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OCEANOGRAPHY.—*The circulation of the abyssal water of the oceans.* Austin H. Clark, National Museum.

The geographical and bathymetrical distribution of the recent crinoids, animals which, occurring at all depths, are thruout life, with very few exceptions, strictly sessile, and of which the young are developed entirely in the water immediately surrounding the adults, furnishes data of the greatest importance for the solution of the problems connected with the abyssal circulation of the oceanic waters. This circulation, as would be expected, differs radically from the circulation of the surface waters, and is altogether of a much simpler type. As indicated by the distribution of the recent crinoids, the general scheme of the abyssal circulation of the oceanic water is as follows:

The surface water of the antarctic regions, bathing the shores of the antarctic continent and forming the circumpolar antarctic stream, is in reality abyssal water, derived entirely from the abysses of the Pacific, Atlantic and Indian oceans. It has nothing whatever to do with the surface water of the rest of the globe, from which it is separated by a broad neutral zone, the so-called west wind drift. Antarctic water enters the basins of the Pacific, Atlantic and Indian oceans in the form of great peripheral currents (the Humboldt, Benguela and Australian currents) flowing along their southern, southeastern and eastern borders, which, in the Pacific and Atlantic, plunge beneath the surface at about the latitude of the equator, but are continued as deep currents northward, westward, and finally for a greater or lesser distance southward, along the eastern, northern and northwestern margins of these basins. At every point in their course these currents give off water from their seaward (left) side which falls into the abysses and forms the strictly abyssal water; on account of the effect of the rotation of the earth this process is carried on far more actively in the southern than in the northern hemisphere. In the northern hemisphere the rotation of the earth; instead of inducing the flow of water from the borders of these currents into the abysses, tends to cause the currents to hug the coast and, by rendering them more compact, to prevent the diffusion of their water and hence to maintain their motion and to preserve them as currents. Also it operates to bring their upper levels near the surface so that, wherever a powerful surface current flowing diagonally away from the shore causes the formation of a vacuum, as it were, between itself and the coast, the water of these peripheral currents, composed of water of the strictly abyssal type, and ultimately of antarctic origin, immediately rises to the surface. This occurs off northwestern Africa and off southern California, and again off the Kurile Islands and off the New England coast from Cape Cod northward; on the New England coast, however, the identity of the antarctic water is more or less concealed by mixture with water of low salinity coming from the north.

In the pocket-like Gulf of Alaska the rotation of the earth causes the water of the antarctic current to pile up, and to rise nearly, in the winter possibly in some places quite, to the surface. Over the surface of this cold antarctic water flows the wind-impelled drift from the Kuro-Siwo, which divides, part of it skirting the northern part of the Gulf of Alaska, and part flowing southward down the coast. The water of the Kuro-Siwo drift and the antarctic water are of the same salinity, and therefore they mix readily. Hence the southern derivative from the Kuro-Siwo drift, the so-called California current, as it flows southward dissolves into itself the cold water of the antarctic stream immediately beneath it, presenting the curious phenomenon of a current flowing southward, yet at the same time becoming colder and colder.

In the southwestern portion of the basins of the Pacific, Atlantic and Indian oceans the abyssal water slowly rises and, flowing southward, takes the place in the circumpolar antarctic circulation of the water lost thru the Humboldt, Benguela and Australian currents.

In the central portion of the oceanic basins the general motion of the water is from east to west, the water lost from the currents flowing northward across the basins and being picked up by the southerly currents on the other side. This circulation is rapid in the high southern latitudes, diminishing in intensity northward.

The water of the circumpolar west wind drift of low southern latitudes, north of the true antarctic current, is mainly surface water from the north caught up and driven forward by the strong wind. This west wind drift forms a band dividing the abyssal antarctic circulation from the superficial circulation further north.

By this drift many organisms, pelagic at some stage of their existence, or capable of transportation by floating objects, are distributed thruout the southern latitudes, tho they are unable to withstand truly antarctic conditions; and to this is largely due the similarity of the faunas of southern Africa, southern South America, southern Australia and New Zealand, a similarity which is in no way indicated by the crinoids of these localities.

GEOCHEMISTRY.—*Note on the chlorine content of rain water at Tortugas, Fla.* R. B. DOLE, Geological Survey. Communicated by F. W. Clarke.

The appreciable quantity of salt carried by normal rainfall off the seacoast is well shown by test of a sample collected by the writer on Loggerhead Key, Tortugas, Fla. After heavy all-night rains and morning showers had thoroly washed the roof of the Marine Biological Laboratory a large sample of rain was collected during the afternoon of June 13, 1913, in a galvanized bucket under one of the gutters. This sample was immediately bottled and later tested at Washington, D. C., by E. C. Bain. A 250 cc. portion concentrated to 25 cc. and titrated with a solution of silver nitrate, 1 cc. of which was equivalent to 0.5 mgm.

of chlorine, had a chlorine content of 2.9 parts per million. The residue from a liter dried at 180°C. was 31 parts per million, only a small part of which could be attributed to solution of the bottles for the residue contained but 2.0 parts per million of silica.

Tho this content of chlorine can not be considered an average because of the variable effect that wind-borne spray has on the salt in the rain it serves as a contribution to the rather scanty knowledge regarding the composition of rain water in the United States. The above-mentioned chlorine, 2.9 parts per million, is equivalent to about 5 parts of sea salt. With an annual rainfall of 60 inches this is equivalent to a precipitation of 65 pounds of salt per acre per annum. Figures quoted by Clarke[1] for Barbados are equivalent to 193 pounds and others range from 24 pounds in England to 298 pounds in Ceylon.

[1] Clarke, F. W., The data of geochemistry: U. S. Geol. Survey. Bull. 491, p. 50. 1911.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted thru the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Some lavas of Monte Arci, Sardinia.* HENRY S. WASHINGTON. Am. Jour. Sci. (4). 1913.

This extinct volcano was visited in October, 1904. It has not been described since 1857. It is shown that the volcano consists of a core of rhyolite, with later flows of dacite, andesite and trachyte, closing with extensive sheets of basalt, in many respects resembling the nearby and better known Monte Ferru. Detailed petrographic descriptions of the lavas are given, together with seven complete analyses. An apparently new mineral was found, which is to be further investigated. The paper is a preliminary one, and the volcano is worthy of another visit and fuller study. H. S. W.

GEOLOGY.—*Observations on the Daubrée experiment and capillarity in relation to certain geological speculations.* JOHN JOHNSTON and L. H. ADAMS. J. Geol. 1913.

Those who believe that meteoric waters are an important factor in the production of the phenomena of volcanism must always face the problem of devising a plausible account of the manner in which accessions of water can be introduced into the magma. This difficulty they have endeavored to obviate by instancing an experiment of Daubrée, who found that water would pass thru a porous sandstone against a certain excess counter pressure of steam. This passage of water is, as Daubrée pointed out, a manifestation of capillary action; the authors show that this same effect may be secured by means of a much simpler experimental arrangement. Now capillary forces are effective only when there is a surface of separation within the pores; moreover they diminish steadily with rise of temperature, and vanish at the critical point of the liquid. Consequently, the Daubrée experiment gives no ground for supposing that capillary forces would be effective in causing water to penetrate into deep seated and highly heated rock-masses. This conclusion has been pointed out before; the purpose of the present paper is to enforce it, since the opposite, and erroneous, conclusion still frequently appears as an argument in favor of the likelihood of the introduction of water by means of capillarity into molten magmas. Even if we make the somewhat unlikely assumption of free liquid surfaces far down in the rocks, any pressure producible by capillarity is in general likely to be small in comparison with the pressure due to the hydrostatic column, except in pores of such fineness that the amount of water that could flow thru them is infinitesimal. J. J. and L. H. A.

PLANT PHYSIOLOGY.—*The water requirements of plants. I. Investigations in the Great Plains in 1910 and 1911.* L. J. Briggs and H. L. Shantz. Bureau of Plant Industry, Bulletin 284, 1913.

This paper deals with the amount of water absorbed by plants in the production of a unit weight of dry matter. In order to determine this ratio, which is called the "water requirement," plants were grown to maturity in large pots having a capacity of about 115 kilos of soil, provided with tight covers, with openings for the plants, the space between the cover and the stem of the plant being sealed with wax. Thirty-one varieties were tested at Akron, Colorado, in 1911, six pots being used in each determination, and the results expressed with their probable error.

Of the crops tested, those most efficient in the use of water were millet, sorghum and corn, the ratio being 275, 306 and 362 respectively, that is, these crops used 275, 306 and 362 pounds of water in the production of one pound of dry matter. The least efficient were the legumes, alfalfa, Canada Pea and sweet clover, with ratios of 1069, 800 and 709, respectively, while the water requirement of the small grains was intermediate, being 507 for wheat, 539 for barley, 614 for oats, and 724 for rye.

Different varieties of the same crop showed measurable differences in their water requirements. Determinations made under field conditions agreed very well with the pot determinations. A comparison of the results with wheat and sorghum grown at Akron, Colorado, and Amarillo and Dalhart, Texas, showed that while evaporation in Texas was 18 per cent higher than in Colorado, sorghum had the same water requirement, while wheat required 36 per cent more water in Texas than in Colorado. L. J. B. and H. L. S.

PLANT PHYSIOLOGY.—*The water requirement of plants. II. A review of the literature.* L. J. Briggs and H. L. Shantz. Bureau of Plant Industry, Bulletin 285, 1913.

This paper reviews the literature relating to the water requirement of plants. In summarizing the papers the data are presented in tabular form and arranged with respect to the subject considered, such as the effect of soil moisture content, type of soil, amount of soil used, fertilizers, temperature, light, humidity, carbon dioxide content of the air, relative leaf area, duration and period of growth on the water requirement, as well as the water requirement of different plants when grown under comparable conditions. L. J. B. and H. L. S.

REFERENCES

TECHNOLOGY.—*Recent papers of the Bureau of Standards:*

The dehydration of clays. G. H. Brown and E. T. Montgomery. Pp. 23. 1913.

The effect of overfiring upon the structure of clays. A. V. Bleininger and E. T. Montgomery. Pp. 23. 1913.

The technical control of the colloidal matter of clays. H. E. Ashley. Pp. 118. 1913.

The determination of phosphorus in steels containing vanadium. J. R. Cain and F. H. Tucker. Pp. 11. 1913.

Electrolytic corrosion of iron in soils. Burton McCollum and K. H. Logan. 1913.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 273d meeting of the Society was held in the Cosmos Club on October 29, 1913.

REGULAR PROGRAM

Physiography of the Southern Andes (illustrated.): BAILEY WILLIS. No abstract.

Use of physiography in the study of Rocky Mountain stratigraphy: W. T. LEE. Reasons are here presented for abandoning the belief that extensive land masses persisted in the southern Rocky Mountain region thruout the Cretaceous period. Radical differences of opinion exist as to the significance of certain continental deposits that rest unconformably on the Cretaceous rocks in the southern Rocky Mountain region. In many places on either side of the mountains the base of these continental deposits is conglomeratic and contains pebbles of older rocks, mainly the pre-Cambrian crystallines which constitute the core of the range. Those who believe that this conglomerate marks an unconformity of considerable magnitude appeal to the evidence of these pebbles as proof of a long interval of erosion following a notable upheaval of the mountains. Others who doubt the magnitude of the unconformity are of the opinion that the pebbles may have been derived from nearby lands that had not been previously submerged, and argue that they might have found their way to their present resting place without any notable upheaval or long interval of erosion. It seems necessary, therefore, to inquire whether the evidence warrants the belief that any considerable part of the southern Rocky Mountain region remained above sea-level thruout Cretaceous time or whether the Cretaceous sea extended uninterruptedly over this region. The determination of this question would materially aid in the solution of the problem whether the unconformity in the southern Rocky Mountain region marking the separation of the conformable Cretaceous beds, mainly of marine origin, from the lowest conglomerate of the younger rocks of continental origin, denotes an orogenic movement and erosion of sufficient magnitude to make it the appropriate line of separation between the Cretaceous and the Tertiary systems.

It seems evident that no notable crustal movement affected the southern Rocky Mountain region for a long time prior to the beginning of the Upper Cretaceous period, and that there was ample time for the formation of a peneplain over this region.

The distribution of the Dakota sandstone about the present mountains and its attitude toward them; its presence within the mountains at great altitudes; and its relation to the older formations seem to prove that the Dakota sandstone extended practically continuously over the present mountain region.

The distribution of the marine sediments of Colorado age, that lie on the Dakota sandstone, is essentially the same as that of the Dakota, that is, they occur on both sides of the mountains and at numerous places within the mountain region and their lithologic character is not such as to indicate that they were derived from the present mountain area rather than from the continental land masses that existed both east and west of the interior Cretaceous sea. Their presence near Breckenridge, Colorado at an altitude of 13,4000 feet, and in many other places at nearly as great altitudes, proves that these places at least were below sea-level in Colorado time, and an inspection of their distribution leaves little room for doubt that they were deposited continuously over the mountain region.

The sedimentary rocks of Montana age in the Rocky Mountain region are more variable than those of Colorado age, but their general lithologic character does not seem to harmonize with the postulate that any considerable part of them was derived from the present mountain area. In general, the marine shale formations thicken toward the present mountains while the sandstone formations thicken away from the mountains. In brief, the Upper Cretaceous formations behave as if no Rocky Mountains existed when they were laid down.

If the Rocky Mountain region was covered with Cretaceous sediments, it follows that this region must have been uplifted and the older rocks exposed to erosion before the conglomerate, consisting of pebbles of these older rocks, could have been formed.

The 274th meeting of the Society was held in the Cosmos Club on November 12, 1913.

Under informal communications Mr. Edson S. Bastin discussed the origin of the titaniferous iron ore at Caribou, Colorado. These ores occur within small, irregular bodies of gabbro which in turn lie within a large stock of monzonite. There is clear field evidence that both gabbro and iron ores are magmatic differentiations from the monzonite magma. The differentiation has proceeded along two lines leading to the formation within the same gabbro mass of (1) iron ores composed essentially of augite, magnetite and spinel, and (2) ores much richer in magnesia composed of olivine and magnetite. The chemical changes during differentiation were shown by plotting a number of analyses of these rocks and ores in diagrammatic form.

REGULAR PROGRAM

The change of optical and crystallographic properties of quartz with temperature. F. E. Wright. This paper is published in full in Jour. Wash. Acad. Sciences, **3**, 485. 1913.

Evidence of the inorganic origin of petroleum: C. W. WASHBURNE. No abstract.

Resins in Paleozoic Coals: DAVID WHITE. The discoveries by European paleobotanists of supposed secretory cells and canals in petrified woods of Paleozoic age, were reviewed, and in the light of data afforded by certain American coals of low bituminous rank, interpreted as probably resin-bearing for the most part. This conclusion rests on the examination of the canal casts found in certain carbonized woods in the bituminous coals of the interior basins; on the observation of lumps of exudate resins in Paleozoic coals of Iowa, Illinois and Indiana, and, in particular on the physical and chemical characters of the canal fillings found in carbonized petioles in the upper part of the Quadrant quartzite of Montana all of which indicate that these secretions are resinous, and that, accordingly, some of the Paleozoic woods found petrified were resin-bearing. It appears that the resin contributions of the Paleozoic plants were perhaps as large as those furnished by the coal-forming floras of the Cretaceous and Tertiary.

