wulfenite.

Vanadinite is a source of vanadium salts, which are used in dyeing fabrics, and for the production of vanadium bronze, vanadium ink, etc.

Olivenite $Cu_2(OH)AsO_4$

Olivenite is a basic arsenate of copper. It occurs in small orthorhombic crystals of prismatic habit and often acicular; also in velvety or drusy masses of fibrous crystals and in globular forms. The luster is adamantine to vitreous and the color olive-green of various shades passing to brown and sometimes almost black, more rarely yellow or grayish white.

It is found in Cornwall, Devonshire, the Tyrol, the Ural mountains, Chile and in the Tintic district of Utah.

Libethenite $Cu_2(OH)PO_4$

Libethenite is a basic copper phosphate. It occurs in small orthorhombic crystals closely resembling those of olivenite in form and luster; the color is in general somewhat darker than that of olivenite.

Lazulite

Lazulite is a basic phosphate of aluminium, iron and magnesium.

It occurs in monoclinic crystals of pyramidal habit and in granular to compact masses. The luster is vitreous and the color deep sky-blue.

It occurs in veins in clay slate, quartzite, etc. and is found in Salzberg, Styria, Sweden and in North Carolina and Georgia.

Vivianite (blue iron earth) $Fe_3(PO_4)_2+8H_2O$

Vivianite is a hydrous phosphate of ferrous iron.

It occurs in monoclinic prismatic crystals, often in stellate groups; also as an earthy material replacing organic remains as bones, shells, etc. The luster is vitreous to dull. The unaltered material is colorless but gradually becomes blue or bluish green on exposure to air.

It occurs associated with pyrrhotite and pyrite in veins of copper or tin, in beds of clay or associated with limonite; also in cavities of fossils or buried bones.

Vivianite occurs in the United States in New Jersey, Virginia and Kentucky.

Erythrite (cobalt-bloom) $Co_3(AsO_4)_2+8H_2O$

Erythrite is a hydrous arsenate of cobalt.

It occurs in monoclinic prisms striated vertically and sometimes in stellate groups. Small globular and incrusting forms with drusy or velvety surfaces are of frequent occurrence as well as an earthy variety pink in color. The luster is vitreous to adamantine, pearly on some faces, also dull or earthy. The color is crimson-red to peach-red.

It is found in Saxony, Baden, Norway and in the United States in Pennsylvania, Nevada and California.

Wavellite $Al_6(OH)_6(PO_4)_4+9H_2O$

Wavellite is a hydrous basic phosphate of aluminium.

Distinct orthorhombic crystals are rare. The mineral is commonly found in hemispheric or globular aggregates of radiating fibrous crystals (pl. 37_2). Stalactitic forms also occur. The luster is vitreous and the color white, yellow or green, occasionally brown, blue or black.

It is found in Devonshire, Saxony, Bohemia, Brazil and in Pennsylvania, Arkansas and North Carolina.

Turquoise $Al_2(OH)_3PO_4+H_2O$

Turquoise is a hydrous basic phosphate of aluminium with some copper, to which it owes its color.

It occurs in sky-blue to green nodules, veins or rolled masses with a dull or waxlike luster; also stalactitic or incrusting.

Turquoise occurs in porphyritic trachyte and in a clay slate which, in the Persian locality, is found penetrated by trachyte. It was formerly extensively mined in Persia; recently, however, important workings in New Mexico have been reopened and are producing very good material. Localities are also known in Arizona, California, Colorado and Nevada.

Turquoise is used as a gem.

Torbernite (copper uranite) $Cu(UO_2)_2P_2O_8+8H_2O$

Torbernite is a hydrous phosphate of uranium and copper.

It occurs in small tabular tetragonal crystals often extremely thin, of a bright green color and pearly luster. Less frequently it occurs in pyramidal forms or in foliated micaceous aggregates.

It has been found in Cornwall, Saxony and Bohemia.

Autunite (lime uranite) $Ca(UO_2)_2P_2O_8+8H_2O$

Autunite is a hydrous phosphate of uranium and calcium.

It is found in tabular orthorhombic crystals very similar to those of torbernite but lemon-yellow or sulfur-yellow in color.

It occurs in Connecticut, North Carolina and in the Black hills of South Dakota.

BORATES

Boracite $Mg_7Cl_2B_{16}O_{30}$

Boracite is a chloro-borate of magnesium.

The crystals are of the tetrahedral class of the isometric system and are commonly small and cubic (fig. 239), tetrahedral (fig. 240), octahedral or dodecahedral in habit; these usually occur isolated embedded in gypsum, anhydrite or salt. A massive variety occurs in snow-white, soft and powdery masses. The crystals are colorless, white to gray, yellow or green and vitreous to adamantine in luster.

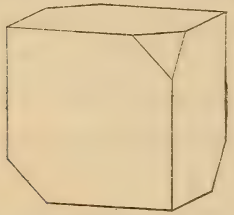


Fig. 239

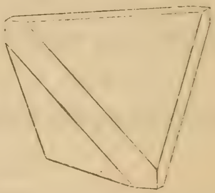


Fig. 240

Boracite

Boracite is found associated with other minerals which have been deposited from solution and occurs in many parts of Europe notably at Stassfurt, Prussia.

Colemanite $Ca_2B_6O_{11}+5H_2O$

Colemanite is a hydrous borate of calcium often occurring in monoclinic crystals, short prismatic in habit, and somewhat resembling those of datolite, also in cleavable to granular and compact masses. Colemanite is commonly white or colorless and of a vitreous to dull luster.

Under this species are included:

Priceite. A massive variety, white and chalky in appearance and loosely compacted in structure.

Pandermite. A white variety in firm, compact, porcelainlike masses.

Colemanite is found quite abundantly in California, Nevada and Oregon. Pandermite is mined near Panderma in Turkey. Colemanite is an important source of the borax of commerce.

Borax (tinkal) $Na_2B_4O_7.10H_2O$

Borax is a hydrous borate of sodium.

It occurs in sharp, well formed monoclinic crystals transparent to opaque resembling those of pyroxene in habit. The color is white to gray sometimes inclining to greenish or bluish and the luster is vitreous to dull.

Borax is present in solution in many lakes of a saline or alkaline nature and is found crystallized in the mud at the bottom and in deposits in the surrounding marshes. Deposits of considerable importance occur in Nevada and California.

It is used in many industries such as soap, glass making etc., as a preservative and in washing, bleaching and antiseptic preparations.

Ulexite $NaCaB_5O_9.8H_2O$

Ulexite is a hydrated borate of sodium and calcium.

It occurs in loose rounded masses of fibrous crystals, white in color and with a silky luster.

Its occurrence is similar to colemanite and borax and it is found in Nova Scotia and Chile as well as in the borax localities of Nevada and California.

It is much used in the manufacture of borax.

URANATES

Uraninite (pitchblende)

Uraninite is a uranate of uranyl, lead, usually thorium (or zirconium) and frequently metals of the lanthanum and yttrium groups. The relation between the bases, however, varies so widely that no definite formula can be given.

It rarely occurs in isometric crystals of octahedral habit but is commonly found in botryoidal or granular masses pitchlike in luster and appearance and generally black in color.

Uraninite occurs as a primary constituent of granitic rocks and as a secondary mineral with silver, lead and copper ores. The main supply is obtained from Bohemia. It is mined, however, in Colorado and is found to some extent in North Carolina, South Carolina, Texas and in the Black hills of South Dakota.

It is the principal source of the uranium salts used in painting on porcelain and in the manufacture of fluorescent glass.

SULFATES, CHROMATES, ETC.

Barite (heavy spar, barytes) $BaSO_4$

Barite is the sulfate of barium, sometimes containing strontia, silica, clay, etc. as impurities.

It occurs in orthorhombic crystals which are often tabular in habit (fig. 241, 242); these are sometimes united in divergent groups giving the crested appearance shown in pl. 38_1, and passing by insensible gradations into straight or curved laminated masses. Crystals with prominent dome faces (fig. 243) are also frequent. Massive forms are of a granular, fibrous, earthy, stalactitic or nodular structure. Barite cleaves easily parallel to the basal and prismatic faces. The color is commonly white or light shades of yellow, brown, red or blue; the luster is vitreous to pearly.

Fig. 241

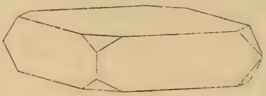


Fig. 242

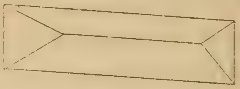


Fig. 243

Barite

Barite frequently occurs associated with metallic deposits, particularly with lead, copper, iron, silver, manganese and cobalt. It is mined in North Carolina, Virginia and Missouri, and is also found in Connecticut, Tennessee, Kentucky, Illinois and in Jefferson and St Lawrence counties, of New York. It is also mined in Germany and Hungary.