Studies in a number of western coal fields of the occurrence of resins, which are always present and often conspicuous in the lower rank coals of the Cretaceous and Tertiary, show that when, as the result of regional metamorphism,.these coals are brought to a low bituminous rank the effects of pressure metamorphism are found in physical changes as well as in probable chemical changes in the resin lumps; also that during the alteration indicated by the passage from about 58 per cent to 68 per cent fixed carbon (pure coal basis) the resin lumps have become crackled, changed to a dark brown, to a brownish black and, successively, to a black carbonaceous granular powder. The process seems, in effect, to be a devolatilization (carbonization) of the resin lumps. So far as known no resin lumps are present in coals characterized by so high a percentage of carbon (pure coal basis) as 68.

The deadening of the cannel coals found in association with high rank coals, such as semi-bituminous and anthracite, is thought to be due to the reduction of the waxy and resinous substances characteristic of the cannel group of coals. As causally related to this phenomenon attention was called to the fact that, so far as observed by the speaker, no commercial oil field has yet been found in any part of the earth in regions where the coals of the formations that contain or overlie the oil sands have been brought to a carbonization represented by 70 per cent or more, the inference being that the distillation of the organic matter has gone so far as to devolatilize or drive off the petroleum in the formations of these regions.

The 275th meeting of the Society was held in the Cosmos Club on November 26, 1913.

REGULAR PROGRAM

Quaternary History of the Mount St. Elias Region, Alaska: A. G. MADDREN. The southern slopes of the Mount St. Elias region front on the Pacific Ocean with a rather regular coast line that is in marked physiographic contrast with the deeply-fiorded coast line of the southeastern Alaska and Prince William Sound regions on either side of it. This contrast is further accentuated by the much higher relief and rejuvenated recent glaciation of Alpine type, so strongly developed in the extensive area dominated by the great mountain masses of St. Elias and Logan, whose heights are about 18,000 and 19,500 feet respectively. The physiographic evidence clearly indicates that the Mount St. Elias province has not passed thru the same episodes of Quaternary development as have the deeply fiorded provinces which characterize the remainder of the Pacific continental shores of Alska to the southeast and southwest of its central part. The geologic evidence in this regard appears to prove that the relief of the Mount St. Elias region has been profoundly rejuvenated in late Pleistocene time, and to indicate the strong probability that this deformational uplift has continued thruout Recent up to present time. This evidence is in the form of a stratified marine coastwise terrane, from 4000 to 5000 feet thick where well developed, which is quite fossiliferous to the westward in the Yakataga district and in the Chaix Hills, where it is not altered by deformation as it is about Yakutat Bay and eastward. This terrane comprises one or more thick marine shale members that are remarkable from the fact that they contain quantities of ice-borne and glaciated bowlders and cobbles of a great variety of metamorphic rocks in unassorted arrangement. Blocks of these 5 to 10 feet in diameter are common in the shale matrix and give a most distinctive lithologic character to the terrane thruout its distribution, which enables it to be recognized where the shales are too much mashed to yield fossil remains. The fossils appear to be of early Pleistocene age. The whole terrane has been uplifted and deformed, so that it now stands at elevations from 3000 to 6000 feet above present sea level and forms the foothill mountains along the south flank of the St. Elias range.

The Cretaceous-Eocene contact in the Atlantic and Gulf Coastal Plain. L. W. Stephenson. The Cretaceous deposits of the Atlantic and Gulf Coastal Plain are separated from the overlying Eocene and younger formations by an unconformity of regional extent. Several authors, including Harris, Vaughan, Hill and Vaughan, and Dall, have stated some of the important facts in regard to the differences exhibited by the faunas on either side of the contact, but the magnitude of these differences has not been sufficiently recognized by geologists.

During the time represented by the unconformity separating the Cretaceous and Eocene strata some very important changes took place in the molluscan life of the area. A preliminary study of the mollusks of the upper part of the Cretaceous (*Exogyra costata* zone) of the eastern Gulf region, where the hiatus is as narrow as it is anywhere in the Atlantic and Gulf Coastal Plain, has shown that of 168 identified species practically all became extinct before the Eocene Midway formation began to be deposited. These species represent 89 genera, of which at least 16 of the more common genera, including one whole order—the Ammonoidea—became extinct. These faunal differences are greater than those which transpired thru evolutionary development during the time of deposition of the Tombigbee sand and the overlying Selma chalk and its non-chalky equivalents, or in terms of the Western Interior section, approximately during the time required for the deposition of the Niobrara formation and the Montana group.

Harris and Vaughn have both published statements to the effect that there is a great break, both stratigraphic and faunal, between the Cretaceous and the Eocene, as evidenced by the fact that not a single species is known certainly to have crossed from one system to the other. Vaughan characterized the differences as expressive of a complete faunal revolution. In his opinion the changed that took place in the marine life of the Atlantic and Gulf Coastal Plain during the time represented by the unconformity, are more striking than those that have taken place between earliest Midway time and the present, for no great orders that lived during Midway time, comparable to the Ammonoidea, have become extinct.

In the opinion of E. W. Berry, as expressed in a letter to the writer, the differences in the Cretaceous and Eocene floras of the eastern Gulf region are profound, and he believes that the unconformity represents a very long interval.

The hiatus marks a great diastrophic movement, as a result of which the shore lines were pushed far to the eastward and southward. The faunas were thus forced into new environments. Altho there is no evidence of marked climatic changes, unknown factors may have induced more rapid evolutionary changes in the marine life, but liberal allowance being made for a quickening of development, the hiatus must have been of great duration in order to produce the observed changes, even when measured in terms of geologic time. How much of that time should be classed as Cretaceous and how much as Tertiary cannot be determined with the available data. Cretaceous time, however, did not end with the deposition of the uppermost Cretaceous strata as preserved, neither did Eocene time begin with the deposition of the lowermost Eocene strata, but the lines separating the two periods probably lies somewhere toward the middle of the hiatus.

The contact metamorphic copper deposits at Mackay, Idaho. J. B. Umpleby. The contact metamorphic copper deposits at Mackay, Idaho, are of particular interest because they represent the replacement of engulfed blocks of limestone after the solidification and jointing of the porphyry inclosing them. Eight of these engulfed blocks and several shoots of garnet-diopside rock, clearly of limestone derivation, crop out in an area of about one square mile. The most complete metamorphism is of blocks along a pronounced fault, but metamorphism is locally intense where only normal jointing of the porphyry was observed.

Both exomorphism and endomorphism are clearly recorded. The former changed the blue limestone of White Knob into white marble thruout a mass one square mile in area and 1000 feet thick. It also caused a conspicuous marmorization of the engulfed blocks of limestone. Here a broken zone of garnet-diopside rock is external to the marble zone. On White Knob lime-silicate rock is not abundant, but in one place it comprises a vein 3 to 5 feet wide which cuts across the marble beds.

The garnetization of the porphyry is clearly shown at several places in the mine. In one specimen garnet replaces the granite-porphyry along joints and in another as a wave advancing into unfractured but permeable material. In places ore bodies cut directly across the limestone-granite-porphyry contact. Elsewhere garnet-chalcopyrite ore, in bunches of minable size, occurs at the intersection of joints well out in the granite-porphyry.

These features are believed to indicate: (1) that the garnetization took place after the solidification and fracturing of the inclosing porphyry, and (2) that, because the limestone blocks were entirely surrounded by rigid porphyry at the time of metamorphism, the silica, alumina, and iron of the silicate rock could not have been concentrated from the limestone, but must have been supplied by deeper unconsolidated portions of the batholith.

Adolph Knopf, *Acting Secretary.*

THE CHEMICAL SOCIETY

The 231st meeting was held at the Cosmos Club on November 25, 1913. Dr. P. A. Levene, of the Rockefeller Institute of Medical Research of New York City spoke on *The chemistry of the nucleic acids.* He told the story of his own initiation into the study of the chemistry of living tissue, and sketched the early history of the researches on the nucleic acids of protein. It was early established that the molecule of one of the more complicated of these acids contains two purin bases, two pyrimidine bases, phosphoric acid, and a carbohydrate. The German investigators directed attention to a simpler acid, inosinic acid, the study of which was taken up by Dr. Levene and his co-workers, with gratifying success. This acid contains hypoxanthin, phosphoric acid and a new pentose sugar, ribose. Further studies showed the relations of these groups in the compound. The successive details by which the structure of the other analogous acids was worked out, both as to the main groups and the structures within the groups, cannot be given in a brief abstract, altho of the greatest interest even to those comparatively uniformed in this complex branch of organic chemistry.

Discussion. Acree pointed out that the work of Dr. Levene has cleared up the configuration of the pentoses, and emphasized the ultimate practical importance of these researches. Seidell inquired as to the synthesis of these compounds; Dr. Levene stated that most such efforts have been unsuccessful; furthermore, that their analysis is more important at present than their synthesis. Schreiner gave an appreciation of these researches from the standpoint of the student who wishes to get at the composition of the compounds commonly produced in nature, as against those devised by man. Berg inquired as to the molecular weight of the nucleic acids; the simplest has been shown to be probably twice the structural formula. Voegtlin spoke of the application of enzymes in analyzing the acids into their component groups. In reply to questions by Johnston, Acree, Chesnut and others the following points were brought out: There is no evidence that there is more than one animal nucleic acid and one plant acid of the polynucleitide structure, tho there are several mono-nucleitides. The origin of the sugar groups is not known; experimentally, the breaking up of the hexoses by enzymes always leads to two 3-carbon chains, never to a pentose. The animal acid contains a hexose, whose structure is not yet known. A living animal enzyme is necessary for the analysis of the animal acid, and the technique involves the skill of the surgeon as well as that of the chemist.

Robert B. Sosman, *Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 469th regular meeting of the Anthropological Society of Washington, was held November 25, 1913, in the National Museum.

Dr. Daniel Folkmar, who has charge of the report on "Mother Tongue" in the census, addressed the Society on *Some results of the first census of European races in the United States.* Statistics of the mother tongue, or native language, of the "foreign white stock" of the United States are presented in the report soon to be issued by the Bureau of the Census. It was prepared under the supervision of the chief statistician for population, assisted by the speaker as expert special agent. There are presented, for the first time in the census, figures directly relating to the ethnic composition of the white population of the United States, in so far as that is indicated by the native language. This term is taken to mean the language of customary speech in the homes of the immigrants before immigration.

One of the most interesting facts disclosed in this report is the great numerical preponderance, which is still held by the mother tongues of northwestern Europe as a whole, notwithstanding the high rank numerically which has been gained by a few individual mother tongues from eastern and southern Europe—especially the Italian, Polish, and Yiddish. These three now stand third, fourth, and fifth in rank. The English mother tongue is by all odds the one most largely represented in the foreign white stock of the United States. The number, 10,037,420, is considerably greater than that of the German mother tongue, which latter, contributes more than one-fourth (27.3 per cent) of the total foreign white stock of the United States, as reported in 1910. Italian, Polish, and Yiddish come next in rank, but none of them number as much as one-fourth of the German. To these three mother tongues, intermediate in rank but considerable in number, may be added the Swedish, French, and Norwegian, all belonging to northwestern Europe, except a portion of the French. No other mother tongue than the eight thus far enumerated furnishes as much as 2 per cent of the total of the foreign white stock of the United States, or numbers as much as

1,000,000. The eight major mother-tongue stocks already named account for 87.5 per cent of the total foreign white stock.

How small a factor the "new" immigration from southern and eastern Europe really is up to the present time, may be better shown by comparing it with the total white population of the United States. Taking as 100 per cent the total white population of the United States in 1910, numbering 81,731,957, the so-called "native stock" constitutes 60.5 per cent and the three great linguist families of foreign stock from northwestern Europe constitute 27.1 per cent, making a total of 87.6 per cent. The elements from southern and eastern Europe constitute, therefore, less than 13 per cent of the total. Of this the two principal Latin mother tongues—the French and the Italian—contribute less than 5 per cent, and the two principal Slavic mother tongues—the Polish and the Bohemian—and the Hebrew, taken together, contribute also less than 5 per cent, leaving to all the remaining mother tongues another 5 per cent or less of the total. Of the total foreign white stock of the United States, 32,243,382, there are 8,817,271 persons who are of German stock when counted according to mother tongue, but a trifle under 8,500,000 (8,495,142) of German stock when counted by their country of origin, Germany.

Immigrants from Austria are far more Slavic than Germanic. Russian immigration is shown to be far more Hebrew (52.3 per cent) than Russian (2.5 per cent) or even Slavic. Immigration from Turkey in Europe is not so much Turkish as Greek and Bulgarian.

Both the first and the second generations of immigration from Russia show that over 0.50 per cent report Yiddish and Hebrew as their mother tongue.

The returns for "Yiddish and Hebrew" reflect ethnic composition less satisfactorily than the returns for other mother tongues. A part—how large a part there is no means of judging—of those whose ancestral language is Hebrew doubtless have reported German, English, Polish, or other mother tongues. Of the total number of Yiddish-speaking people 838,193 come from Russia, 144,484 from Austria-Hungary, 41,342 from Roumania, 14,409 from the United Kingdom and 7,910 from Germany.

The paper was discussed by Messrs. Stetson, Hough, and Farquhar and Mrs. James.

Daniel Folkmar, *Secretary*.

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METEOROLOGY.—*A return to normal atmospheric transparency.* H. H. Kimball. Weather Bureau.

Attention has already been invited in this *Journal*, **3**, 269, to the diminution in atmospheric transparency which was quite generally observed during the latter part of 1912, and which was attributed, in part at least, to the presence at high levels of great quantities of dust derived from the eruption of Katmai Volcano in Alaska, in June, 1912. It will doubless be recalled that the first violent eruption occurred on June 6, that the dust cloud was first observed at Madison, Wis., on June 8, at Mount Weather, Va., on June 10, at various points in Europe between June 20 and June 27, and at Bassour, Algeria, on June 19.

The purpose of the present paper is to present evidence derived from observations made at the Mount Weather Observatory, or under its supervision, relative to the gradual precipitation of this dust from the atmosphere.

Humphreys[1] has computed that dust particles of the size that are thrown to the greatest heights by the most violent volcanic eruptions require from one to three years to fall to the under surface of the isothermal layer. From this level they will quickly be carried to the surface of the earth by the processes of condensation and precipitation of atmospheric moisture. These computations seem to be in accord with the duration of the various optical phenomena that have been observed to follow volcanic eruptions.

[1] Bull. Mount Weather Obs., **6**, 11, 1913.

The following observations are available for a study of the gradual precipitation of dust from the atmosphere during the past year:

1. Measurements of the intensity of insolation, or the incoming solar radiation.
2. Measurements of the percentage of polarization of skylight.
3. Measurements of the solar and the anti-solar distances of the neutral points of Babinet and Arago, respectively.
4. Observations of the intensity and duration of twilight colors.

Solar radiation intensity measurements have been made at frequent intervals thruout the day at Mount Weather since the beginning of 1908. But few observations were obtained in 1910, and in the winter months previous to 1912–1913.

For comparative purposes I have summarized in Table 1 the observations made since May 1, 1912, with the sun at zenith distance 60°, which is the highest point reached by the sun in December at the latitude of Mount Weather. The monthly means of measurements made in the successive years are not strictly comparable, for the reason that since May, 1911, the attempt has been made to obtain measurements whenever the sun was unobscured by clouds, while previous to that time measurements were made on the best days only, and when there was a prospect of obtaining a series extending over at least two hours.

The ratios in column 6, Table 1, are the means of the quotients obtained by dividing the monthly means, given in columns 2 and 3, by the corresponding averages for the respective months, derived from observations obtained previous to June, 1912.[2] Similarly, the ratios in column 7, Table 1, are the means of the quotients obtained by dividing the monthly maxima, given in columns 4 and 5, by the corresponding average maxima for the respective months, derived from observations obtained previous to June, 1912.

After what has been said relative to the monthly means for consecutive years we might expect that the ratios given in column 7, which are derived from maximum radiation values, would be

[2] These observations will be found tabulated in Bull. Mount Weather Obs., **5**, 303–310, 1913.

larger than the ratios of column 6, which are derived from mean radiation values. Actually, however, the averages of columns 6 and 7 are practically in accord for 1912, omitting the ratios for May 1 to June 9, inclusive, while for 1913 the average of column 7 exceeds the average of column 6 by about 5 per cent.

TABLE 1

MONTHLY SUMMARY OF SOLAR RADIATION INTENSITIES WITH THE SUN AT ZENITH DISTANCE 60°. MOUNT WEATHER, VA.

MONTH	MEAN		MAXIMUM		RATIO CURRENT AVERAGE		MEAN RATIO
	a. m.	p. m.	a. m.	p. m.			
	Gram calories per min. per cm²				mean	max.	
1912							
May 1–June 9	1.08	1.01	1.25	1.26	1.06	1.15	1.10
June 10–30	0.90		1.05	1.01	0.86	0.86	0.86
July	0.83	0.88	0.93	0.93	0.86	0.77	0.81
August	0.77		0.86	0.75	0.73	0.70	0.71
September	0.89	0.94	1.05	0.97	0.80	0.81	0.81
October	1.03	0.97	1.22	1.24	0.81	0.91	0.86
November	1.14	1.12	1.24	1.17	0.90	0.88	0.89
December	1.26		1.33		0.97	1.01	0.99
1913							
January	1.21		1.29	1.24	0.90	0.93	0.92
February	1.15	1.13	1.27	1.24	0.91	0.94	0.93
March	1.04	1.05	1.16	1.16	0.85	0.94	0.89
April	0.97	0.88	1.18	1.11	0.79	0.95	0.87
May	0.90	0.82	1.06	0.96	0.87	0.92	0.90
June	0.90	0.93	1.15	1.09	0.89	0.93	0.91
July	0.88	0.87	1.06	1.04	0.88	0.86	0.87
August	0.91	1.04	1.03	1.16	0.93	0.96	0.95
September	1.11	1.06	1.26	1.20	0.95	0.99	0.97
October	1.18	1.12	1.30	1.24	0.87	0.94	0.91
November	1.19	1.17	1.32	1.33	0.94	0.97	0.96
December	1.31		1.42		1.01	1.08	1.04

The last column of Table 1 is simply the average of the two preceding columns. It is believed that it gives a close approximation to the monthly means of the relative intensity of solar radiation for the period under consideration, as compared with the intensity under normal conditions for the respective months. These relative intensities, together with intensities for Madison, Wis.,[3] obtained in a similar manner, are plotted in figure 1. The curve that best fits the data shows a rapid fall from above normal between May 1 and June 9, 1912, to 29 per cent below normal in August 1912, followed by a rapid rise during the autumn of 1912, and a slower rise in 1913 to normal values at the end of the year. So few radiation measurements have been obtained during winter months that the relative intensities computed for these months are of doubtful value. The intensities measured at Mount Weather on December 13, 1913, are as high as have ever been measured at this observatory with the sun below zenith distance 60°.

TABLE 2

TOTAL RADIATION RECEIVED ON A HORIZONTAL SURFACE FOR HOURS THAT WERE CLOUDLESS. RATIO $\frac{1912}{1913}$. MOUNT WEATHER, VA.

PERIOD	HOUR ANGLE FROM NOON 7-6 6-7	6-5 5-6	5-4 4-5	4-3 3-4	3-2 2-3	2-1 1-2	1-0 0-1
May 20–June 9	0.61	0.87	0.96	0.98	1.04		
June 10–July 31	1.04	1.00	1.05	1.02	0.94		
September 1–October 31			0.96	0.95	0.96	0.94	0.96

Measurements of the total radiation received on a horizontal surface from the sun and sky have been made at Mount Weather since May, 1912. A comparison of the results for 1912 and 1913 for hours when the sky was cloudless is given in Table 2. The results for August are omitted, as a different register was used in August, 1913 from that in operation during the other months.

There are not many hours during the summer, at Mount Weather, when the sky is free from clouds. It can therefore only be claimed that the data in Table 2 indicate that with a cloudless sky the total radiation received on a horizontal surface during September and October, 1912, was about 5 per cent less than that received during the same period in 1913, and that there was much less heat received diffusely from the sky between May 20 and June 9, 1912, than during the same period in 1913. This

[3] The observations for Madison, Wis., previous to July, 1912, will be found tabulated in Bull. Mount Weather, Obs., **5**, 177–181, 1912.

latter is indicated by the smallness of the ratios for early morning or late afternoon hours for the first period in Table 2. With low

TABLE 3

MONTHLY SUMMARY OF SKYLIGHT POLORIZATION IN THE SUN'S VERTICAL AND AT SOLAR DISTANCE 90°, WITH THE SUN AT ZENITH DISTANCE 60°. MOUNT WEATHER, VA.

	Percentage of polarization						Departure from average	
	1908	1909	1910	1911	1912	1913	1912	1913
January								
Mean	58		69			52		−12
Maximum	65		69			57		−10
February								
Mean	53		71			46		−16
Maximum	54		71			53		− 9
March								
Mean	57		67			44		−18
Maximum	61		69			50		−15
April								
Mean	62	62				42		−20
Maximum	64	62				49		−14
May								
Mean	58	64		48	54	41	− 2	−15
Maximum	61	65		56	65	50	+ 4	−11
June								
Mean	59			61	42	·44	−18	−16
Maximum	64			70	53	50	−14	−17
July								
Mean	62			55	39	44	−19	−14
Maximum	70			71	47	54	−23	−16
August								
Mean	61	56		59	32	49	−27	−10
Maximum	63	67		69	40	58	−26	− 8
September								
Mean	65	64		60	40	56	−23	− 7
Maximum	69	67		70	44	63	−25	− 6
October								
Mean	66	70		69	44	57	−24	− 4
Maximum	71	71		75	51	63	−21	− 9
November								
Mean	62				47	58	−15	− 4
Maximum	62				53	66	− 9	+ 4
December								
Mean	68				52	59	−16	− 6
Maximum	70				61	66	− 9	− 4

sun, the proportion of the radiation that is received diffusely from the sky is relatively great.

Skylight polarization is intimately connected with atmospheric transparency, since an increase in the primary diffusion is accompanied by an increase in the secondary scattering in the lower atmosphere. This increases the intensity of the horizontally or negatively polarized component of the light, and neutralizes to some extent the postive or vertical polarization of skylight. In Table 3 are summarized skylight polarization observations made

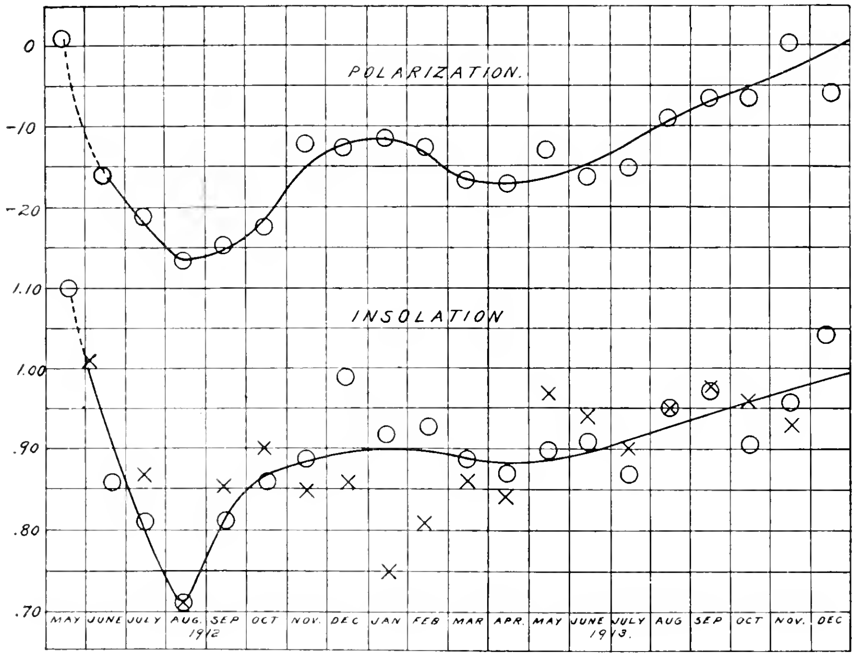

Fig. 1. Variations in solar radiation intensities and in the percentage of skylight polarization. Circles indicate data for Mount Weather, Va.; crosses, data for Madison, Wis.

at Mount Weather when the sky was free from clouds and there was no snow on the ground. In the last two columns are given the departures of the monthly values for 1912 and 1913 from the averages for the respective months derived from observations taken previous to June, 1912. These departures are plotted in figure 1, and their variations are in close accord with the variations in the relative intensity of solar radiation.

TABLE 4

ANTISOLAR DISTANCE OF ARAGO'S NEUTRAL POINT. MOUNT WEATHER, VA.

ALTITUDE OF SUN	DATE OF OBSERVATIONS				
	May, 1911–June, 1912	July 27, 1912	September, 1912–June, 1913	August–November, 1913	December, 1913
degrees	*degrees*	*degrees*	*degrees*	*degrees*	
+13.0			25.8		
12.0			26.1		
11.0			26.8		
10.0			26.7		
9.0			27.0		
8.0				23.7	
7.5			24.6	24.0	
7.0			25.3	23.4	
6.5			25.8	23.4	
6.0	19.7		25.8	23.4	
5.5	20.3		26.4	23.2	23.2
5.0	20.1		25.7	23.3	23.3
4.5	20.1		25.6	23.3	23.3
4.0	19.5		25.8	23.3	23.2
3.5	18.8		25.4	23.2	23.1
3.0	18.7		25.4	23.4	22.9
2.5	18.5		25.1	23.0	23.0
2.0	18.6		24.6	22.8	22.7
1.5	18.6	21.7	23.8	22.5	22.8
1.0	18.4	21.7	23.3	22.2	22.4
+0.5	18.3	19.8	22.2	21.7	22.0
±0.0	17.8	18.6	21.1	20.9	21.6
−0.5	17.8	16.5	19.5	20.2	21.5
−1.0	17.8	14.8	18.0	**19.4**	20.8
−1.5	17.0	14.5	17.0	19.5	**19.7**
−2.0	**16.3**	14.1	17.1	20.2	20.4
−2.5	16.3	13.7	17.0	20.7	20.8
−3.0	17.4	**13.6**	16.7	21.0	20.5
−3.5	17.5	13.8	**16.5**	20.9	21.1
−4.0		14.8	17.6	20.8	21.0
−4.5		15.5	18.7	20.8	21.2
−5.0		18.1	18.9	21.5	
−5.5			20.6	22.8	
−6.0				23.5	
−6.5				23.6	

During the early part of 1913, it was noticed that after sunset, as the lower atmosphere became less and less illuminated, the skylight polarization increased rapidly, sometimes by as much as 50 per cent, and to nearly the degree of polarization under normal conditions. This increase became noticeably less after the middle of August, 1913.[4]

The solar and the antisolar distances of the neutral points of Babinet and Arago, respectively, have varied in accordance with the variations in skylight polarization. This was to be expected, since these distances depend upon the relative intensities of the vertically and the horizontally polarized components of skylight.

Table 4 will serve to illustrate the movements of both the neutral points. It will be noticed that simultaniously with the increase in the diffusion of light by the dust in the upper atmosphere, there was an increase in the antisolar distance of Arago's neutral point with the sun above the horizon. With the sun below the horizon, however, the intensity of the primary-diffused light from the upper atmosphere, which was highly but not necessarily completely polarized, caused a decrease in the antisolar distance of this neutral point. The minimum distance was not only smaller, but it occurred with a lower sun than under normal conditions.

With the decrease in the intensity of the primary-diffused sunlight, in 1913, the antisolar distance of the neutral point gradually increased with the sun below the horizon, and the minimum distance occurred with a higher sun.

Jensen[5] has shown that there may be a relation between variations in the color of skylight and the positions of the neutral points.

At the present time the solar and the antisolar distances of the neutral points appear to be decreasing with the sun both above and below the horizon.

[4] Skylight polarization measurements made after sunset will be found tabulated in Bull. Mount Weather Observatory, **6**, 39, 1913.

[5] Jensen, Dr. Chr., Über die grosse atmospherisch-optische Störung von 1912, pp. 10–11 (Separatabdruck aus den Mitteilungen der Vereinigung von Freunden der Astronomie und kosmischen Physik).

The twilight colors are intensified by the presence of fine dust in the atmosphere, as was markedly the case after the eruption of Krakatoa Volcano in 1883. In another paper[6] I have presented evidence that during the fall of 1912 the red colors, especially, were unusually brilliant, and perhaps, also, of unusual duration. At the Mount Weather Observatory the brilliancy of the twilight colors has been the occasion of frequent remark during the past few months, and especially during September, October, and November. On some evenings the glow in the west has been distinguishable for nearly an hour and a half after sunset.

During the fall of 1912 a noticeable feature of twilights was the streaked appearance of the sky, as tho the dust or haze was arranged in horizontal layers. This has not been the case during the fall of 1913.

Notes relative to twilight colors made by Weather Bureau Observers at the various stations thruout the United States are rather inconclusive as to the intensity of these colors in 1913 as compared with their intensity in 1912. It seems evident, however, that while the maximum of intensity culminated in the month of November, in 1912, in 1913 the maximum was reached as early as September.

Summary. Pyrheliometric and polarimetric observations unite in indicating a gradual increase in atmospheric transparency since the marked minimum in August, 1912. This increase is probably due to the precipitation from the atmosphere of the dust that was introduced into high levels by the eruption of Katmai Volcano in June, 1912.

At the same time, the solar and the anti-solar distances of the neutral points of Babinet and Arago respectively, indicate that there may still be traces of this dust in the upper atmosphere.

The duration of the Katmai dust cloud appears to have been less than the duration (2 years) of the dust cloud that followed the eruptions of 1902–03, and markedly less than the duration (3 years) of the dust cloud that followed the eruption of Krakotoa in 1883.

[6] Monthly Weather Review, **41**, 153–159, 1913.

GEOLOGY.—*Sketch of the geologic history of the Florida coral reef tract and comparisons with other coral reef areas.*[1] THOMAS WAYLAND VAUGHAN, U. S. Geological Survey.

GEOLOGIC FORMATIONS OF SOUTHERN FLORIDA

The southern end of the mainland of Florida is underlain by two limestone formations, viz: the somewhat sandy, rather soft, light colored Miami oolite, and the more or less sandy, non-oolitic, dark or light Lostmans River limestone, which may be friable or indurated, and sometimes is crystalline. Four principal kinds of material are represented in the Florida keys. The surface of the keys north of Cape Florida is sandy. The most conspicuous constituent of the main keys from Soldiers Key to the southern end of Big Pine Key is the Key Largo limestone, an elevated coral reef rock. The prevalent rock from the Pine Keys westward to Boca Grande Key is the soft, non-arenaceous Key West oolite. The surface material of the Marquesas is largely composed of the detrital remains of calcareous algae probably overlying an oolitic foundation, while that of the Tortugas is largely coral detritus underlain by more consolidated limestone.