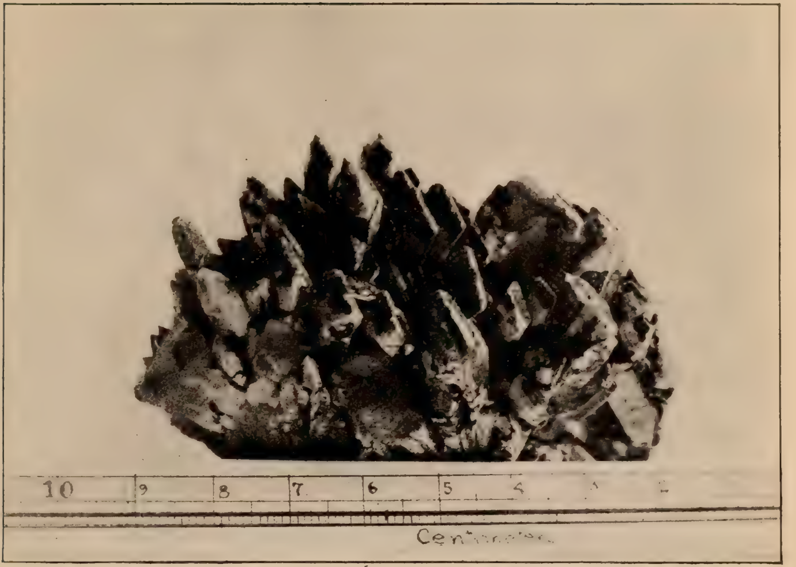
White varieties of barite are ground and used as an adulterant of white lead and to give weight and body to paper and certain kinds of cloth. The colored varieties are sometimes polished for ornamental purposes.

Anhydrite $CaSO_4$

Anhydrite is an anhydrous calcium sulfate.

It is rarely found in orthorhombic crystals; massive forms are often characterized by rectangular cleavage in three directions.

Plate 38



1 Barite, Hartz, Germany

2 Gypsum, Paris, France

Fibrous, granular and marblelike masses occur, sometimes exhibiting a sugarlike appearance on the fracture. The color is commonly white or gray, often bluish, reddish or brick-red. The luster is vitreous inclining to pearly.

Anhydrite occurs associated with rock salt, gypsum and limestones of various ages. It is found in New Brunswick and Nova Scotia and to a limited extent at Lockport N. Y. and in eastern Pennsylvania and Tennessee.

Anglesite $PbSO_4$

Anglesite is a sulfate of lead containing 26.4% sulfur trioxid and 73.6% lead oxid.

The crystals are orthorhombic and of varied habit. Massive forms are extremely common, the mineral frequently forming in concentric layers around a core of galena. Anglesite is white, gray or more rarely bluish or yellowish in color; the crystals are often transparent and colorless. The luster is adamantine to vitreous.

It is a frequent decomposition product of galena with which it is commonly associated and often alters to cerussite. It is found throughout the United States in the lead regions notably in Pennsylvania, Missouri, Wisconsin and Colorado. Extensive deposits occur in Mexico and Australia.

It is mined with other lead minerals as an ore of lead.

Celestite $SrSO_4$

Celestite is a sulfate of strontium sometimes containing small amounts of calcium and barium.

It crystallizes in the orthorhombic system in forms generally similar in type to those of barite, often tabular parallel to the base or prismatic to the macro or brachy axes (fig. 244). Fibrous massive forms occur with a parallel or radiated silky structure; also cleavable masses and more rarely granular varieties. In color celestite varies from white to pale blue, sometimes reddish; the crystals are often transparent and colorless. The luster is vitreous to pearly.

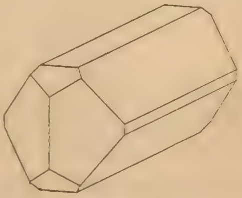


Fig. 244
Celestite

Celestite is of frequent occurrence in limestone and sandstone, in beds of gypsum, rock salt, etc.; and in volcanic regions associated with sulfur and other eruptive minerals. Beautiful crystals have been obtained from Girgenti, Sicily. It also occurs at several localities on Lake Erie; at Lockport, Chaumont bay, Rossie and Schoharie N. Y.; in Pennsylvania, West Virginia, Tennessee, Kansas, Texas and California, and at Kingston Canada.

As a source of strontium nitrate, celestite is much used in the manufacture of fireworks.

Crocoite $PbCrO_4$

Crocoite is a lead chromate occurring in monoclinic crystals of prismatic habit and in imperfectly columnar and granular masses. It is of a bright hyacinth-red to orange-yellow color. The luster is adamantine.

Brochantite $4CuO.SO_3.3H_2O$

Brochantite is a basic sulfate of copper commonly found in acicular orthorhombic crystals or drusy crusts of an emerald-green or blackish green color and vitreous luster.

Gypsum (selenite, alabaster) $CaSO_4+2H_2O$

Gypsum is a hydrous calcium sulfate.

The crystals are monoclinic and commonly quite simple in form, fig. 245 and 246 representing types of common occurrence.

Fig. 245

Fig. 246

Gypsum

Twins of the arrowhead form shown in pl. 38_2 are quite frequent. Massive forms have a foliated, lamellar or granular structure and a fibrous variety known as satin spar is often of marked beauty. Easy cleavage parallel to the clinopinacoid yields thin polished plates. The color varies from white to gray, flesh-red, yellow or light blue. The luster is pearly to subvitreous.

VARIETIES

Selenite. A colorless transparent variety usually in distinct crystals or broad folia.

Fibrous. A coarse or fine fibrous variety, translucent and silky in luster.

Alabaster. A compact, fine grained gypsum much used for carved objects.

Rock gypsum. An earthy dull colored variety often containing clay, calcium carbonate or silica as an impurity.

Extensive deposits of gypsum have resulted from the evaporation and concentration of ancient seas and landlocked waters. Gypsum is also produced by volcanic action and from the decomposition of limestone by sulfuric acid. In New York gypsum is found throughout the rocks of the Salina group in considerable quantities associated with halite. Deposits also occur in Ohio, Illinois, Virginia, Tennessee, Kansas and Arkansas and to a considerable extent in Nova Scotia.

Gypsum is burned and ground for plaster of paris and when ground from the raw material is of considerable value as a fertilizer. Alabaster and, to some extent, satin spar are used for carved ornamental objects.

Epsomite (epsom salt) $MgS0_4+7H_20$

Epsomite is a hydrous magnesium sulfate. It is usually found in white botryoidal masses and delicately fibrous crusts and is characterized by its bitter saline taste.

Alunite (alum stone) $K(Al0)_3(S0_4)_2+3H_20$

Alunite is a hydrous sulfate of aluminium and potassium. It crystallizes in rhombohedrons closely resembling cubes. It also occurs in massive forms of fibrous, granular or impalpable structure. The color is generally white, often shading to grayish or reddish. The luster is vitreous to pearly.

It occurs as seams in rocks of a trachytic character where it has been formed by the action of sulfur dioxid and steam. It is found in Rosita hills, Col.

Alunite is used in the production of alum.

TUNGSTATES, MOLYBDATES

Wolframite (wolfram) $(Fe,Mn)WO_4$

Wolframite is a tungstate of iron and manganese in which these metals are present in varying amounts.

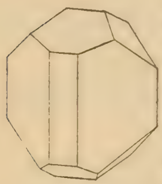


Fig. 247
Wolframite

The crystals are monoclinic, of the general type shown in fig. 247. These are commonly tabular parallel to the orthopinacoid; also prismatic. Twins are quite frequent; granular or columnar masses also occur. Perfect cleavage parallel to the clinopinacoid is characteristic as well as parting planes parallel to the orthopinacoid and hemiorthodome. The color is a dark grayish or brownish black and the luster is submetallic.

Wolframite occurs associated with tin ores and other metallic minerals notably in the Cornwall and German mines. It is also found in New South Wales and Bolivia and in Connecticut, North Carolina, Missouri and Dakota.

It is used in the manufacture of tungsten steel and as a source of the tungsten salts, which are of considerable importance in dyeing.

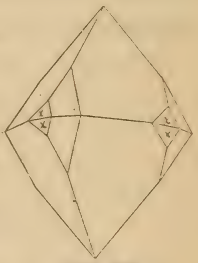


Fig. 248
Scheelite

Scheelite $CaWO_4$

Scheelite is a calcium tungstate crystallizing in the pyramidal class of the tetragonal system.

The crystals are pyramidal in habit (fig. 248), more rarely tabular. These often occur in drusy crusts. The color is white or light shades of yellow, brown, red, rarely green. The luster is vitreous tending to adamantine.

Scheelite occurs in crystalline rocks associated with cassiterite, fluorite, topaz, apatite, molybdenite or wolframite, incrusting or in quartz, and sometimes associated with gold. It is of comparatively rare occurrence but is found at Monroe and Trumbull Ct. and in South Carolina, Nevada, Idaho and Colorado.

Wulfenite $PbMoO_4$

Wulfenite is a lead molybdate crystallizing in the pyramidal class of the tetragonal system.

The crystals are commonly thin tabular in habit of the general type shown in fig. 249; octahedral or prismatic forms are much less frequent, as are also granular massive forms. The commoner colors include a wax-yellow, orange to bright red and brown; an olive-green variety is rather rare.

Fig. 249
Wulfenite

Wulfenite occurs in veins associated with other ores of lead particularly vanadinite and pyromorphite. In the United States it is principally found in Arizona and New Mexico though smaller deposits have been found in Massachusetts, near Ossining N. Y., in Pennsylvania, Missouri, Wisconsin, Nevada, Utah and California.

HYDROCARBON COMPOUNDS

With few exceptions, hydrocarbon compounds are not homogeneous substances and hence are not to be classed as definite mineral species. On the other hand, several substances belonging to this division have acquired so much importance from an economic point of view that it is thought best to briefly describe them here.

Amber

Amber occurs in irregular masses which break with a concoidal fracture. It has a resinous luster, is usually yellowish in color and is transparent to translucent. Amber is of vegetable origin and is derived from the fossilization of gums or resins, a fact which is frequently shown by the presence of insects in it.