In order to indicate the relative importance of oolite and the elevated coral reef rock in the formation of the keys and nearby parts of the mainland, the following rough planimeter measurements are given: Miami oolite, area 1300 square miles; Key West oolite, area 370 square miles—oolite, total area 1670 square miles. Key Largo limestone, elevated coral reef, area 66 square miles. According to these measurements chemical precipitation of calcium carbonate with subsequent transformation into oolite has predominated over the constructive agency of corals in the ratio of roughly 25: 1, but, as undoubtedly the figures for the oolite are too small and those for the elevated coral reef are too large, 100 : 1 is probably nearer to the proper ratio. In this connection it will be stated that on Andros Island, Bahamas, the ratio of the constructive work of the present reef to that of the agencies that previously resulted in the formation of the Pleisto-

[1] Published by permission of the Director of the U. S. Geological Survey and of the President of the Carnegie Institution of Washington.

cene oolite, is approximately as 1 to several thousand, or, as a constructive agent, chemical precipitation has been several thousand times more effective in forming limestone than corals.

TOPOGRAPHIC RELATIONS OF THE FLORIDA BARRIER REEF

The living barrier reef of Florida extends as a broken chain from Fowey Rocks at the north to off Key West near Sand Key at its southwest end. Luxuriant reefs also occur around the Tortugas atoll. The principal reefs lie just within the 10-fathom curve and stand on the seaward margin of a platform. They are separated from the main line of keys by Hawk Channel, which has a maximum depth of about 7 fathoms, and the keys in their turn are separated from the mainland by a series of shallow bays and sounds. The platform on which the reefs stand extends around the entire coast of Florida. Northward of Fowey Rocks the reefs disappear but the platform continues. The platform also exists on the west side of the peninsula of Florida but bears no reefs. It is evident that the platform is independent of corals and that it owes its existence to agencies other than those dependent upon the presence of coral reefs.

BUILDING OF THE MARQUESAS AND THE TORTUGAS

There are two rival hypotheses for the formation of atolls, one of these attributes them to the submarine solution of the interior of a mass of limestone; the other accounts for them by constructional agencies. In order thoroly to test the solution hypothesis the results of four lines of invetigations were brought to bear upon it, and all are concordant. (1) All the bays, sounds, and lagoons within the Florida reef and key region are filling with sediment; (2) Drew's investigations of denitrifying bacteria show that chemical precipitation of calcium carbonate is taking place in the lagoons; (3) the chemical examination by R. B. Dole of samples of sea-water flowing into and out of the Tortugas lagoon, collected twice daily for a lunar period, show that altho both carbonate and bicarbonate radicles are in solution uncombined carbon dioxide is not present, and that the water possesses no capacity for further solution of calcium carbonate by virtue of its content of free carbon dioxide; (4) the determinations by Dole of the salinity of the water within the Tortugas lagoon and at the southern end of Biscayne Bay show a higher concentration than that in the open sea-water on the outside, indicating that tidal inflow and outflow are not sufficient completely to mix the water in the lagoons with the water of the surrounding sea and that concentration by evaporation is taking place. As the results of these lines of inquiry are so positive, the formation of lagoons by submarine solution may be definitely eliminated from consideration.

Of the constructional agencies to which the rims of atolls might be attributed attention was directed to the effects of winds and currents. It is a matter of common knowledge that if a current impinges against an obstruction lying across its course it divides, a part swerves to each side and incurves on the back of the obstruction, with the result that crescentic accumulations are built whenever the moving medium deposits material. It is also well known that the form of a deposit from a current moving in a straight line is correspondingly rectilinear. Current-shaped crescentic keys and crescentic sand dunes are familiar phenomena; as also are linear ridges formed either of water-borne sediment or of wind-driven sand. Good instances of crescentic keys and a mud atoll (Breton Island) are found off the mouth of Mississippi River.

As regards coral reefs, Hedley and Taylor have pointed out that, for the Great Barrier Reef of Australia:

> The growth of an individual reef is shown to proceed in a regular cycle. If the reef reaches the surface with its axis along the wind, then its shape endures; but if across the wind, then its extremities are produced backward, forming first a crescent, later a horseshoe, and lastly an oval, thus inclosing a lagoon.

There is a striking similarity in the configuration of the Marquesas and the Tortugas. There is an entrance to the lagoon of each in the southeast, southwest, and northeast quadrants; and the principal arc of the rim of each is from the southeast to the northwest entrance. The bow of this arc in each instance is against the prevailing direction of the wind, which is predominantly from the east, and against the direction of movement of the Florida counter-current, while its northern limb in each instance trails with these currents. As many details of the Marquesas and the Tortugas can not be considered in this summary, the conclusion will at once be expressed that the atoll rims of both the Marquesas and the Tortugas are constructional phenomena and owe their configuration to the prevailing winds and currents. The detrital material on which these agencies have worked in the Marquesas is mostly of other than coral origin; while in the Tortugas, altho of complex composition, it consists largely of coral débris.

The Marquesas rim is geologically Recent, and evidently required no change of sea level for its formation. As the surficial material of the Tortugas rests upon an older, harder, calcareous basement, it appears that the Tortugas atoll with its inclosed lagoon was outlined during a previous physiographic cycle. Further evidence, later to be adduced, renders it reasonably certain that the Tortugas were initially outlined during subsidence after uplift following the close of the Pliocene, that they were then elevated to an amount of perhaps 50 feet, that the last event has been one of subsidence back nearly to the same level as that preceding the elevation, and that the Recent corals have established themselves on an old atoll basement already prepared for them.

OSCILLATIONS OF THE FLORIDA REEF TRACT

A study of the Florida coast line shows that its last important movement was downward. This deduction is based on the existence of submerged channels and submarine fresh-water springs on the east coast, on the indented character of the coast line with accompanying submerged channels on the west coast, and on the presence of underground passages containing salt water and free openings or cavities that extend to a depth as great as 30 feet below sea level on the southern keys. The evidence is clear that the keys participated in the uplift and subsequent depression that affected the mainland, and that at one time they stood more than 30 feet higher with reference to sea level than they now do. This uplift and the subsequent depression, according to all available evidence, extended to the Tortugas.

The evidence presented shows that the platform on which the present barrier reef of Florida is growing has, geologically just antecedent to its present relation to sea level, stood 30 feet or more higher, and has been brought to its present position by depression.

The Pleistocene barrier reef, which is 105 feet thick according to the boring on Key Vaca, was formed during the period of subsidence which followed uplift at the close of Pliocene deposition.

SUMMARY OF THE GEOLOGIC HISTORY OF THE FLORIDA REEF TRACT

The geologic history of the Florida reef tract may be summarized as follows: During Pleistocene time along a curve from the eastern side of Biscayne Bay, first trending southward and then bending westward, a barrier coral reef flourished. This was separated by a channel from the main bank on which the Miami oolite was forming or had formed in strongly agitated waters. West of the coral reef, on an extensive flat in shallow water, the Key West oolite was forming, while still farther westward the Tortugas were outlined under the influence of winds and currents. This period of events was succeeded by elevation of the entire key region to probably 50 feet above its previous level. The last period of uplift was succeeded by one of depression, lowering the surface 30 feet or more and establishing practically the same relation of the sea level to land as now prevails. Subsequent to the beginning of this depression the present barrier reef has developed seaward of the keys on a platform already prepared for it, the Marquesas have been formed by winds and currents, and coral reefs have again established themselves in the Tortugas.

COMPARISONS OF THE FLORIDA REEF TRACT WITH THOSE OF ANDROS ISLAND, BAHAMAS, CUBA AND AUSTRALIA

Hayes, Vaughan, and Spencer showed in 1902, as is evidenced by the pouch-shaped harbors of the Cuban coast and by the submerged filled channels, such as the one in Havana harbor, that the last movement of the Cuban coast was downward. Therefore, the platform on which the Cuban reefs occur has been brought to its present position by subsidence. The barrier reef of Andros Island, Bahamas, also occupies the outer edge of a depressed platform.

It has been shown by the Australians, Andrews, Hedley and Taylor, and David, that the platform of the Great Barrier Reef of Australia has been brought to its present position thru subsidence apparently associated with extensive faulting along the eastern Queensland coast. Therefore the Floridian, Cuban, Bahaman, and Australian barrier reefs all have a similar relation to change of sea level, as in each instance the platforms on which they occur have been brought to their present position thru subsidence.

There is one important difference between the relations of the Recent barrier reefs of Florida and Andros Island, Bahamas, and those of Cuba. The oscillations of the strand line in Florida and Andros Island have taken place without appreciable differential crustal movement, while in Cuba there was notable deformation antecedent to the last depression. The Pleistocene terraces rise in height toward the eastern end of Cuba in Oriente Province where altitudes of about 600 feet are attained near Cape Maisí. The terraces decline in height toward the west, and west of the longitude of Manzanillo there is a slope from the north to the south coast. In Barbados Pleistocene reefs extend to 1000 feet in elevation.

COMPARISON OF WEST INDIAN WITH CENTRAL PACIFIC REEFS

Alexander Agassiz discovered that in the Paumotuan atolls the Recent corals were growing as a thin crust on an older limestone foundation. His explanation of the formation of the atolls by the destruction of the interior of a limestone mass must be discarded. As there was evidently a period of atoll formation in the Paumotus previous to the establishment of the Recent corals the conditions there simulate those in the Tortugas, Florida. A great developnent of Pleistocene and perhaps late Tertiary coral reefs in the tropical Pacific has been proven in the most convincing manner, and there is abundant evidence of differential crustal movement in the tropical Pacific in Pleistocene time similar to that indicated for the West Indies. E. C. Andrews and C. Elschner have both described warping and tilting, the former for the Fijis, the latter for the Pacific more or less in general. Agassiz described an elevated atoll Makatea, in the Paumotus; and Andrews has given a detailed description of the elevated atoll of Mango, Fijis. Because of the differential nature of the earth movements, in certain places old atolls have been uplifted to heights as great as 230 feet in Makatea, and 600 feet in Tuvuthá, Fijis; while other old atolls, such as Rangiroa and others in the Paumotus, now stand at or near sea level. In other areas there has been depression, Bora Bora for instance, as Dana, P. Marshall, and more recently W. M. Davis, have shown. Systematic, detailed studies of the relations of the Recent to the older reefs, with special reference to oscillation of sea level and differential crustal movement in Pleistocene time, are among the desiderata in the investigation of coral reefs.

BARRIER REEF PLATFORMS

It has already been stated that the existence of the platform on which the Recent barrier reef of Florida stands is independent of the reefs, as it is continuous irrespective of the geographic limits of the reefs. A similar statement may be made regarding the Bahamas and Cuba, where in each instance the platform is independent of the reefs which merely grow upon its surface where conditions are favorable for the life of corals. E. C. Andrews in 1902 remarked regarding the platform of the Great Barrier Reef of Australia that "the continuance in width of the shelf southwards of the limits of reefs (coralline), and the great shoals thereon, points to a minor part only of the shelf being formed of coral growth." An inspection of the Admiralty charts for the eastern coast of Australia shows conclusively that the platform on which the Great Barrier Reef of Australia stands has an existence independent of the Great Barrier Reef, and that corals have established themselves on this platform where the conditions favorable for their life are realized.

An examination of the barrier reef platforms of Florida, Andros Island, Bahamas, Cuba, and Australia, all lead to the same conclusion, viz: (1) The platforms have an existence independent of coral reefs and were formed by other than coral reef agencies; (2) the reefs exist only on those portions of the platforms where the conditions requisite for the life of reef corals prevail.

In this connection attention is especially directed to the persistence along the margin of continental plateaus of a rapid declivity from about the 30-fathom curve to the 50-fathom curve as compared with the usually gentler slope from the shore to between 30 and 40 fathoms. This relation is well exhibited along both the Australian and the North American platforms.

Having presented criteria for recognizing the relations of continental and large insular platforms supporting barrier reefs to the presence of the reefs, islands such as those in the Society and Fiji groups may be considered. Daly in 1910 pointed out that the depth of the drowned valleys in these groups "appears never to exceed 45 fathoms." The maximum depth according to his compilation is from 19 (Raiatea) to 41 fathoms (Murea), both members of the Society group. There is wonderful accordance between the maximum depths within the barriers of the Pacific Islands and the depths on the Australian continental shelf both within and without the Great Barrier Reef region. A study of the charts of barrier reef islands, as Viti Levu, Fijis, and Tahiti, Society Island, shows that the platforms are independent of the presence of reefs, and therefore the relations in these islands are similar to those indicated for barriers off continental shores, for here the reefs are also superimposed on platforms antedating their presence. The problem of the depth of barrier platforms is a world-wide one for it is only an aspect of the general problem of the history of continental shelves.

ATOLLS

The atolls previously discussed in this paper occur on platforms, rise from comparatively shallow depths, and owe their shapes to winds and currents. The atolls that margin flat summits of eminences rising from oceanic depth must be attributed to somewhat different causes. The greater abundance and luxuriance of reef-forming organisms on the peripheries of atolls are due mostly, if not solely, to the intolerance of such organisms to sediment. Certain of my experiments show conclusively that, if the colonies are protected from sediment, the growth of corals within a lagoon may exceed that of corals on the outside. The possibilities of a basement attaining the proper depth, where the other necessary vital conditions prevail, are numerous and need not here be recapitulated.

As bearing on the relative stability of one so-called coral island, it will be stated that Dr. Jos. A. Cushman has found *Nummulites* in the borings from the Bermuda deep well at depths from 131 to 193 feet, or, expressed in fathoms, from 22 to 32 fathoms below sea level. As these fossils indicate either a lower Oligocene or an upper Eocene age for that part of the bore, it is evident that crustal changes in the Bermudas since that time have been slight. Relative crustal stability for the Paumotus has been indicated. Daly's compilation of the depth of atoll lagoons is most significant, as it shows accordance in depth with the lagoons of barrier islands. Whether or no his hypothesis of the rise of sea level to an amount of about 30 fathoms in the tropics, due to the disappearance of glaciers, be accepted, it at least is evident that great crustal subsidence for atoll areas is not indicated by the facts at present available.[2]

[2] This paper is an abstract of data and conclusions bearing on the coral reef problem from the following publications by the writer:

A contribution to the geologic history of the Floridian Plateau. Carnegie Institution of Washington, Publication 133, 99–185, 15 pls., December, 1910.

Remarks on the geology of the Bahama Islands and on the formation of the Floridian and Bahaman oolites (abstract). Jour. Washington Acad. Sci., **3**, 302, 303, May 19, 1913.

Preliminary remarks on the geology of the Bahamas, with special reference to the origin of the Bahaman and Floridian oolites. Carnegie Institution of Washington, Publication 182, 47–53, 1914 (in press).

The building of the Marquesas and Tortugas atolls, and a sketch of the geologic history of the Florida reef tract. Idem, 55–67, 1914 (in press).

To the abstract of discussions included in the papers cited are added a more general account of barrier reef platforms and some remarks on atoll rims that margin the flat summits of eminences rising from oceanic depths.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BOTANICAL SOCIETY OF WASHINGTON

The 92d regular meeting of the Botanical Society was held at the Powhatan Hotel on Tuesday evening, December 2, 1913, at which a dinner and special program were given in honor of the seventieth birthday of Dr. Edward Lee Greene.