It is found in Denmark and Sweden, on the Prussian coast of the Baltic and in Russian Baltic provinces. It is used for jewelry and for mouthpieces of pipes.

Petroleum

Members of this series grade from a thin yellow fluid to dark brown or nearly black viscid oils; the greenish brown colors are the most common. The density also varies and it may be generally stated that the light varieties are richest in volatile constituents while the heavier and darker kinds produce the benzins on distillation.

Petroleum is found in rocks of various ages from the Lower Silurian to the present epoch but is most abundant in argillaceous shales, sands and sandstones. Considerable petroleum is furnished by the regions of western Pennsylvania, southwestern New York and Ohio. It is also largely produced in the neighborhood of the Caspian sea and occurs in many other localities.

Asphaltum

Asphaltum or mineral pitch is an amorphous mixture of hydrocarbons, for the most part oxygenated. It is characterized by a black color and dull luster and melts at about 100° F.

Asphaltum is not associated with rocks of any particular age but is most abundant in formations containing bituminous material or vegetable remains. It is found in the region of the Dead sea; in Trinidad, where it forms a lake about a mile and a half in circuit; and in various places in South America and elsewhere.

Its use for paving purposes is well known.

Uintaite (gilsonite). A variety of asphalt found in considerable deposits in Utah.

Albertite. An amorphous hydrocarbon compound differing from ordinary asphaltum in its very imperfect fusibility and in the fact that it is only partially soluble in oil of turpentine. It has a brilliant luster and is jet black in color. Albertite occurs in the rocks of the Lower Carboniferous in Nova Scotia.

Mineral coal

Coal is a compact massive substance consisting mainly of oxygenated hydrocarbons. It is black, grayish black or brownish black in color, occasionally iridescent, and has a luster varying from dull to brilliant.

Coal owes its origin to the gradual alteration of organic deposits, chiefly vegetable. It occurs in beds interstratified with shales, sandstones and conglomerates, sometimes forming distinct layers of varying thickness.

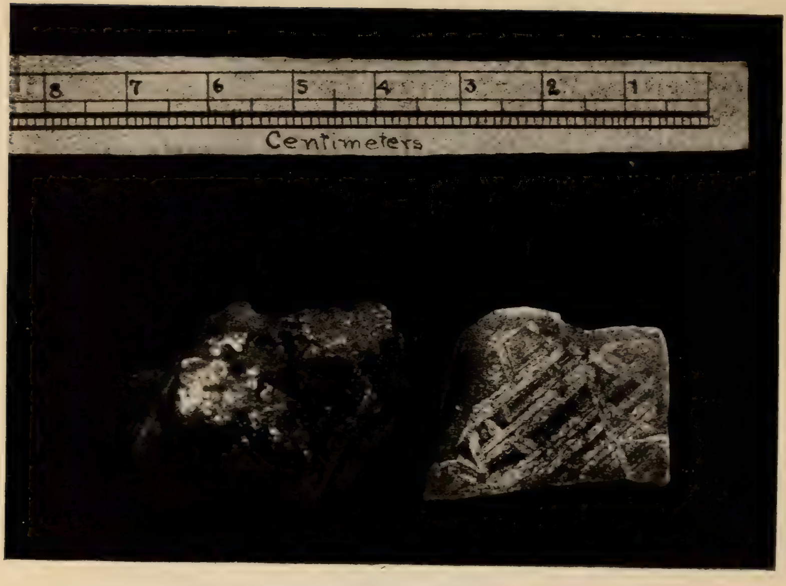
Anthracite. Anthracite or hard coal is characterized by a bright, often submetallic luster and is iron-black in color, frequently iridescent. It contains comparatively little volatile matter.

Anthracite beds occur in the formations east of the Alleghany range, which in Pennsylvania reach a thickness of 3300 feet.

Bituminous coal. Bituminous coal differs from the above chiefly in the higher percentage of volatile hydrocarbon oils contained in it. Bituminous coal may be classed as:

1 caking or coking coal
2 noncaking coal
3 cannel coal

Plate 39



1 Iron (meteorite), Schwarzenberg, Saxony

Brown coal or lignite. Brown coal contains more oxygen than bituminous coal, is compact or earthy and yields a brownish black powder.

For a more detailed discussion of the occurrence and geologic relations of coal deposits the reader is referred to New York state museum bulletin 19 or to some work on economic geology.

METEORITES

Considerable knowledge regarding the probable character of heavenly bodies other than the earth is furnished by the meteorites or fallen stars. These fragments from planetary space contain a number of minerals which are identical with terrestrial species, as well as several which have not, up to this time, been found on the earth.

They have been classified into three groups:

1 **Siderites.** Metallic masses composed principally of iron alloyed with nickel and some manganese and cobalt. Polished surfaces of siderites when etched with dilute nitric acid develop a series of intersecting lines or bands which are known as Widmanstätten figures (pl. 39_1).

2 **Siderolites.** Masses of a spongy, cellular character composed partly of iron and partly of stony material and frequently containing embedded grains of chrysolite.

3 **Aerolites.** Masses composed principally of stony material in the form of silicates including chrysolite, enstatite and minerals in the pyroxene group.

Meteorites are of universal distribution and can not be said to be characteristic of any locality.

APPENDIX

GLOSSARY OF CRYSTALLOGRAPHIC TERMS

Acicular. Needlelike in structure.

Arborescent. With a branching structure like a tree or plant.

Axes. Imaginary lines drawn within a crystal for the purpose of studying the relation of its planes.

Axial ratio. The relations between the lengths of axes which are not interchangeable as determined by the intercepts of a prominent pyramid face.

Basal plane or base. A plane which truncates the crystal parallel to the basal axes.

Biaxial crystals. A term used to include in an optical division crystals of the orthorhombic, monoclinic and triclinic systems.

Binary. Twofold.

Bladed structure. Composed of bundles of broad flat crystals resembling the blades of knives.

Botryoidal. Derived from a Greek word meaning a bunch of grapes.

Brachyaxis. The shorter of the two basal axes in the orthorhombic and triclinic systems. The term brachy is derived from a Greek word meaning short.

Brachydomes. Domes or horizontal prisms parallel to the brachyaxis.

Brachypinacoid. A pinacoidal plane parallel to the vertical and brachy axes.

Brachyprisms, brachypyramids. Crystal forms the planes of which are more nearly parallel to the brachyaxis then those of the form which determines the axial ratio. [*See* p. 32, fig. 124]

Capillary crystals. Extremely elongated individuals resembling hairs or threads.

Clinoaxis. The axis which in the monoclinic system is oblique to the plane of the other two but is perpendicular to one of the latter.

Clinodomes. Domes or horizontal prisms the faces of which are parallel to the clinoaxis.

Clinopinacoid. A pinacoid parallel to the vertical and clino axes.

Clinoprisms, clinopyramids. Crystal forms the faces of which are more parallel to the clinoaxis than the form which determines the axial ratio.

Columnar structure. Composed of aggregates of elongated crystals resembling columns.

Coralloidal. Branching and interlacing forms resembling coral.

Crystalline aggregate. An aggregate of imperfect crystals.

Cube. An isometric form bounded by six rectangular faces. In ideal crystals the faces are square.

Dendritic. *See* Arborescent.

Dihexagonal. Presenting in section, a 12 sided symmetric figure closely related to a hexagon. [*See* p. 26, fig. 98]

Diploids. Isometric forms bounded by 24 four sided faces. The diploid is so named from the fact that the faces are grouped in pairs.

Ditetragonal. Presenting in section an eight sided symmetric figure somewhat resembling an octagon but more closely related to a square.

Divergent. Composed of elongated crystalline individuals which diverge or radiate from a center.

Dodecahedron. An isometric form bounded by 12 (dodeca) rhombic faces.

Domes. Horizontal prisms which in the orthorhombic, monoclinic and triclinic systems are parallel to one basal axis. The term is derived from the Latin *domus*, a house, to describe their resemblance to a hip roof.

Drusy. Covered with extremely minute crystals producing a roughened surface.

Faces. The bounding surfaces of a crystal.

Fibrous. Composed of slender filaments or fibers.

First order. A term applied in the tetragonal and hexagonal systems to pyramids and prisms the faces of which intersect two basal axes with equal intercepts; any plane of the hexagonal forms is parallel to the third basal axis.

Foliated. Composed of layers of imperfectly formed crystals which may be separated from one another with ease; derived from the Latin *folio*, a leaf.

Geode. A hollow rounded fragment lined with crystals.

Granular structure. Composed of irregular particles or grains.

Habit of crystals. The general preponderance of certain forms in crystals of a given species and from a given locality.

Hemimorphic. Having a dissimilar development of crystal planes on the two extremities.

Hexagonal. Sixfold.

Hexakistetrahedrons. Tetrahedral forms of the isometric system bounded by 24 triangular faces arranged in four groups of six each.

Hexoctaherons. Forms of the normal group of the isometric system bounded by 48 triangular faces. The name derived from the Greek refers to the grouping of the faces in eight groups of six each.

Inclusions. Foreign matter of a solid, liquid or gaseous nature inclosed within the crystal.

Isometric. Presenting the highest degree of symmetry in which the three crystallographic axes are interchangeable. The term is derived from two Greek words meaning equal measure and refers to the ideal development in which the three axes are of equal length.