Dr. C. L. Shear presided. Mr. John H. Parker was elected to membership. The program was as follows:

Personal experiences: FREDERICK V. COVILLE. Mr. Coville related incidents in connection with his first meeting with Dr. Greene at the Madison Botanical Congress in 1893, and expressed a high appreciation of his work, particularly of his *Landmarks of Botanical History.*

Berkeleyan days: V. K. CHESTNUT. Mr. Chestnut spoke of his student days at the University of California and of the inspiration received from Dr. Greene by his botanical students.

Botanical writings: A. S. HITCHCOCK. As a writer, Dr. Greene has been prolific. Besides numerous papers in various periodicals, such as the bulletins and the proceedings of the California Academy, *Botanical Gazette, Bulletin of the Torrey Club* and *Erythea,* he has published several books, notably *Flora Franciscana, Manual of the Botany of the Region of San Francisco Bay,* five volumes of *Pittonia* and two volumes of *Leaflets.*

The value of Dr. Greene's influence upon botanical thought does not rest solely upon the large number of new species he has described, but in that he has studied many groups of plants from Cruciferae to Compositae, from Viola, Rhus and Eschscholtzia to Boraginaceae and Polemoniaceae, has revised many genera, sections and groups, discussed relationships, and set on their feet, as it were, species and genera of early authors that had been relegated to oblivion by those that followed.

Reminiscences: IVAR TIDESTROM. Mr. Tidestrom gave a brief account of Dr. Greene's earlier work, particularly his early collecting and his work at Berkeley.

Rocky Mountain flora: Prof. AVEN NELSON. Dr. Greene's work in the Rocky Mountain states was reviewed briefly and special emphasis was laid on the influence of this work on that of the later botanists.

Response: Dr. GREENE. After expressing his appreciation of the honor accorded him by the Botanical Society, Dr. Greene related a few interesting incidents connected with his life, particularly his early trips of botanical exploration in the Southwest.

P. L. RICKER, *Corresponding Secretary.*

THE CHEMICAL SOCIETY

The 232d meeting was held at the Cosmos Club on December 11, 1913. Dr. M. X. Sullivan was nominated to represent the Society as a vice-president of the Washington Academy of Sciences. The president appointed A. B. Adams, J. A. Le Clerc, and R. C. Wells as an auditing committee to audit the accounts of the treasurer for the year.

The following papers were then read:

J. G. Fairchild, of the Bureau of Mines: First paper: *Electro-analysis of the copper alloys.* The methods described were planned in order to obtain more rapid results in analyzing brass, bronze, type metal and other copper alloys. The paper has been published in *Met. and Chem. Eng.*

Second paper: *The iodometric determination of iron.* This paper, like the preceding, gave details of procedure for a rapid commercial method.

Discussion: Andrews pointed out that the reaction used in the method for iron comes to an equilibrium, which can be displaced toward ferrous iron by extracting the iodine with a solvent such as carbon bisulfide.

W. D. Collins, of the Bureau of Chemistry: *Radioactivity of Virginia mineral waters.* The tests were made by boiling out the gases from the sample and observing their effect on an electroscope. Activities of from 110 down to 0.7, in terms of the 10^{-11} unit, were found. These are of the same order of magnitude as radioactive springs in other parts of the world.

Discussion: Ross called attention to investigations published in the french *Comptes Rendus* showing that certain Italian springs caused, rather than cured, certain diseases. He showed that quantities of radium emanation that can be taken without effect greatly exceed the amounts that can be obtained from any spring water. Custis stated that experiments show that repeated small doses of the emanation produce effects that cannot be obtained by single large doses. I. K. Phelps mentioned that practically all waters are radioactive, but Collins pointed out that the activity of sea-water, for instance, is only about 0.001 of that of the least active of the springs in question.

G. A. Menge, of the Hygienic Laboratory: *The Preparation of amino-nitriles.* The speaker described the methods for preparing nitriles, going from anhydrous hydrocyanic acid thru cyanhydrin by means of liquid ammonia, as the methods described in the literature did not give satisfactory results. Amino-aceto-nitrile and a number of other members of this series were prepared. The liquid ammonia method gives practically the theoretical yield.

G. B. Spencer, of the Bureau of Chemistry: *Goettingen.* The speaker first paid a tribute to Wallach, who has recently received the Nobel prize for his work on the terpenes. He then described the city and the university, and spoke in particular of the many important discoveries which the sciences of chemistry, physics, and mathematics owe to the men of Goettingen.

Robert B. Sosman, *Secretary.*

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GEODESY.—*Our Northern Boundaries.*[1] O. H. Tittmann. Coast and Geodetic Survey.

In accordance with the custom of this Academy, which prescribes a theme in which the retiring President is especially interested, I have chosen "Our Northern Boundaries."

It happens that your speaker has been engaged for the last ten years as Commissioner on the part of the United States, in cooperation with Dr. W. F. King, the British Commissioner, in the formidable task of delimiting the Alaska boundary and re-marking and establishing in precise manner the boundary from the Pacific Ocean to Lake Superior and from the St. Lawrence River to Grand Manan Channel.

It would lead too far afield in an address of this kind to enter into a detailed account of the complications and controversies which had to be settled by various commissions before the treaties negotiated by Secretaries of State John Hay and Elihu Root afforded the means and prescribed the method for finally fixing our northern boundaries. My purpose is to confine myself to a few illustrative references of their origin and in this connection I recall an incident which may serve to suggest the cause of many difficulties in boundary questions. While serving on the staff of General Foster, the American agent before the Alaskan Boundary Tribunal which convened in London in 1903, a banquet was given at which I was placed at a narrow table immediately oppo-

[1] Address of the retiring President of the Washington Academy of Sciences. Delivered before the Academy on Thursday evening, January 14, 1914, at the Cosmos Club.

site Lord Alverstone, Chief Justice of England, who presided over the Tribunal. In introduicng me to two gentlemen, between whom I sat, he explained that they had been associated with him in the consideration of various grave international boundary questions and that they had all come to the conclusion that maps were very unreliable evidence.

Having in mind that our contention before the Tribunal involved the use of maps, the obvious answer was that some maps were doubtless unreliable.

This difficulty of the unreliability of maps was encountered immediately after the signing of the Treaty of Peace of 1783, in regard to our northeastern boundary. For, that treaty carried the boundary down the middle of the St. Croix River to its mouth. This, in the light of our modern geography seems quite explicit, but after the lapse of eleven years it became necessary to appoint a commission to decide upon the identity of the St. Croix River. This identification was successfully accomplished under the Treaty of 1794. But how about the line from the mouth of the St. Croix thru Passamaquoddy Bay?

Its course was defined in the Treaty of Peace of 1783 to be such as to assign to the United States "all islands within 20 leagues of any part of the shores of the United States and lying between lines to be drawn due east from the points where the aforesaid boundaries between Nova Scotia on the one part and east Florida on the other shall respectively touch the Bay of Fundy and the Atlantic Ocean, excepting such islands as now are, or heretofore have been, within the limits of the said province of Nova Scotia."

This general provision was difficult of interpretation because both governments claimed some of the islands. Several treaties which failed of ratification were proposed. One of them contained an extraordinary provision which would have placed Campo Bello Island within the limits of the United States boundaries, but provided that it should remain under British jurisdiction.

Thus, there was no settlement of the disagreement of the two governments until the Treaty of Ghent in 1814, the beginning of the hundred years of peace which we are to celebrate in December of this year. Under that treaty Commissioners were appointed for the settlement of the dispute and altho they decided on the ownership of the principal islands, they were not required to lay down the line. Their decision rendered in 1817, may therefore be likened to a first approximation of the solution of the problem. Three-quarters of a century later, under the convention of 1892, Commissioners were again appointed and they marked a part of the line and disagreed as to the rest, principally because the nationality of a little islet, less than half an acre in extent, and lying in the course of the boundary, had not been specifically established by the Commissioners under the treaty of 1814. This was a second approximation. One hundred and eighteen years after the Treaty of Peace of 1783, it became possible to fix this part of the line by courses and distances and by reference to monuments on the ground and it may surprise you to know that the line from the mouth of the St. Croix to its headwaters has never been laid down on a chart, or marked on the ground, except in so far as the work of the present commission has progressed.

These complications in the settlement of the boundary thru Passamaquoddy Bay, briefly outlined in the foregoing, are typical of the process of the delimitation of the whole line.

In 1803 Jefferson, in his annual message to Congress, said that a further knowledge of the ground in the northeastern and northwestern angles of the United States had evidenced that the boundaries established by the Treaty of Paris between the British Territories and ours in those parts, were too imperfectly described to be susceptible of execution.

At one time a part of the northeastern boundary matter was submitted to the King of The Netherlands for arbitration, but his decision rendered in 1831 was rejected by both governments. A remarkable example of difficulties caused by unreliable maps or surveys is afforded by that portion of the line which forms the boundary between the State of New York and the Province of Quebec. As early as 1606, James I proclaimed the 45° parallel as the boundary between the Provinces of New York and Quebec, and between 1771 and 1774, two surveyors, Valentine and Collins, marked the boundary supposedly along the 45th parallel. When the Commissioners under the Treaty of Ghent attempted to trace the line along the 45th parallel, called for by the treaty, it was discovered that the 45th parallel was about three-quarters of a mile south of the Valentine-Collins line and that the United States had built a fort costing about a million dollars at Rouses Point, north of the 45th parallel and therefore under the treaty definition in British territory. This discovery was made in 1818 and caused a dispute which was settled by the Webster-Ashburton treaty of 1842 under which the Valentine-Collins line was adopted by a compromise in regard to other disputed parts of the boundary.

Here I may digress from my subject for a moment to interject the remark that the Commissioners under the Treaty of Ghent missed their opportunity of demonstrating the great practical value of one of the most useful and precise astronomical instruments, the Zenith telescope. For they were equipped with one, but failed to use it, because its verticality was dependent on a plummet. A similar instrument, which however was equipped with a level, was in the possession of the Coast Survey and this was transferred, "ceded" as Superintendent Hassler said, to Lieut. Talcott for the purpose of another boundary survey in 1833 and to him fell the distinction of developing and applying the method of determining latitudes with the Zenith telescope.

We may resume the story of treaties based on incorrect maps, at the northwestern angle of the Lake of the Woods. The Treaty of 1783 provided that the boundary should run from the northwesternmost point of the Lake of the Woods, on a due west course to the Mississippi. A glance at the map will show the impossibility of such a line and the fact was recognized in the Treaty of 1794 by the admission that the course and location of the Mississippi was uncertain and, in the Treaty of 1818, it was provided that if the northwesternmost point of the Lake of the Woods was not on the 49th parallel, a line should be drawn north or south to the 49th and the boundary should run from their intersection due west to the Stony Mountains. By the time of the Webster-Ashburton Treaty in 1842 it was known that the northwesternmost point of the Lake of the Woods was north of the 49th parallel and the description of the boundary was accordingly modified.

In this cursory account we have now reached the summit of the Rocky Mountains. The controversies connected with the Oregon question were formally settled by the Treaty of 1846 which defined the boundary from the summit to the Pacific Ocean.

That portion of the boundary which was described as running to the middle of the channel which separates the continent from Vancouver's Island and thence southerly thru the middle of said channel and of Fuca's Straits to the Pacific Ocean gave rise to a serious and prolonged controversy as to which channel was meant, a controversy in which insufficient charts played but a minor part, but which would have been avoided if the treaty makers had laid down the line concurrently with the making of the Treaty. This dispute was submitted to the German Emperor who decided in favor of the United States by the award of October, 1872.

A review of the condition of the demarcation of the northern boundary when Secretaries Hay and Root undertook to perfect it, discloses that from Grand Manan Channel to the headwaters of the St. Croix, a distance of 110 miles, the boundary had not been marked on any series of maps nor had reference monuments been placed on the ground.

From the headwaters of the St. Croix to the River St. John it was monumented. Thru the St. John and to the headwaters of the St. Francis it was marked on treaty maps. Thence to the St. Lawrence it was monumented and laid down on maps.

Thru the Great Lakes and thru the water communication, to the northwestern angle of the Lake of the Woods, a distance of 1500 miles it was unmarked, but was laid down on inaccurate maps and therefore impossible of definition on the ground by either government acting for itself.

It was marked at intervals from the Lake of the Woods to the Gulf of Georgia, but in the region between the summit of the Rocky Mountains and the Gulf of Georgia, a distance of 410 miles, about 220 miles had never been surveyed, traced or monumented. From Point Roberts on the Gulf of Georgia to the Pacific Ocean it was laid down on a chart, but had never been referred to objects on shore or defined with such accuracy that it could be reproduced without question. This condition was giving rise to international questions on different parts of the boundary.

In connection with the re-marking of the boundary from the summit of the Rocky Mountains westward, it developed that no trace could be found of the report of the American Commissioners on the delimitation of the boundary between 1856 and 1869. By a singular coincidence and fatality no trace could be found by the British Government of the records of its Commissioner, altho copies of the maps were on file in both countries. The circumstances connected with the discovery of the British records have perhaps never been published and may be here recorded. Pending the consideration of the marking and re-marking of the line the Dominion Government despatched Dr. Otto Klotz, a Canadian astronomer, to London to make another attempt at their recovery. He searched the archives of the Foreign Office and War Department, but in vain. While on a visit to the observatory at Greenwich, he happened to note a box on one of the upper shelves with the letters "B.N.A." inscribed on it. He interpreted them to mean British North America and their possible significance flashed thru his mind. He asked what the box contained. No one knew. A ladder was sent for and the box opened and the records were found.

The relevant and important parts were printed for the use of the Canadian Government. A copy was furnished to this government. This happy find by Dr. Klotz doubtless prevented complications which might otherwise have arisen as to the details of the boundary and obviated the necessity of a new treaty or of special provisions in the general treaty already referred to in the beginning of my address as having been negotiated by Secretary Root. Under this Treaty of 1908, the task of marking and re-marking the boundary was assigned to two Commissioners. The definition of the line through the Great Lakes was assigned to the existing International Waterways Commission and extends through a distance of about 1200 miles.

The survey and re-marking of the remainder of the distance, about 2500 miles, that is from the Pacific Ocean to Lake Superior and from the St. Lawrence to the Grand Manan Channel, was entrusted to the Superintendent of the Coast and Geodetic Survey, representing the American Government and Dr. W. F. King, Chief Astronomer of the Dominion of Canada, representing the British Government.

To avoid wearying you with details, I have placed against the wall a map which will convey to your eyes the progress made. It indicates that a careful trigonometric and topographic survey has been made of the greater part of the line and that comparatively little of the field work remains to be done on the boundary under consideration. The labors of the International Waterways Commission, it is understood, are also drawing to a conclusion and thus we shall soon have a thoroly marked boundary and be in possession of accurate maps and a precise definition of the whole line as the result of processes based on sound engineering principles.

THE ALASKA BOUNDARY

Included in my subject is the delimitation of the Alaskan frontier, but this chapter I shall treat very briefly, as the circumstances connected with it are fresh in your memories.

The Alaskan boundary naturally divides itself into two sections. The first is the 141st meridian of west longitude and runs from the Arctic Ocean to a point about 10 marine leagues from the coast, a distance of 645 miles. About this stretch there never was any dispute, but it was deemed best to prescribe by a treaty, signed at Washington in 1906, the manner of ascertaining the location of the 141st meridian and of tracing the line.