Isomorphic. Presenting the close chemical and crystallographic relations stated on p. 45.

Macroaxis. The longer of the two basal axes in the orthorhombic and triclinic systems. The term macro is derived from a Greek word meaning long.

Macrodome. A dome or horizontal prism parallel to the macroaxis.

Macropinacoid. A pinacoidal plane parallel to the vertical and the macro axis.

Macroprisms, macropyramids. Crystal forms, the planes of which are more nearly parallel to the macroaxis than those of the form which determines the axial ratio. [*See* p. 32, fig. 124]

Mammillary structure. Consisting of rounded prominences; the term is derived from the Latin *mamma*, meaning a female breast.

Micaceous structure. In thin leaves which may be separated from one another as typified in the mica group of minerals.

Octahedron. A crystal form bounded by eight equilateral, triangular faces; derived from a Greek word meaning eight.

Orthoaxis. The axis which, in the monoclinic system, is perpendicular to the plane of the other two.

Orthodomes. Domes or horizontal prisms parallel to the orthoaxis.

Orthopinacoid. A pinacoid parallel to the vertical and ortho axes.

Orthoprisms, orthopyramids. Crystal forms the faces of which are more parallel to the orthoaxis than the form which determines the axial ratio.

Orthorhombic. Presenting the symmetry of the orthorhombic system, referable to three uninterchangeable axes which are at right angles to one another. Orthorhombic crystals are characterized by binary symmetry in three directions.

Pinacoids. Crystal forms composed of planes parallel to two axes and corresponding in position to the faces of a cube; the term is derived from a Greek word meaning a board.

Plane. One of the bounding plane surfaces of a crystal; the term is extended to include the imaginary extension of this bounding surface to meet the axes.

Prisms. Crystal forms the planes of which intersect two basal axes and are parallel to a third. Domes as described above may be regarded as horizontal prisms.

Pseudohexagonal. Apparently hexagonal; many crystals *seem*, by reason of twinning, to be hexagonal though belonging to a system of lower symmetry.

Pseudoisometric. Apparently isometric; note above.

Pseudomorph. A substance having the form of one mineral and the composition of another; the term is derived from two Greek words meaning a false form.

Pyramids. Crystal forms the planes of which intersect all three axes. In the isometric system forms of this type are designated by special terms such as octahedron, trioctahedron, etc.

Pyritohedrons. Isometric forms so named from their common occurrence in the species pyrite.

Radiated structure. Consisting of crystalline individuals which radiate from a center.

Reniform. Kidney-shaped; from the Latin *renes*, a kidney.

Reticulated. Interlaced like a net; from the Latin *reticulum*, a net.

Rhombohedrons. Hexagonal forms of trigonal symmetry bounded by six rhombic faces.

Scalenohedrons. Crystal forms of the tetragonal and hexagonal systems bounded by scalene triangles and presenting in general a somewhat wedgelike shape.

Second order. A term applied, in the tetragonal and hexagonal systems, to pyramids and prisms the faces of which are related to those of the corresponding first order forms as shown on p.26, fig.98.

Sphenoids. Crystal forms of the tetragonal and orthorhombic systems bounded by four triangular faces and closely related by analogy to the isometric tetrahedron.

Stalactitic structure. Consisting of pendant columns or forms resembling icicles.

Stellated structure. Consisting of radiating individuals producing star-like forms.

Striated. Grooved or furrowed in parallel lines.

Striations. Parallel grooves or furrows on the surfaces of crystals.

Symmetry. The regularity in the recurrence of faces and angles of the same kind.

System. One of the six divisions based on symmetry into which all crystals are divided.

Tetragonal. Fourfold.

Tetrahedron. An isometric form bounded by four equilateral triangles: identical with the regular polyhedron of solid geometry.

Tetrahexahedrons. Isometric forms bounded by 24 isosceles triangles, the faces are grouped in six groups of four, each group corresponding to one face of a cube or hexahedron.

Third order. A term applied, in the tetragonal and hexagonal systems, to pyramids and prisms the faces of which are related to those of the corresponding first order forms as shown on p. 27, fig. 102.

Trapezohedrons. Crystal forms of the isometric, tetragonal and hexagonal systems bounded by trapezohedral faces.

Triclinic. Presenting the lowest degree of symmetry and referable to three inclined axes.

Trigonal. Threefold or triangular.

Trisoctahedrons. Isometric forms bounded by 24 triangular faces arranged in eight groups of three, each group corresponding to one of the faces of an octahedron.

Twin crystals. Intergrowths of like crystals of the same substance symmetrically disposed with respect to certain lines but not in parallel position.

Twinning plane. In twin crystals, an imaginary plane common to both individuals.

Uniaxial. A term used to include in an optical division crystals of the tetragonal and hexagonal systems.

Unit form. A prominent crystal form which is arbitrarily chosen from among those of a given species to determine the axial ratio.

Vicinal planes. Low prominences produced on some crystal faces by disturbances during the growth of the crystal or by other causes.

Widmanstätten lines. Lines of crystalline structure developed on the polished surfaces of meteorites by the action of corrosive agents.

LIST OF ELEMENTS

THEIR SYMBOLS AND ATOMIC WEIGHTS

Aluminium	Al	27	Bromin	Br	79.8
Antimony	Sb	120	Cadmium	Cd	111.7
Argon	A	40	Calcium	Ca	39.9
Arsenic	As	74.9	Carbon	C	12
Barium	Ba	137	Cerium	Ce	140
Beryllium	Be	9.1	Cesium	Cs	132.7
Bismuth	Bi	207.5	Chlorin	Cl	35.5
Boron	B	11	Chromium	Cr	52.5

Cobalt	Co	58.7
Columbium, *see* Niobium		
Copper	Cu	63.2
Didymium	Di	142
Erbium	Er	166
Fluorin	F	19.1
Gadolinium	Gd	156
Gallium	Ga	69.9
Germanium	Ge	72.3
Glucinum, *see* Beryllium		
Gold	Au	196.7
Helium	He	4.3
Hydrogen	H	1
Indium	In	113.4
Iodin	I	126.5
Iridium	Ir	192.5
Iron	Fe	55.9
Lanthanum	La	138
Lead	Pb	206.4
Lithium	Li	7
Magnesium	Mg	24
Manganese	Mn	54.8
Mercury	Hg	199.8
Molybdenum	Mo	96
Neodymium	Nd	143.6
Nickel	Ni	58.6
Niobium	Nb	93.7
Nitrogen	N	14
Osmium	Os	191
Oxygen	O	16
Palladium	Pd	106.2
Phosphorus	P	31
Platinum	Pl	194.3
Potassium	K	39
Praseodymium	Pr	140.5
Rhodium	Rh	104.1
Rubidium	Rb	85.2
Ruthenium	Ru	103.5
Samarium	Sm	150
Scandium	Sc	44
Selenium	Se	78.9
Silicon	Si	28
Silver	Ag	107.7
Sodium	Na	23
Strontium	Sr	87.3
Sulfur	S	32
Tantalum	Ta	182
Terbium	Tb	160
Tellurium	Te	125
Thallium	Tl	203.7
Thorium	Th	232
Thulium	Tu	170
Tin	Sn	118
Titanium	Ti	48
Tungsten	W	183.6
Uranium	U	240
Vanadium	V	51.1
Ytterbium	Yb	172.6
Yttrium	Yt	89
Zinc	Zn	65.1
Zirconium	Zr	90.4

THE MINERAL COLLECTION OF THE NEW YORK STATE MUSEUM

Probably no mineral collection, however large and comprehensive in a comparative sense, can be regarded as exhaustive or complete. New minerals are constantly being discovered and new occurrences of known minerals constantly noted, so that as in the collections of every other department of science, a mineral collection is bound to increase to keep pace with the progress of discovery.

The mineralogic student should not lose sight of the fact that though comparatively few of the many hundreds of mineral species known to science are found in sufficient abundance to be of importance in the arts, the discovery of a considerable deposit of a species which is at present considered rare may at any time raise it to a high rank in commercial importance. A notable instance of the latter case is afforded by the group of gold and silver tellurids developed within the last 10 years at Cripple Creek, Col. Prior to 1892 these minerals were classed among the rare species and were considered valuable only as mineral specimens.

The principal mineral collection of the New York state museum is displayed in vertical cases which line the walls of the mineral section beginning to the left of the entrance to the section. In arrangement the collection follows the order of this guide which is that of J. D. Dana's *System of mineralogy.* The disposition of the principal divisions is as follows:

DIVISION	CASE
Native elements	1
Sulfids, selenids, tellurids etc.	2
Sulfo salts Haloids	3
Oxids	4–8
Carbonates	9–13
Silicates	14–22
Titanates Niobates, tantalates	23
Phosphates, arsenates, vanadates etc.	24
Borates, uranates Sulfates	25
Tungstates, Molybdates Hydrocarbon compounds	26

In disposing the specimens in the cases the top and bottom shelves of each case are reserved for the display of large specimens representing the species of the divisions and groups installed in the case and the five intermediate shelves for the smaller specimens arranged in consecutive order. The swinging card catalogue installed in the spaces between the cases is practically exhaustive, the species represented in the cases being indicated by the letter w (wall cases) and the number which in every instance precedes the species name corresponding to a number placed in the upper left corner of the specimen label; these numbers also correspond to the numbered species of Dana's *System of mineralogy* cited above.