Our knowledge of geodesy makes it evident that if in a stretch of 600 miles various points should be determined astronomically on the 141st meridian, the resulting line would be a zigzag, following the intersection of the verticals with the ground, that is, the meridian would not lie within the plane of one geometric great circle.

The Commissioners were therefore directed to determine the 141st meridian by telegraphic longitude at a suitable point thru which they were to trace a north and south line. This point having been established at the crossing of the meridian and the Yukon River, a zealous, able and energetic corps of engineers cut a line thru the timber from Mount Natazhat on the south, to the Arctic Ocean, monumented it and made a careful trigonometric and topographic survey, extending about 2 miles on each side of the boundary. Aside from its immediate purpose this monumented line and attendant triangulation will serve as a most valuable base for the orientation of future topographic and economic surveys both sides of the line. In the main this distance was a transit line, but owing to the difficulty of traversing the ice fields and rugged mountains, between Mount Natazhat and Mount St. Elias, a trigonometric survey was carried for a distance of about 150 miles, around by way of the Scolai Pass to the meridian south of Mount Natazhat to a point on the slopes of the Elias Alps.

It gives me pleasure to announce to the Academy that the Commissioners believe that the field work along the 141st meridian is completed. The reservation implied by the word "believe" means that the final plotting of the work between Mount Natazhat and Mount St. Elias has not been completed and that this plotting may develop a topographic lacuna in the ice fields of that region.

The other section of the line extending from Mount St. Elias to the Portland Canal and thence thru Dixon Entrance to Cape Muzon shared the fate of our other boundaries in being a subject of controversy which was happily settled by the Tribunal of London which rendered its decision in 1903. It is interesting to recall, however, that at the time of the Alaska Purchase, Senator Sumner, in advocating the purchase, began his scholarly speech with the following words: "In endeavoring to estimate its character, I am glad to begin with what is clear and beyond question. I refer to the boundaries fixed by the treaty."

The correctness of this statement was not borne out by subsequent events. Thirty-six years elapsed before the ensuing disputes were settled by arbitration. Under the terms of the arbitral award, Messrs. King and Tittmann were appointed to effect the delimitation on the ground. Excepting some trigonometric determinations and a final monument or two this has been accomplished. The boundary peaks have been determined trigonometrically, a photo-topographic survey has been made and monuments have been placed at important and accessible points and now the preparation of the final maps for the whole boundary from Cape Muzon to the Arctic Ocean, a distance of about 1600 miles, measured along the frontier is in progress.

All honor to the distinguished statesmen of both countries who successfully strove to find a peaceful settlement of the many controversies which have been barely touched upon by me. Their justification lies in the homely adage, that, "Good fences make good neighbors."

PHYSICS.—*Micrometer microscopes.* ARTHUR W. GRAY. Bureau of Standards. To appear in the Bulletin of the Bureau of Standards.

The purpose of this communication is to outline a simple and rapid method of applying the proper corrections to the readings of micrometer microscopes when making length measurements of precision, and also an accurate graphical procedure for computing convenient correction tables. The numerous sources of error that need attention will not be discussed in this brief paper.

TABLE 1

	A	B	C	D	E
1	+151	−38	−1	−8	−15
2	+102	+27	0	+1	− 9
3	+101	−21	+1	+8	+12
4	− 40	−49	+1	+7	+ 9

In order to emphasize the advisability of examining a microscope intended for accurate measurements Table 1 is introduced, which shows the magnitudes of the periodic errors found in some microscopes. On the assumption that the micrometers read correctly at the beginning and at the end of a turn, the corrections in ten-thousandths of a turn that must be added to the reading at the end of each fifth turn indicated in the first column are recorded in the other columns. Under A are the corrections for one turn of a microscope that had been repaired as well as possible after its micrometer thrust bearings had been discovered scored by a grain of dirt. Under B are those found for a turn of a microscope used in making important length measurements. The instrument had never before been investigated. A curious feature of this microscope was the regular repetition of this series of corrections every other turn, with a somewhat different but equally regular series for the alternate turns. Column C represents a screw of unusual excellence, made by a firm noted for high-grade astronomical instruments. D represents the average and E the worst of a group of ten others made by this same firm. The irregularities which these ten exhibit are of the same order of magnitude as those of the best microscopes belonging to the International Bureau of Weights and Measures.

While the need of applying corrections to some of these microscopes is perfectly evident, it may be well to point out that screw irregularities are of importance even in such micrometers as those of the International Bureau of Weights and Measures. An examination of the correction tables appended to one of Benoit's papers[1] shows that an error of about 1.5 μ can be made in comparing two lengths if the only corrections applied are those for deviations of the mean screw values from the nominal value of 100 μ per revolution; and further that most of the error will be due to neglecting the *periodic* corrections.

In comparing two lengths with a transverse comparator it is a common practice to multiply the changes in each micrometer reading by the mean scale-value and subtract. But even less labor is required to take into account *all* necessary corrections, after the microscopes have been calibrated once for all. The writer's method of doing this is essentially a simplification of the procedure followed by the International Bureau of Weights and Measures in measuring the national prototype meters.[2] The principal gain is effected by reducing to two tables (both of which can be mounted on a single card) all the information contained in the six tables used by the International Bureau. The table for the left microscope gives at one inspection the total correction ΔL that must be added to any reading L' of the left microscope to give the corrected reading ΔL; that for the right microscope gives $-\Delta R$, the

[1] J. R. Benoit: Mesures de dilatation et comparaisons des règles métriques, Trav. et Mém., **2**, C. 131, 1883. The tables are on pp. c, xi, and xii.

[2] Described in the above mentioned paper by Benoit.

negative of the total correction to the reading R'. Reversing the sign of ΔR is merely a matter of convenience. It is usually sufficient to enter the corrections for every tenth of a turn and to obtain those for the hundredths by interpolation. A convenient arrangement is one similar to that followed in most mathematical tables: the whole turns are indicated at the side and the tenths at the top.

The displacement corresponding to one division (= 0.01 turn) of the microscope may differ so little from 1 μ that only small corrections will be required to reduce the readings to microns. It may however, well happen that reduction to the desired length unit might require corrections so large as to be inconvenient. It then becomes advisable to select an auxiliary unit corresponding to the average screw-value, and to express all corrections in terms of this unit, which should be *the same for both microscopes.*[3] It is further advantageous to minimize the magnitude of the corrections by adjusting both microscopes to give almost the same magnification—if possible one that permits a simple reduction factor. Then all computations can be made in terms of the auxiliary unit, multiplication by the reduction factor being deferred until the end.

Another gain is effected by recording observations in such a form that the corrections can be added directly without any copying of figures. For example, the complete record and computation for a single comparison of two bars A and B would appear about as follows:

	A	B
L'.	3027.9	2431.9
R'.	2938.1	3505.7
L'−R'.	89.8	−1073.8
△L − △R.	3.0	−1.4
L − R.	92.8	−1075.2

[3] All these considerations apply with increased force to a larger group of microscopes, for example; a group of four used to read a divided circle, or several used to step off a considerable length by means of a bar reaching from one microscope to the next.

$\therefore\ L_A - L_B = 1168.0$ divisions. Since the magnification by the microscopes was such that 1 division $= \frac{3}{4}\ \mu$

$$L_A - L_B = \tfrac{3}{4} \text{ of } 1168.0 = 876.0\ \mu.$$

The accuracy that can be obtained with microscopes having errors even as large as those listed under A in Table 1 is shown by measuring three times with each of a pair the same interval of $999.05\ \mu = 1332\ (\frac{3}{4}\ \mu)$. The results are recorded in Table 2 below. In each series the center of the field was located consecutively near the right edge, the center, and the left edge of the image, so as to obtain wide variations in the corrections, which were taken from a correction table of the type described. Part of the deviations from the averages are to be ascribed to inaccurate focusing and another part (perhaps)to linear interpolation, which is not altogether justifiable with such large and irregular periodic errors. Nevertheless, the agreement is even better than would have been predicted.

The calibration of a microscope by one of the processes usually described involves such laborious computations and least-square adjustments that it is no wonder to find it attempted only as a last resort when the demands of high accuracy compel. While, of course, the complete calibration of any divided scale requires considerable time, it is, however, possible to determine microscope corrections more accurately and with less labor than would appear from previous accounts. The whole procedure can be made one of direct measurement and simple graphical addition.

In determining the screw errors it is customary to use the ocular of the microscope under investigation for viewing the displacement of the spider-lines. An enormous gain, however, is secured by removing the ocular and measuring the displacements by means of a second micrometer microscope.[4]

[4] The use of an auxiliary microscope for this purpose was first brought to my attention by Mr. E. D. Tillyer, of the Bureau of Standards, to whom I am indebted for many valuable suggestions and criticisms. He informed me that it was the regular practice at the United States Naval Observatory. (See J. C. Hammond: Introduction to Publications of U. S. Nav. Obs. **6**, A XIII. 1911.) Sir David Gill (Roy. Astron. Soc. Monthly Notices **45**, 65. 1884) also employed a compound microscope in a simple apparatus he designed for rapidly and accurately investigating screw-errors; but his method is in several respects inferior to that of the Naval Observatory.

With this second microscope the following distances are determined: (1) That traveled by the spider-lines as the screw (S) under investigation is advanced five whole turns. (A different number of turns may sometimes be more convenient.) (2) That traveled during each single turn. (3) That traveled during each fifth (or tenth) of a turn. It is not necessary that the screw of the auxiliary microscope (A) be very accurate, because all the pointings will be confined to the same portions of this screw, each only a fraction of a turn long. Besides, any irregularities here will be rendered negligible by choosing an objective that will magnify the interval to be measured sufficiently to make its image nearly fill the usable portion of the field of view. The measurement of consecutive five-turn intervals for the entire length of the screw is not necessary, but it is advisable in order to reduce the acumulation of errors by addition in determining the progressive corrections; and the extra time consumed is a small item. Again, it is hardly worth while to carry out measurements (2) and (3) with every turn. It will usually be found sufficient to measure the first and the last turn of each five-turn interval. Since adjacent turns are not likely to differ much, this grouping in pairs will check blunders.

After all the intervals have been measured, a length close to the average for one turn of S is selected as a basis of comparison. A multiple of ten divisions of A is convenient. By simply adding the deviations of the measured five-turn intervals from five times this basis, we compute the progressive corrections at the beginning of each five turns, choosing the point of zero correction at the middle of the screw. These corrections will be expressed in divisions of A, and the same unit is retained in all stages of the computation until the end, when the correction curves are read off by a scale which automatically translates into the numbers to be entered in the final table.

We now plot a series of curves the abscissae of which are the whole turns of S, that is, the comb readings of the micrometer to which it belongs. The ordinates of the first curve (C_0) are the progressive corrections mentioned in the preceding paragraph; those of the second (C_{100}) are the lengths of the one-turn intervals; those of the next five (${}_0p_{20}$, ${}_{20}p_{40}$, ${}_{40}p_{60}$, ${}_{60}p_{80}$, ${}_{80}p_{100}$) are the lengths of the one-fifth turn intervals in proper order. The next step is to adjust these curves so that they are mutually consistent, that is to say, the progressive corrections found by adding five consecutive ordinates of C_{100} should agree with the corrections represented by C_0, and any ordinate of C_{100} should equal the sum of the corresponding ordinates of the curves ${}_0p_{20}$, ... ${}_{80}p_{100}$. If the curves are plotted to a suitable scale the additions are quickly made by marking off the distances on strips of paper. These adjusted curves afford a fairly safe means of interpolation to obtain the corrections for intervals not actually measured. The curve plotted from the sums of the components of each interval is likely to lie above or below that plotted directly from the entire intervals. This divergence can proceed from progressive error or gradual change of scale value in the screw of the auxiliary microscope, or from thermal expansion of S; but it is of no consequence. The adjustment is first directed towards rendering the two curves parallel, then any distance separating them is divided among the curves representing the components of the interval by merely shifting the base lines from which the deviations would be measured.[5]

After the adjustments have been completed, the curves for the one-fifth turn intervals are added graphically to form a new set (C_{20}, C_{40}, C_{60}, C_{80}) yielding the corrections at the beginning of each fifth. If interpolation is necessary, it is readily accomplished graphically with sufficient accuracy. The interpolating curve for any selected turn will exhibit the corrections at every drum reading within this turn. Five points besides the initial zero are obtained from the correction curves just mentioned. If interpolating curves are plotted for several turns evenly distributed along the course of the screw, sufficient data can be obtained for plotting curves (C_{10}, C_{30}, C_{50}, C_{70}, C_{90}) to give the correction at every tenth of a turn, or oftener, as functions of the comb readings.

[5] Altho adjustments of this kind made by different computers would probably differ slightly, a least-square solution would be a sheer waste of effort, since the differences in almost any case would affect the final corrections by considerably less than the accidental error of a pointing in using the micrometer of which S forms a part.

All that now remains is to determine the magnification and to translate these curves into the figures that forms the final table.

It is, of course, desirable that the numbers in the correction table, and also the tabular differences, be small. Tabular differences arising from periodic irregularities cannot be reduced except by improving the screw. Progressive errors and deviations from the nominal screw-value, however, even if small, lead to the accumulation of large corrections when many turns must be used. But if the magnification is adjustable, these corrections can often be materially reduced. The first of the series of curves plotted, namely, that representing the progressive errors, was based on deviations of the measured lengths of individual turns from the length represented by the basis selected for comparison. If a known length, such as a standard millimeter, be measured with the microscope to which the screw S belongs, and the readings corrected by using the curves described above, the distance measured that would correspond to the basis of comparison is likely to differ somewhat from the distance to be represented by 100 divisions (one turn) in the correction table. A little reflection will make it apparent that corrections for this divergence can be added to the progressive corrections by the simple device of drawing a line at the proper angle thru the point selected for zero correction. The distance parallel to the axis of ordinates between this line and the progressive curve (C_0) measures the total correction for any comb reading. It is, therefore, evident that these corrections can be reduced to a minimum for any given part of the screw by adjusting the magnification of the microscope so as to give this line the most favorable slope. A moment's inspection of the progressive curve will decide what this should be. After the magnification has been adjusted with sufficient closeness, a standard length interval should be carefully measured, and the correcting line accurately located. Several measurements using different parts of the screw will afford valuable checks on the accuracy of the correction curves. Table 2 represents measurements of this kind.

We are now ready for the final step of reading off the corrections from the curves and entering them in the table. A translating scale is used which reads the plots in terms of the unit chosen for expressing the corrections in the table. A piece of co-ordinate paper cut diagonally at the proper angle forms a convenient scale. The corrections at the beginning of each turn are measured by the distances between the curve of progressive corrections and the inclined line correcting for magnification. The corrections at the

TABLE 2

Measurement of $999.05\mu = 1332$ ($\frac{3}{4}\mu$)

UNCORRECTED	CORRECTIONS	CORRECTED	DEVIATIONS
1341.5	−8.7	= 1332.8	+0.8
1333.1	−1.4	= 1331.7	−0.3
1337.1	−5.5	= 1331.6	−0.4
Averages with left microscope		1332.0	±0.5
1319.5	+13.1	= 1332.6	+0.5
1316.0	+15.5	= 1331.5	−0.6
1318.7	+13.6	= 1332.3	+0.2
Averages with right microscope		1332.1	±0.4

tenths of a turn are read from the corresponding curves, the base line of each being shifted if necessary to correct for magnification within a turn. (Progressive errors within a turn as well as periodic errors were cared for in deriving the curves.) These internal corrections must, of course, be added to the correction at the beginning of the turn before entering in the table.