In every instance the most characteristic specimens under each species are to be found in the front row and are therefore best available for detailed study; the back row contains duplicates, massive specimens, and in general, material requiring less close examination. In most instances where the crystallization is of interest and importance wooden models are placed at the head of the species; these are followed by the best examples of crystallization available, crystalline masses and massive forms following the order given in the descriptive text.

An introductory collection illustrating the text of part 1 of this guide is displayed in the table cases of the southern half of the mineralogic section.

The student is also referred to a collection of minerals of economic importance at present displayed in the table cases of the northern half of the mineralogic section. The material here displayed is grouped under the following divisions:

Metalliferous division

- *A* Metalliferous ores
  - 1 Arsenic antimony and bismuth minerals
  - 2 Gold minerals
  - 3 Silver minerals
  - 4 Mercury minerals
  - 5 Copper minerals
  - 6 Lead minerals
  - 7 Zinc and cadmium minerals
  - 8 Tin minerals
  - 9 Nickel minerals
  - 10 Uranium and chromium minerals
  - 11 Iron minerals
  - 12 Manganese minerals
  - 13 Aluminium minerals

Nonmetalliferous division

- *B* Substances used for chemical purposes
  - 1 Sulfur, sulfuric and hydrofluoric acids

Nonmetalliferous division *(cont'd)*

  - 2 Salt, potash, soda, borax and alum
  - 3 Magnesium, strontium, titanium and thorium compounds
  - 4 Plaster of paris
  - 5 Substances used in the manufacture of chemical compounds
- *C* Ceramic materials
  - 1 Porcelain, earthenwares and bricks
  - 2 Pottery and glassware
- *D* Refractory materials
  - 1 Graphite
  - 2 Asbestos
  - 3 Mica
- *E* Materials of physical application
  - 1 Abrasives
  - 2 Graphic materials
  - 3 Pigments
  - 4 Fertilizers

BIBLIOGRAPHY[1]

For more detailed and exhaustive information on the subject of mineralogy the reader is referred to the following books:

Bauerman. Text book of descriptive mineralogy. 1884.

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Dana, E. S. Minerals and how to study them. 1895.

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Merrill, G. P. Guide to the study of the collections in the section of applied geology; Smithsonian institution. 1900. 1901.

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Williams, S. G. Applied geology. 1885.

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[1] This list is confined to works in English and could be materially added to should the student wish to consult French and German publications.

GENERAL INDEX

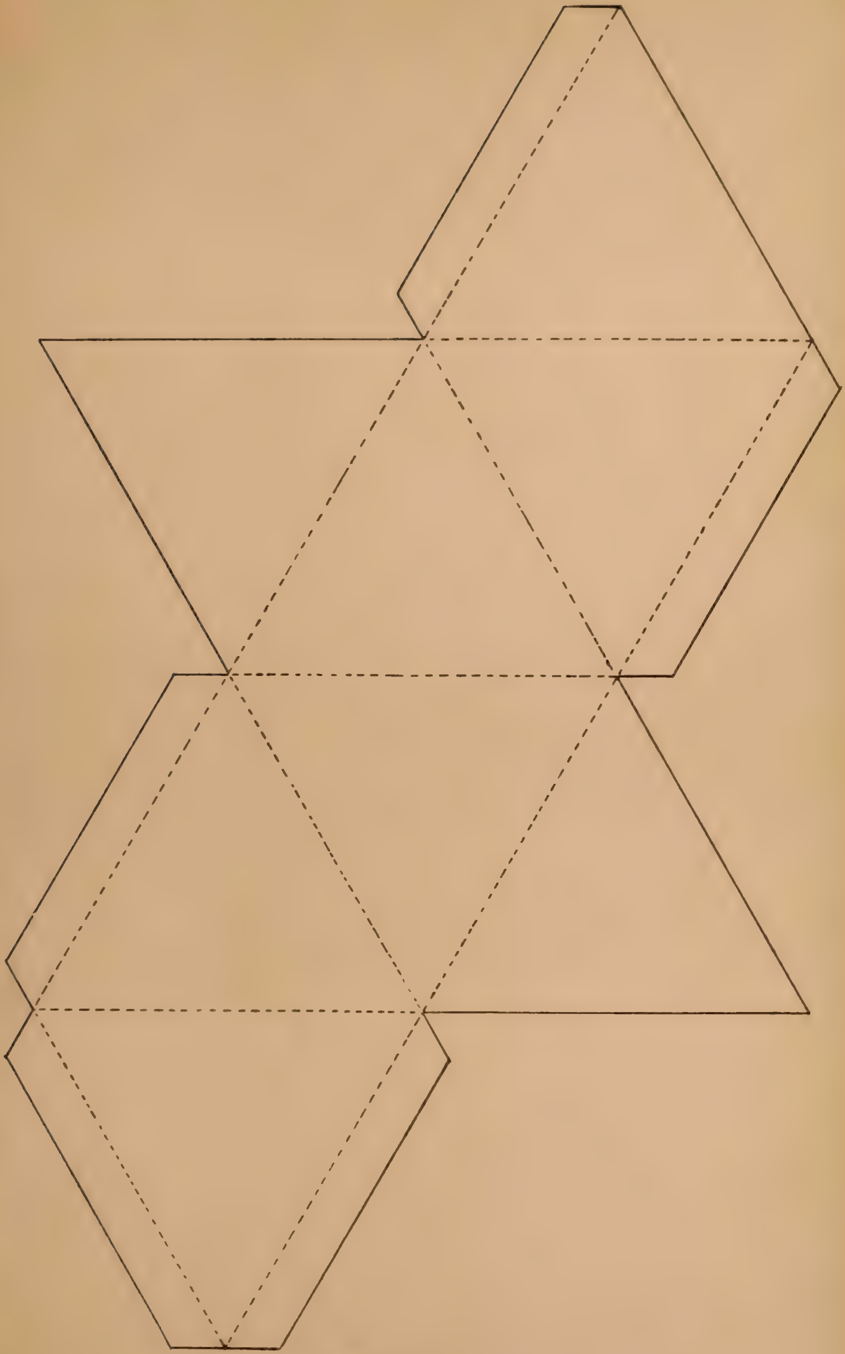
INDEX TO MINERAL SPECIES

(*Pages 149–150 were bulletin cover pages*)

MINERALOGY 2

Crystal models

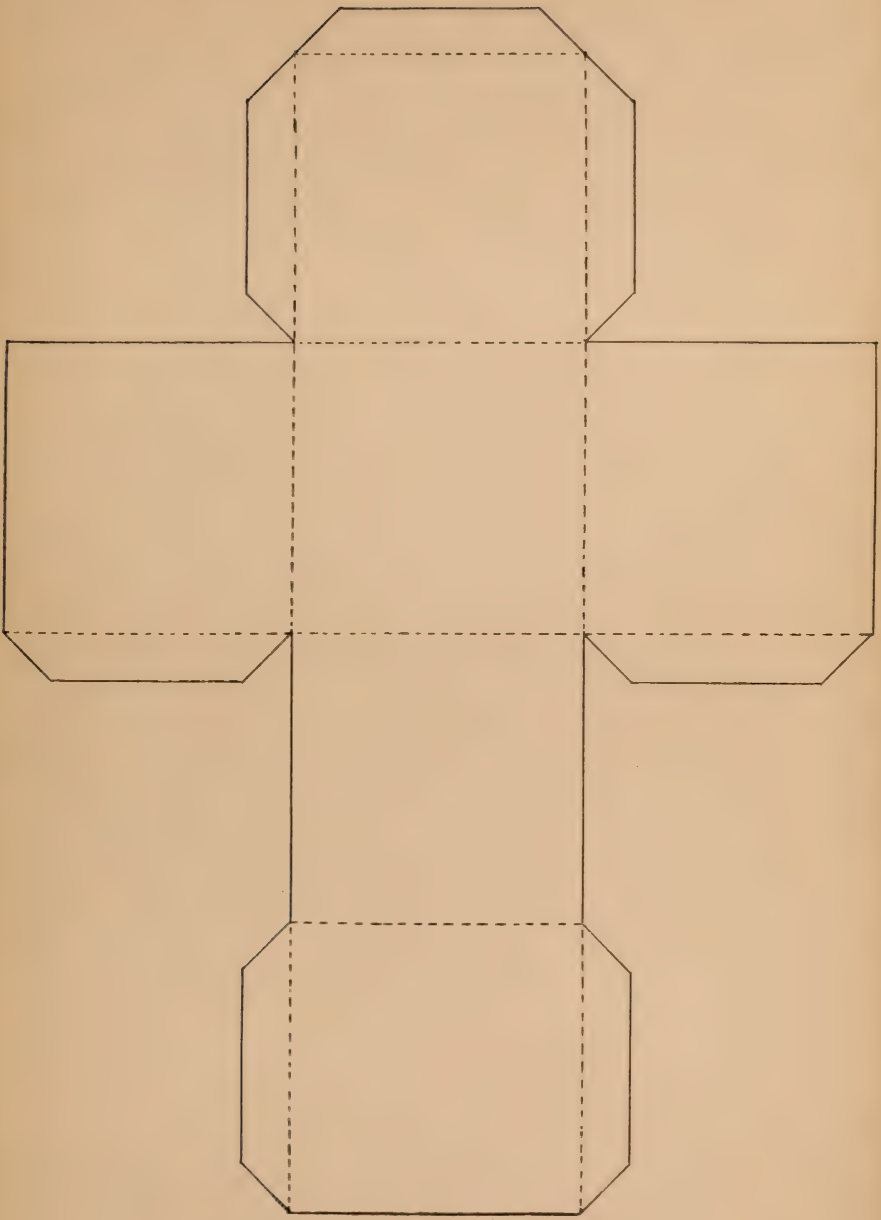
In folding these models, hold the edge of a ruler or papercutter firmly on the dotted line and crease the cardboard well over by means of the finger nail or the back of a penknife. In pasting the model together begin by joining those faces which form a continuous series, as for instance the four connected faces of model 2,



Model 1

Cut out solid lines.
Fold dotted lines.
Join with paste or mucilage.