ELECTROCHEMISTRY.—*The silver voltameter. Part IV.* E. B. Rosa, G. W. Vinal, and A. S. McDaniel. To appear in full in the Bulletin of the Bureau of Standards.

In the three papers preceding this, the course of the work has been traced from its beginning in 1908 until the International Technical Committee met in Washington in April, 1910, to carry out a joint investigation of the voltameter and to determine the voltage of the Weston Normal Cell in terms of the international ohm and the international ampere, the latter being derived from the silver voltameter. The object of the present work is to make a further comparison of the porous cup and Smith forms of voltameter, since these have been found the most reliable forms during the committee's work and to make such other experiments as might afford data for the voltameter specifications, not yet adopted.

The International Committee fixed the voltage of the cell to five significant figures (1.0183 volts at 20°C.), but it is desirable to reach an accuracy sufficient to justify recording six figures, since the voltameter is a primary standard. Results are expressed as the voltage of the Weston Normal Cell at 20° computed from the defined electro-chemical equivalent of silver, 1.11800 mg. per coulomb.

The procedure was according to the best methods learned from previous work. In all cases the electrolyte was carefully tested for its purity and the acidity determined. The voltameters used were chiefly the porous pot and Smith's form, but on several occasions we used the siphon form, the modified ring-shaped siphon, and the Poggendorff form.

Since we had learned from previous work that the effect of acid in pure electrolyte is to lower the deposit, we sought to find if possible a quantitative relation between the amount of acid, expressed in equivalents of HNO_3 per million, (X) and the decrease in deposit, also expressed in parts per million, (Y). As a result of a large number of comparisons of neutral voltameters with others made acid by varying amounts we have found the following relation

$$Y = -4.5X + 0.02\,X^2$$

which we think is justified by the figures given in the complete paper.[1]

For acidities below 10 parts per million the square term is of course unnecessary. The above equation was used in computing a correction to each deposit, but this correction was very small in all cases for the results given below. The result of 156 deposits in the porous cup form is:

$$1.01826_7 \text{ volts}$$

The average deviation of a single observation from the mean is

[1] Von Steinwehr's recently expressed opinion to the contrary (Instrumentenkunde, November 1913) was based on earlier work which was not so conclusive as our recent work.

0.00003_0 and the computed probable error of a single observation is 0.00002_5. The probable error of the mean result is 0.00000_2.

The result of 55 deposits in the Smith form is:

$$1.01827_4 \text{ volts}$$

The average deviation of a single observation from the mean is 0.00004_0 and the computed probable error of a single observation is 0.00003_4. The probable error of the mean result is 0.00000_5.

The mean of the porous pot form and the Smith form is therefore

$$1.01827 \text{ volts}$$

which we give as the final result. The electrolyte was so pure that no volume effect was observed in either form of voltameter.

With other forms of voltameter we have obtained the following results: Siphon form (relative experiments, 5 observations) 1.01832; Modified siphon (7 observations) 1.01835: Poggendorff form (9 observations) 1.01830. We thus have results with five forms of voltameter all confirming the decision of the International Committee, but the difficulties arising from the anode slime in the last two make them more uncertain and difficult to use. The siphon voltameter requires so much electrolyte that the presence of the slightest trace of impurity increases the "volume effect" noted previously in several other forms.

We made a number of miscellaneous observations on the effect of various impurities, but will mention here only the excessive deposits obtained when considerable CO_2 is present in the atmosphere above the voltameters. Two possible theories are given in the complete paper to account for the slight difference occasionally appearing in the deposit between the Smith form and the porous pot form.

A further study of the effect of acid on solutions *known to be impure* has shown the effect to be quite variable depending on the nature of the impurity. This fact we believe accounts for much of the conflicting opinion found in the literature on this subject. We have endeavored to find just what the action of acid is by which it reduces the deposit from pure electrolyte, but our results are chiefly negative. It seemed possible that in the case of an electrolyte appreciably acid the decrease might be due to a depositing out of the hydrogen ions before the silver begins to deposit, since there is probably at the instant the current begins to flow a greater difference of potential at the cathode than obtains later, as the discontinuous character of the deposit indicates that the potential difference must break thru a sort of surface film and establish outlets for the current to the platinum cathode. If this were possible, by making deposits of about 1 mg. each from solutions containing acid and without acid, the difference ought to be apparent. This we have done for varying lengths of deposit, measuring the silver by titration with ammonium sulphocyanate. The results showed always an agreement of both deposits between themselves and with the computed value for the silver within the experimental error. But when we electrolyzed oxygen into the platinum cathode for four hours previous to making a deposit a loss of about 0.2 mg. was observed, this was not again found on subsequently using the bowl unless it had been oxygenated as before.

We have made a careful study of the effect of various septa other than filter paper on the voltameter. First raw silk was investigated. Extracting raw silk in neutral double distilled water we find the extract to be distinctly basic toward both methyl and iodeosine and the concentrated extracts will restore the color to magenta solution previously decolorized by sulphurous acid, thus indicating the presence of an aldehyde. The colloidal character of the solutions was ascertained by the ultra-microscope. After prolonged washing or use in the voltameter the so-called "silk glue" which probably gives rise to the above effects is eliminated and a hydrolytic process into amino acids appears causing a reverse action in the voltameters. We have never claimed that these two actions take place at the same time, as implied recently by von Steinwehr. We think that silk like filter paper should be excluded from use in the silver voltameter.

Our experimental evidence indicates that porous pots if properly prepared are without influence on silver nitrate. A new pot or one that has been baked may contain free alkali which must be washed out with nitric acid and water until perfectly neutral and then several portions of silver nitrate filtered thru the pores until equilibrium between the pot and solution is obtained since at the beginning the pot acts as a catalyzer, to reduce a very small amount of solution. After being properly prepared there is no evidence of stenolysis or other abnormality in the ordinary use.

The question of the purity of the deposited silver is an important one, but the conflicting evidence in the literature does not enable one to decide even whether inclusions are present or not. The uniformity of the results that we have obtained in three series of experiments suggests that the inclusions must be very small or surprisingly constant in amount. It seems to us that inclusions if present would be between crystals rather than in a crystal perfectly formed according to the cubic system and hence greater inclusions are to be expected in deposits which are less crystaline because of the action of colloids.

We have endeavored to detect the presence of $AgNO_3$ in the deposits by amalgamating them with mercury then washing the amalgam and testing for nitrates by phenol sulphonic acid. Our blank experiments, adding $AgNO_3$ to the amalgam after precipitating any mercury and silver salts present worked satisfactorily, but we have been unable to detect any appreciable $AgNO_3$ in the best deposits altho a trace was found in striated deposits. If considerable filter paper was used some organic matter was visible after amalgamating the deposit. We tried to determine the water content of a striated deposit having an excess weight over a normal deposit of 0.56 mg. by alloying the deposit to the platinum crucible in which it was made over an alcohol blast, and found a loss of 0.053 mg. which previous experiment showed was not due to the change in the platinum crucible alone. We were not able at this time to make further experiments and therefore do not consider the result conclusive.

The reactions in the voltameter have not generally been considered as reversible, that is, an equivalence of the loss in weight at the anode and gain at the cathode, but since our previous work has shown that the supposed complex reactions at the anode do not probably exist we examined the possibility of reversibility. For an anode we used a heavy deposit contained in a large platinum bowl and connected the electrolyte in this thru a siphon to a second bowl serving as cathode. First we measured the progressive change in acidity of the anode solution as electrolysis took place and found that practically no change of acidity occurs until the silver on the anode was reduced to about 0.5 gram after which it rose very abruptly. Next we measured the potential difference between the anode and an intermediate electrode and found this also constant until about 2.5 gram of silver remained. We then examined the question quantitatively as follows:

WEIGHT OF SILVER ON ANODE BOWL	CURRENT	LOSS AT ANODE	GAIN AT CATHODE	DEPOSIT IN STANDARD VOLTAMETER
grams	*amp.*	*mg.*	*mg.*	*mg.*
8	0.500	2164.81	2164.78	2164.81
9	0.500	2092.12	2091.92	2091.83

The results show a surprising agreement. These were made using a pure crystalline deposit for the anode. With a striated deposit made from a filter paper contaminated solution the result was very different. The anode turned dark and had a very large amount of slime all of which was collected and added to the bowl. The results using a pure solution and this impure anode are as follows:

Anode lost	2095.43 mg.
Cathode gained	2092.21 mg.
Standard voltameter	2091.83 mg.

The conclusion leaves no room for doubt that the purity of the anode is essential in such an experiment and this should be considered in voltameter work in general.

We have added to our complete paper a further discussion of the volume effect (see Part III) in reply to von Steinwehr's criticisms. (Zs. f. Instr., November, 1913) we have shown that this phenomenon of excess deposit in large bowls over small bowls, when impure electrolyte is used, is not confined to the porous cup form as von Steinwehr asserts, but has been observed in the filter form by Schuster and Crossley and in the siphon and Smith forms by ourselves. We have overcome this troublesome volume effect by *purifying the electrolyte*. We wish to lay great stress on the purity of the electrolyte used in obtaining the results recorded in this paper. This question of the purity of the electrolyte has received less attention from previous observers than it deserves. We have described our methods for purifying silver nitrate in Part III of this series of papers.

GEOLOGY.—*The relative abundance of several metallic elements.* F. W. CLARKE and GEORGE STEIGER, U.S. Geological Survey.

During the past twenty-five years, several estimates of the relative abundance of the commoner chemical elements have been published from the laboratory of the United States Geological Survey.[1] These estimates, however, covered only such constituents of the earth's crust as are usually determined in the course of fairly complete analyses; including, in many cases, the less important elements barium, strontium, nickel, chromium, vanadium and zirconium. For the more familiar metals, copper, lead, zinc and arsenic, no really adequate data were available; and no attempt was made to compute either their abundance or their frequency. Such attempts have been made by others, however, but not altogether conclusively.[2]

In order to gain a definite idea as to the relative abundance of the elements in question, a number of *composite* analyses were made. That is, in each group of substances investigated, many samples were blended into one uniform sample, and that was then analyzed. The average content of each metal was determined in that way with as close an approximation to accuracy as could have been attained by many individual analyses. Four such composites have been studied thus far; namely, two of oceanic clays, contributed by Sir John Murray;[3] one of silt or mud from the delta of the Mississippi; and one of igneous rocks which had previously been analyzed in the laboratory of the Survey. For the the Mississippi silt the general analysis, not heretofore published, is as follows:[4] The composite was made up of 235 separate sam-

[1] For the latest of these estimates see Survey Bulletins 419 and 491. Also a paper in Proc. Amer. Phil. Soc., **51**, 214.

[2] See for example Vogt, Zeitsch. prakt. Geol., 1898, pp. 225, 314, 377, 413, and 1899, pp. 10, 274; and Kemp, Econ. Geol., **1**, 207.

[3] For the complete analyses of these clays see Journ. Geol., **15**, 783.

[4] Except when otherwise stated the analyses given here were made by Mr. Steiger.

ples, collected by E. W. Shaw. For the determination of NiO, CuO, PbO, ZnO and As_2O_5, 200 grams of the silt were taken. The presence of organic matter prevented the separate. determination of ferrous iron. The chlorine in this analysis is doubtless due to salt from the Gulf of Mexico.

TABLE 1

Composite Analysis of 235 Samples of Mississippi Silt

SiO_2	69.96	Cl	0.50
Al_2O_3	10.52	F	0.07
Fe_2O_3	3.47	Cr_2O_3	0.01
MgO	1.41	V_2O_3	0.02
CaO	2.17	NiO	0.017
Na_2O	1.51	MnO	0.06
K_2O	2.30	BaO	0.08
H_2O-	3.78	SrO	trace
H_2O+	1.96	CuO	0.0043
TiO_2	0.54	ZnO	0.0010
ZrO_2	0.05	As_2O_5	0.0004
CO_2	1.40	PbO	0.0002
P_2O_5	0.18	Organic	0.66
SO_3	0.03		100.6229
S	0.07	Less O	0.13
			100.4929

For the four composite analyses above mentioned the data under immediate consideration are as follows:

A. The "red clay" of the oceanic depths. Composite of 51 samples, dredged from the sea bottom and representative of all the great oceans. The larger part of this material was collected by the *Challenger* Expedition. Determinations (by E. C. Sullivan) of CuO, ZnO, PbO and As_2O_5 made on 150 gram portions.

B. "Terrigenous clays," from oceanic depths of 140 to 2120 fathoms. Composite of 52 samples, namely 4 "green muds," and 48 "blue muds," also mainly from the *Challenger* Expedition. Determinations made on 300 gram portions.

C. Composite of 235 samples of Mississippi silt, as in the foregoing analysis. For the heavy metals 200 gram portions were taken.

D. Composite of 329 igneous rocks, all American. Determinations on 90 gram portions.

In the red clay a trace of molybdenum was also detected by Dr. Hillebrand.

TABLE 2

SUMMARY OF DATA FROM COMPOSITE ANALYSES

	A	B	C	D	AVERAGE
NiO	0.0320	0.0630	0.0170	0.00655	0.0296
As_2O_5	0.0010	trace	0.0004	0.00074	0.0005
PbO	0.0073	0.0004	0.0002	0.00081	0.0022
CuO	0.0200	0.0160	0.0043	0.01167	0.0130
ZnO	0.0052	0.0070	0.0010	0.00638	0.0049

These figures give quite clearly the order of magnitude of the several percentages, and they are corroborated by the work of other investigators. In a series of 36 igneous and metamorphic rocks of British Guiana, Harrison found a mean percentage of 0.025 copper. In 23 of his samples lead was also sought for, and detected in 5 of them, the maximum amount being 0.02 per cent. In a typical specimen of the Columbia River basalt Wells found 0.034 of copper, and the same quantity was determined by Jensen in an andesite from Fiji. In the porphyries of Leadville, Colorado, Hillebrand was able to determine lead. Out of 18 samples, taken at points remote from ore bodies, the average amount found was 0.002 per cent of PbO. One porphyry also yielded 0.008 per cent of zinc oxide, and a rhyolite contained 0.0043 per cent.

In four rocks granite, porphyry and diabase from the Archean of Missouri, Robertson determined the following percentages of lead, zinc, and copper:

Pb	0.00197 to 0.0068; average, 0.004
Zn	0.00139 to 0.0176; average, 0.009
Cu	0.00240 to 0.0104; average, 0.006

The adjacent limestones also carried these metals, but in slightly smaller proportions. Similar results were obtained by Finlayson from igneous rocks adjacent to lead mines in Great Britain. His averages are Pb, 0.0032 per cent, and Zn, 0.028. In the limestones and dolomites of the Dubuque region, Iowa, Weems determined lead and zinc. The average of nine samples gave

0.00326 per cent of Pb, and 0.00029 of Zn. Many other determinations of the heavy metals in rocks are scattered through the literature of geology but these examples are sufficient to illustrate what has long been known. The researches of Forchhammer, of Sandberger, and of Dieulafait are familiar to geologists, but they lack the quantitative basis which is supplied by the composite analyses given here.[5] The heavy metals are widely diffused throughout the crust of the earth, and generally in determinable proportions. The order of abundance, as now ascertained, appears to be Ni, Cu, Zn, Pb, As, with, of course, local variations.