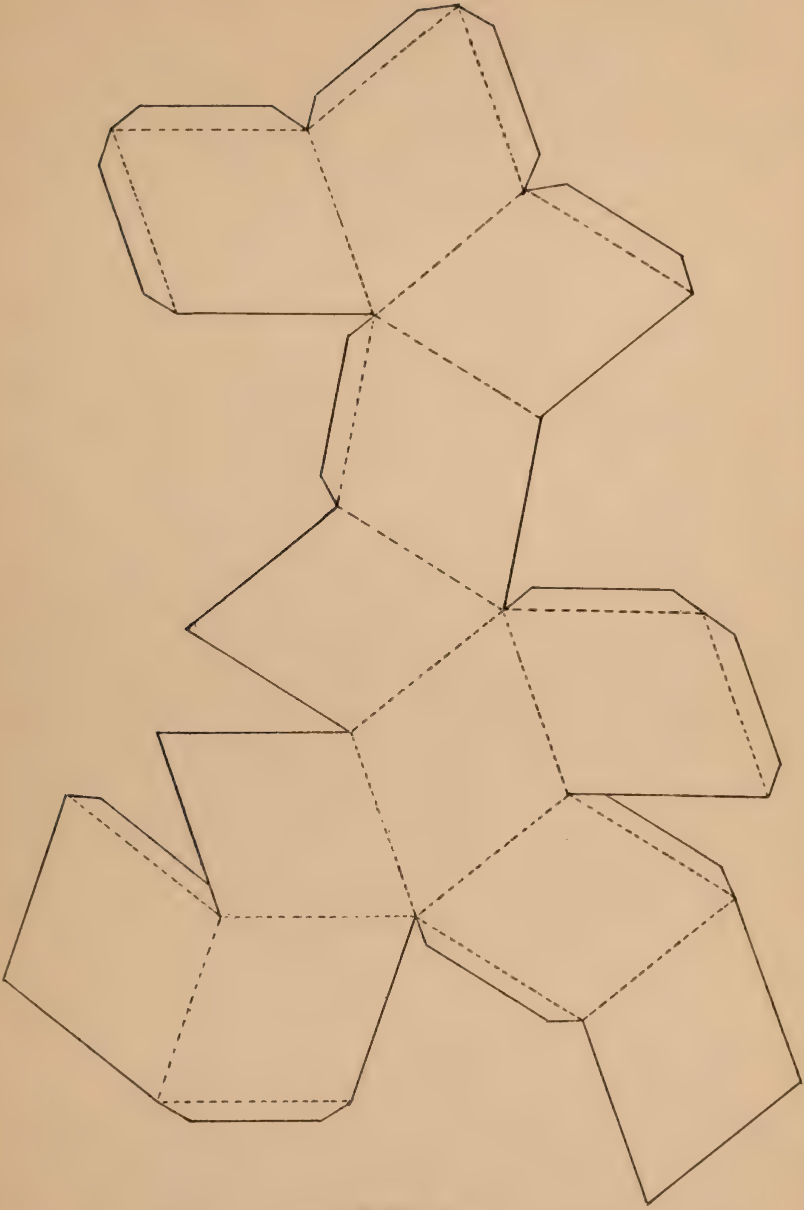
Model 1 Octahedron



Model 2

Cut out solid lines.
Fold dotted lines.
Join with paste or mucilage.

Model 2 Cube

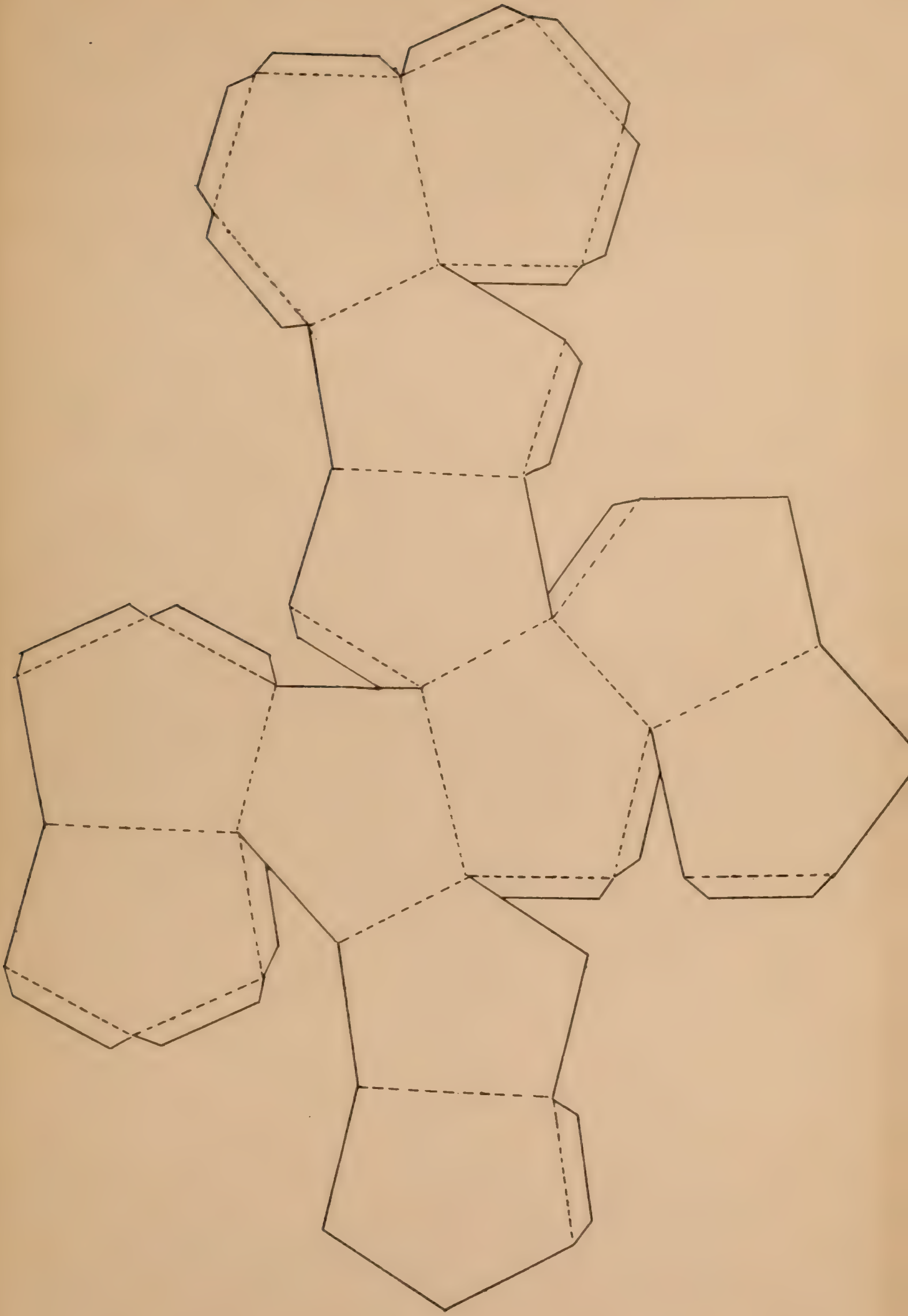


Model 3

Cut out solid lines.
Fold dotted lines.
Join with paste or mucilage.

Model 3

Dodecahedron

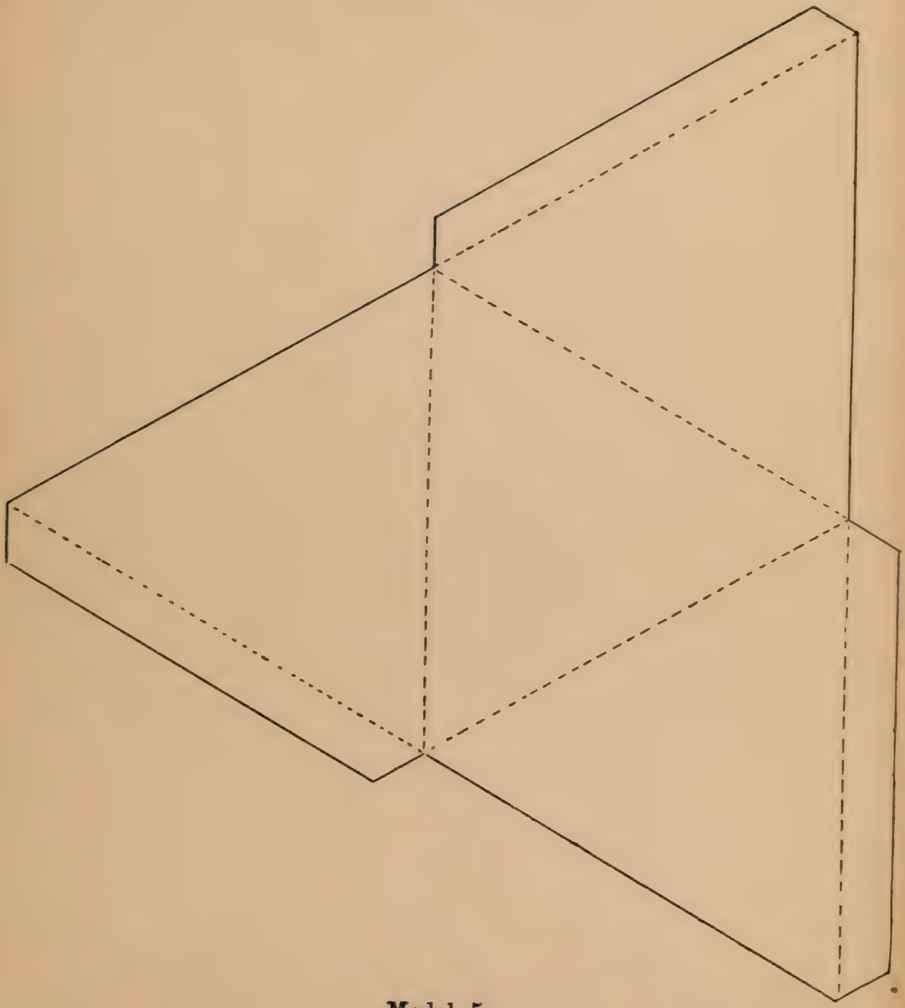


Model 4

Cut out solid lines.
Fold dotted lines.
Join with paste or mucilage.

Model 4

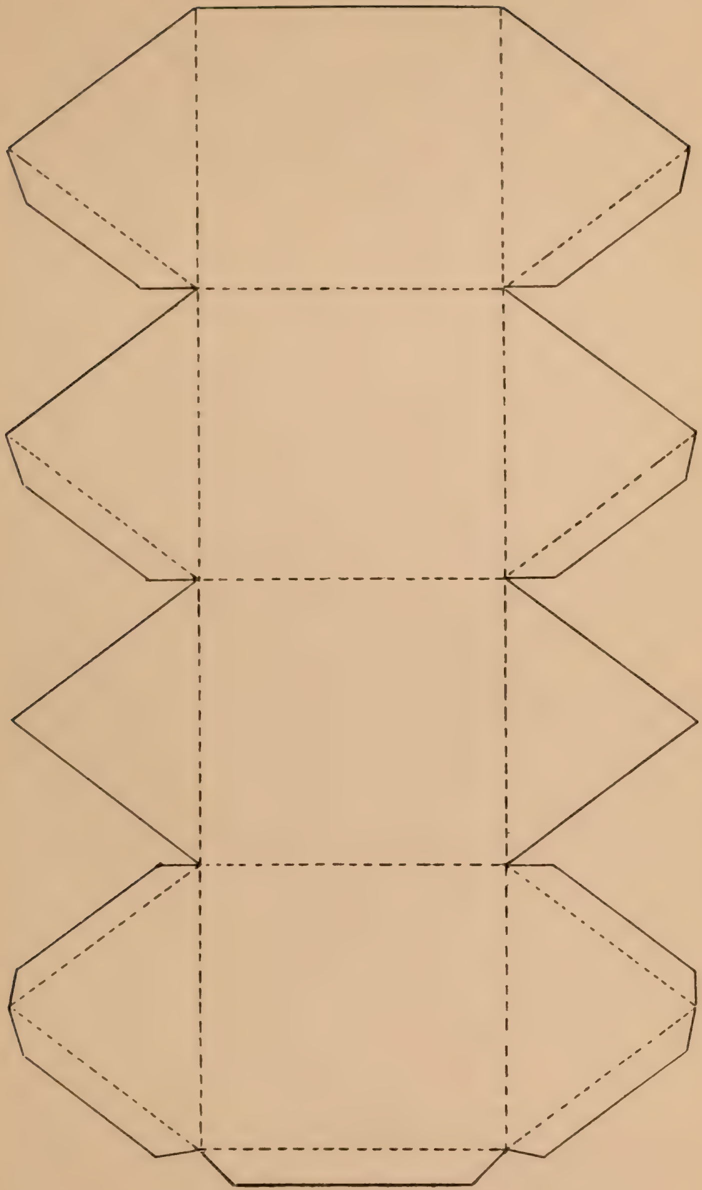
Pyritohedron



Model 5

Cut out solid lines.
Fold dotted lines.
Join with paste or mucilage.

Model 5 Tetrahedron



Model 6

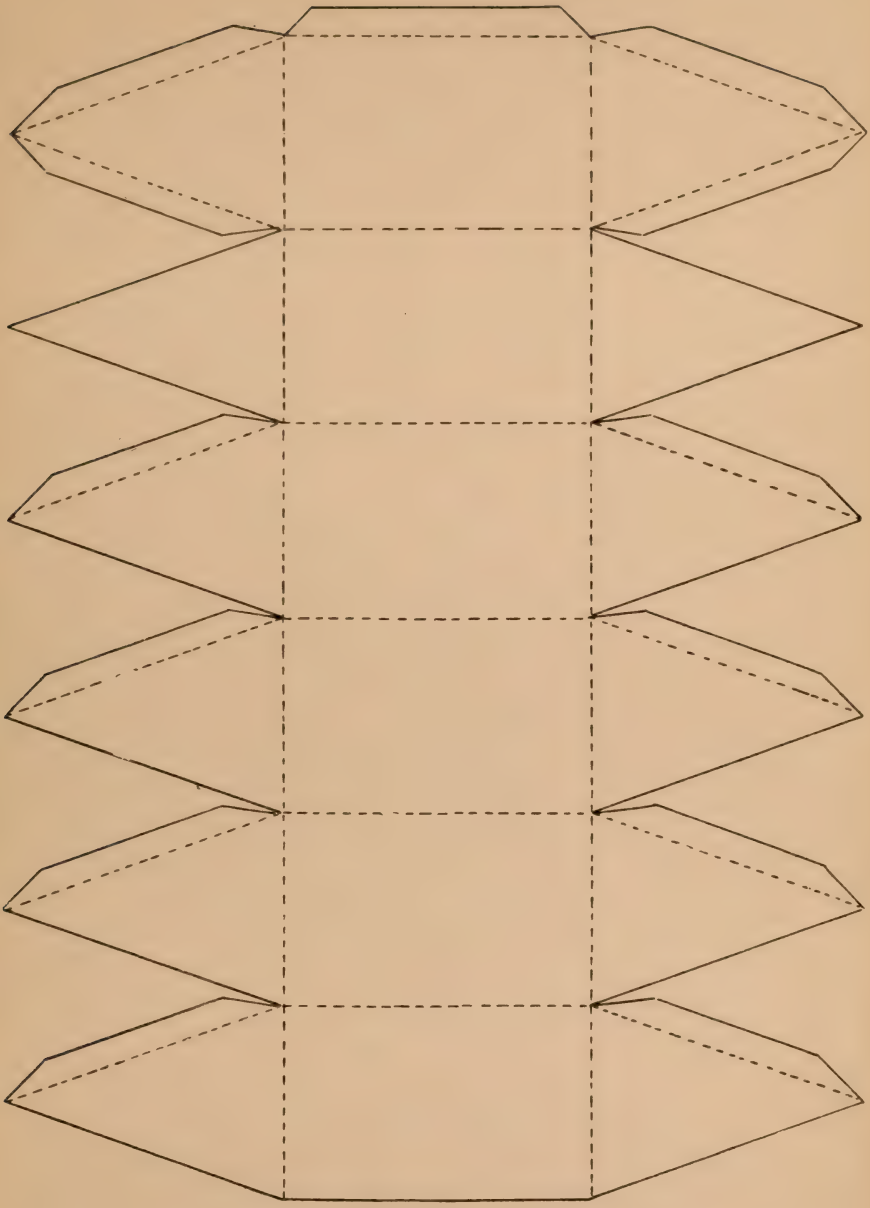
Cut out solid lines.
Fold dotted lines.
Join with paste or mucilage.

Model 6

Pyramid

Prism

Pyramid



Model 7

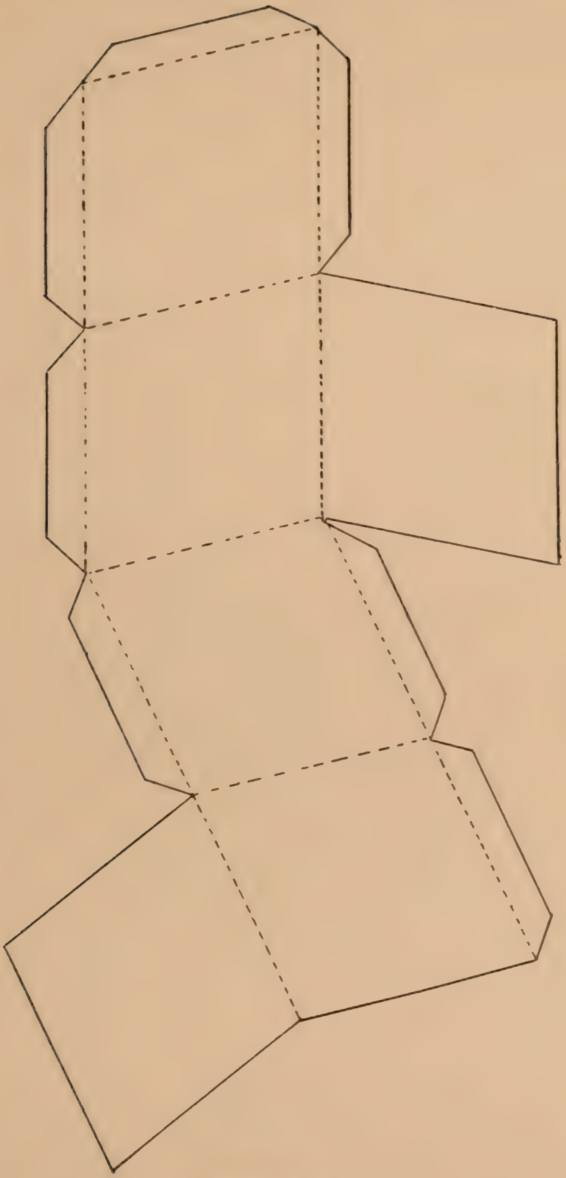
Cut out solid lines.
Fold dotted lines.
Join with paste or mucilage.

Model 7

Pyramid

Prism

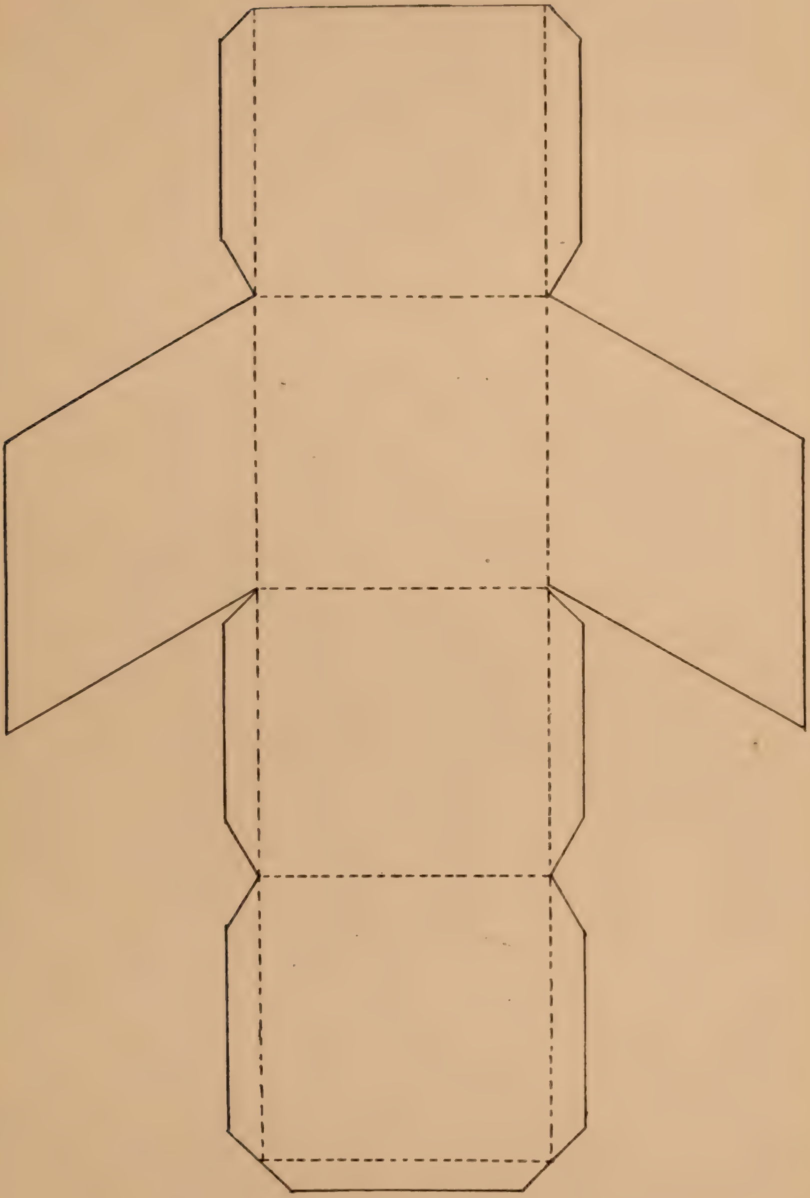
Pyramid



Model 8

Cut out solid lines.
Fold dotted lines.
Join with paste or mucilage.

Model 8 Rhombohedron



Model 9

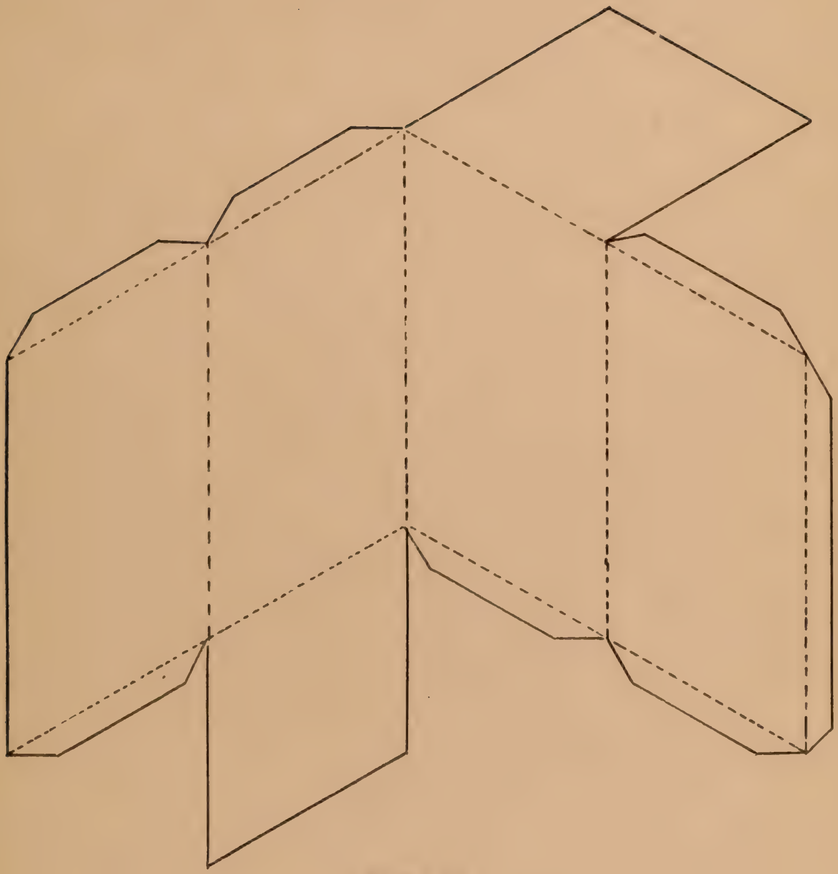
Cut out solid lines.
Fold dotted lines.
Join with paste or mucilage.

Basal pinacoid

Model 9

Prism

Basal pinacoid



Model 10

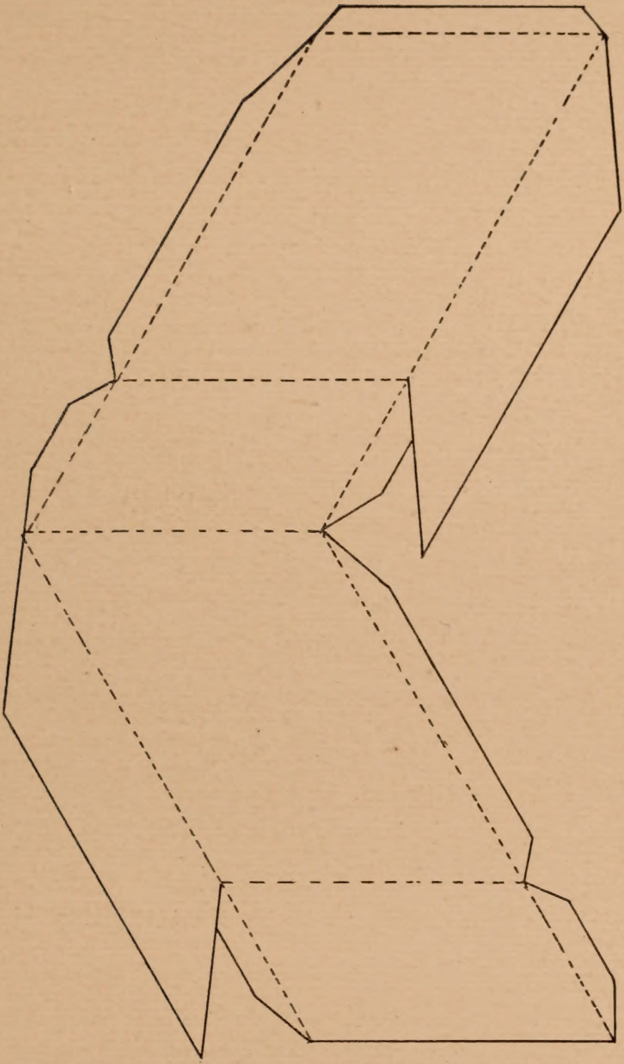
Cut out solid lines.
Fold dotted lines.
Join with paste or mucilage.

Basal pinacoid

Prism

Basal pinacoid

Model 10



Model 11

Cut out solid lines.
Fold dotted lines.
Join with paste or mucilage.

Pinacoid

Pinacoid

Model 11

Pinacoid