With the aid of the estimate here given for zinc, which is near 0.005 per cent of ZnO or 0.004 Zn, it becomes possible to gain some notion as to the relative abundance of cadmium; for the two metals are commonly associated. In 10906 shipments of zinc ores from Webb City and Joplin, Missouri, mostly in carload lots, Waring[6] found an average percentage of 57.96 Zn and 0.358 Cd. The ratio is 1 Cd to 162 Zn. From 42 analyses of sphalerite given in Hintze's Handbuch der Mineralogie, the mean ratio is 1 to 163. From 82 analyses of European zinc ores, cited by Jensch,[7] the ratio 1 to 277 appears. The mean of these three estimates is 1 to 201; that is, in round numbers, zinc seems to be about 200 times as abundant as cadmium. A more precise estimate can hardly be made at present; but the figure is better than no estimate at all. It has a quantitative basis, and is therefore something more than a mere guess. If the percentage of zinc in the earth's crust is 0.004, then that of cadmium is of the order of 0.00002.

In the course of the regular rock analyses made in the laboratory of the Geological Survey, many determinations have been made of elements of minor quantitative importance. These determinations are numerous enough to fix their numerical significance between maximum and minimum limits as follows:

[5] For literature references see Survey Bulletin 491, The Data of Geochemistry, pp. 600–602, 643.

[6] Cited by Siebenthal in U. S. Geological Survey, Mineral Resources, 1908, **1**, 796. See also, for other data, Waring's paper in Journ. Amer. Chem. Soc., **26**, 16.

[7] Ahren's Sammlung chem. techn. Vorträge, **3**, 201.

In round numbers, about 1200 such analyses, nominally complete, have been made and in 793 of them barium oxide was determined or proved to be absent. The mean of these determinations, counting absences as zero, is 0.0104 per cent, which is probably a maximum. If the remaining 407 rocks were all free from barium, and so regarded, the average percentage of BaO would be 0.069, a minimum; and between the two figures the most probable value would lie, their mean being 0.086. Upon this basis of computation the following table of percentages has been constructed.

TABLE 3

SUMMARY OF DATA FROM ROCK ANALYSES

	NUMBER OF DETERMINATIONS	MAXIMUM	MINIMUM	MEAN
BaO	793	0.104	0.069	0.086
SrO	649	0.040	0.022	0.031
Li_2O	581	0.011	0.005	0.008
NiO	299	0.026	0.006	0.016
Cr_2O_3	293	0.050	0.012	0.031
V_2O_3	102	0.026	0.002	0.014
ZrO_2	372	0.023	0.007	0.015

In three of the composite analyses already cited, similar determinations were made, and the results obtained fit in fairly well with the figures of this table.

The percentages found are shown in the following table:

TABLE 4

DATA FROM ANALYSES OF COMPOSITE SAMPLES

	RED CLAY	TERRIGENOUS CLAY	RIVER SILT
BaO	0.17	0.05	0.08
SrO	0.046	0.025	trace
NiO	0.032	0.065	0.017
Cr_2O_3	0.01	0.044	0.01
V_2O_3	0.028	0.028	0.02
ZrO_2	undet.	undet.	0.05

The data so far obtained may not be final; but they clearly indicate the several orders of magnitude which it was sought to determine.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

BOTANY.—*Annona sericea and its allies.* WILLIAM E. SAFFORD. Contributions from the United States National Herbarium, **16,** Part 10. pp. 263–275. December 13, 1913.

In continuance of his studies in the Annonaceae, the writer finds that the silky annona of French Guiana (*Annona sericea* Dunal) is the type of a natural subgroup of the genus Annona, that should be segregated as a section, for which he proposes the name Pilannona to give it co-ordinate rank with Euannona, Atta, Ilama, Annonella, and Chelinocarpus. As in other natural plant groups there are certain species which appear to form connections with allied groups, so in the section Pilannona the type species, *Annona sericea* Dunal, which has normally 3 petals, appears to be allied to the 6-petaled *A. paludosa* Aubl., while at the opposite end of the series *Annona jamaicensis* Sprague approaches *A. cherimola,* belonging to type section Atta. In addition to descriptions of the principal species included in this section photographs of a number of original type specimens are presented, including that of *Annona echinata* Dunal in the De Candolle Herbarium at Geneva, and the flower of *A. sericea* described and figured by Dunal in his classical monograph of the Annonaceae. Among the new species described and figured are *Annona jenmanni,* from British Guiana; *A. trinitensis,* from the island of Trinidad; *A. longipes* from southern Veracruz, Mexico; *A. holosericea,* from the Pacific coast of Costa Rica; *spraguei,* from Panama; *Annona cercocarpa,* from Colombia and *acuminata,* collected on the Isthmus of Panama in 1861 by Dr. Sutton Hayes. In addition to the above *Annona jamaicensis* Sprague is redescribed and illustrated with two photographs.

This paper deals with the taxonomy of the species described. It will be followed shortly by a more comprehensive one on the "Classification of the genus Annona with descriptions of new and imperfectly known species," which will form part 1 of the Contributions from the United States National Herbarium volume 18. Both papers are preliminary to an account of the economic custard-apples and their allies, to be published by the United States Department of Agriculture.

W. E. S.

BOTANY.—*Descriptions of new plants, preliminary to a report upon the flora of New Mexico.* E. O. WOOTON and PAUL C. STANDLEY. Contributions from the U. S. National Herbarium **16,** 109–196. pl. 48–50. 1913.

For some time the authors of this paper have been engaged in the preparation of a Flora of New Mexico. This work, which has now been completed, will, it is expected, be published in the near future. The only general descriptive manual covering any portion of the arid southwestern United States heretofore available has been Coulter's Botany of Western Texas (Contr. U. S. Nat. Herb., vol. 2), a work which unfortunately is now out of print.

Little attention having been given by taxonomists to the flora of New Mexcio in recent years, it was to be expected that many undescribed species would be discovered during the progress of the investigation just mentioned. These are described in the present paper, partly to reduce the bulk of the complete Flora and partly to prevent confusion on the part of those who wish to use it. Altogether 198 species are described as new. The largest number in a single family (50) is found in the Carduaceae, the group which has the largest number of representatives in the state. In this family a new genus, Herrickia, is named, based upon a plant of northern New Mexico, related to Aster and Xylorrhiza. Among the other plants described may be mentioned two new Yuccas, an Agave from the Organ Mountains, two oaks, six species of Padus, a Robinia (the second species of this genus known from the western United States), eight species of Gaura, five of Penstemon, eight of Erigeron, and four thistles. In addition to the new species described, 65 new names or new "combinations" are published.

P. C. S.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

The 16th annual meeting of the Washington Academy of Sciences was held at the Cosmos Club, January 15, 1914, with President Tittmann in the chair. The following were elected officers for the ensuing year: *President,* David White; *Corresponding Secretary,* George K. Burgess; *Recording Secretary,* W. J. Humphreys; *Treasurer,* E. W. Parker; *Vice-Presidents,* Representing the Anthropological Society: F. W. Hodge; Botanical Society: F. L. Lewton; Entomological Society: A. L. Quaintance; Electrical Engineers Society: E. B. Rosa; Foresters Society: W. B. Greeley; Historical Society: J. D. Morgan; Biological Society: Paul Bartsch; Chemical Society: M. X. Sullivan; Engineers Society: G. W. Littlehales; Philadelphia Society: L. A. Fischer; Geological Society: F. L. Ransome; Archaeological Society: Mitchell Carroll; *Non-Resident Vice-Presidents,* Ira Remsen and J. M. Coulter; *Managers, Class of 1917,* A. H. Brooks and L. O. Howard.

The report of the Corresponding Secretary showed the total membership as 369, an increase of 14 during the past year, and that the Academy has lost by death the following: Dr. J. R. Eastman, the first President of the Academy; Prof. Alexander Macfarlane; Dr. Robert Fletcher; Gen. C. W. Raymond.

The Treasurer's report showed the total receipts \$4805.69, disbursements \$3657.82, cash on hand \$1147.87, investments \$12,090.

The report of the Auditing Committee was also received.

The following were elected to resident membership: Erwin F. Smith, L. H. Dewey, W. W. Stockberger, Haven Metcalf, Bert S. Butler, Monroe Hopkins, W. R. Blair, C. W. Burrows, W. Blum, J. T. Kelley, Jr., Paul J. Fox, Dr. W. W. Randall, J. F. Mitchell, W. Salant, A. Seidell, C. S. Hudson, W. N. Berg, G. E. Patrick, R. O. E. Davis, Percy H. Walker, W. W. Skinner, W. H. Waggaman, H. C. Gore, Rene de M. Taveau.

President-elect White then took the chair and President Tittmann delivered an address on "Our Northern Boundaries" (this Journal **4,** 37, 1914).

George K. Burgess, *Corresponding Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 516th meeting was held November 15, 1913. Vice-President Paul Bartsch in the chair and thirty-five persons present.

F. V. Coville presented a communication on *The physiology of the blueberry.* His remarks were based on wide experience in green house and outdoor culture of this plant. Three conditions are essential to its successful propagation: (1) an acid soil; (2) the presence of the micorrhizal fungus to enable the plant to obtain nitrogen; and (3) the stimulating effect of cold on the twigs while they are dormant. The last is a condition of vital importance, associated as it is with the transformation of starch into sugar. As a result of this series of experiments, the commercial propagation of the blueberry is now possible. Very large berries have been developed, some of them from $\frac{1}{2}$ inch to $\frac{7}{8}$ inch in diameter. The various means of cultivation were explained and illustrated by means of numerous lantern slides.

W. C. Kendall, the second speaker announced on the program, was absent, and the chairman asked Dr. Leon J. Cole of the University of Wisconsin to address the Society. He responded by giving an account of his experiments in breeding pigeons for the study of color inheritance.

Owing to the lateness of the hour, the communication by Barton W. Evermann was postponed.

The 517th meeting was held November 29, 1913. President E. W. Nelson in the chair and sixty-three persons present.

The meeting was devoted to a discussion of Parallel Development. A. D. Hopkins read a paper on *Parallelism in morphological characters and physiological characteristics in Scolytoid Beetles.* He had made a special study of these beetles and his ideas of parallelism in nature were largely founded on evidence they have furnished. He defined the subject as follows:

"Parallelism in morphological characters and physiological characteristics in Scolytoid beetles relates to the occurrence of the same or similar elements of structure or the same kind of activity in two or more species, genera, subfamilies, or families. Parallel species, genera, and larger groups are those in which structure or habit is in many respects alike. Such species or groups may be closely allied or more or less widely separated. Universal parallelism relates to repeated or multiple origin, development, and evolution of the same or similar inorganic or organic forms or activity.

"This tendency towards parallel development appears to be in accordance with a fundamental principal or law of *parallelism in evolution,* under which the origin and evolution of the same form or activity, under the same or similar physical influences, has been repeated many times; or, in other words, that under similar environments, needs, and requirements in nature, independent development and evolution from a common base may produce repeatedly the same or similar morphological and physiological results."

Numerous examples were given and illustrated on the board, of characters of structures and characteristics of habit which were paralleled over and over again in connected and disconnected genera, subfamilies, and families. He also illustrated characters and characteristics which were paralleled in all of the species of a single genus and in connected genera, groups, subfamilies, and families, and said further:

"Thus we see that parallel modification in morphological and physiological elements is an important factor to be considered in taxonomy. It is evident from a comparative study of the various systems of classification that the failure of taxonomists to fully realize its importance has led to many erroneous conclusions and much confusion.

"In conclusion, it seems to me that we have two fundamental questions to be answered in regard to the origin, evolution, and classification of organisms.

"1. Are the taxonomic characters and characteristics of the species, genus, family, order, class, and kingdom *the result of phylogenetic descent from a single ancestral nucleus, thru natural selection and the inheritance of selected characters?* or

"2. Are they *the result of phylogenetic descent from many nuclei thru natural selection and natural parallelism?*

"I am inclined to the belief that an affirmative answer to the second question would be more nearly in accord with natural law."

President NELSON exhibited a series of mammal skins in pairs similar in outward appearance but widely different in structure and classification, showing the parallelism of shape and color.

O. C. OBERHOLSER discussed parallel development as illustrated in birds. He showed a large series of specimens in which resemblances in form and color were very striking.

J. W. GIDLEY pointed out the difference between parallel and convergent development.

Messrs. LYON, HAY, BAKER, BARTSCH and GILL took further part in the discussion.

Dr. HOPKINS closed the discussion by stating that the illustrative material presented by Messrs. NELSON and OBERHOLSER had shown only one phase of the principle—homomorphic parallelism, which is not correlated with evidences of natural affinity, but is repeated in more or less widely separated groups and species, while the other—homologous parallelism—is parallelism of structure, color, habit, etc., which is correlated with evidence of natural affinity and is repeated in the same species or in connected genera or larger groups.

The 34th annual meeting and 518th regular meeting was held December 13, 1913, President E. W. Nelson in the chair and twenty-eight persons present.

The annual reports of officers were received. The election of officers for 1914 took place and resulted as follows: *President*, PAUL BARTSCH; *Vice-Presidents*, J. N. ROSE, A. D. HOPKINS, W. P. HAY, MARY J. RATHBUN; *Recording secretary*, D. E. LANTZ; *Corresponding secretary*, W. L. MCATEE; *Treasurer*, WELLS W. COOKE; *Members of council*, WILLIAM PALMER, HUGH M. SMITH, VERNON BAILEY, MARCUS W. LYON, JR., N. HOLLISTER.

The president, Paul Bartsch was selected to represent the Society as a vice-president of the Washington Academy of Sciences.

The president appointed as Committees on Publication the following: N. Hollister, W. L. McAtee, Wells W. Cooke.

D. E. LANTZ, *Recording Secretary*.

JOURNAL

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ELECTROCHEMISTRY.—*Comparison of the silver and iodine voltameters and the determination of the value of the faraday.* G. W. VINAL and S. J. BATES. To appear in full in the Bulletin of the Bureau of Standards and Journal of American Chemical Society. Communicated by E. B. ROSA.

A form of iodine voltameter was devised by Washburn and Bates and described by them in the J. Am. Chem. Soc. **34,** 1341. This instrument was found to be of about the same order of reproducibility as the silver voltameter. Because of the reversibility of the reactions taking place at the anode and the cathode and the character of the deposit which precluded the possibility of inclusions of foreign material it seemed a desirable instrument to use in the determination of the faraday, especially since the values for this constant had heretofore been based on the silver measurements alone.

Accordingly arrangements were made for a comparison of the silver and iodine voltameters at the Bureau of Standards during the summer of 1913. The operation of the iodine voltameters was in general the same as previously described by Washburn and Bates. The silver voltameters were of the porous cup and Smith form following the usual procedure of the Bureau of Standards. Since the same current passed through the silver and iodine voltameters, the ratio of silver to iodine may be immediately calculated. As a result of ten experiments in each of which several voltameters of both types were employed we find the ratio

$$\frac{\text{Silver}}{\text{Iodine}} = 0.85017$$

which is slightly higher than the ratio (0.84998) of the present atomic weights. All sources of error have been carefully examined and are critically discussed in the full paper. None, however, are believed to be sufficient to account for the difference between this value and the ratio of the present international atomic weights.

Using the results of the silver voltameter to measure the coulombs passing through the circuit according to the decision of the London Electrical Conference (1.11800 mg. of silver = 1 coulomb) the electrochemical equivalent of iodine is:

1.31502 mg. per coulomb.

The value of the faraday on the basis of the present international atomic weight of iodine (126.92) and the foregoing value of the electrochemical equivalent of iodine is:

$$\frac{126.92}{0.00131502} = 96{,}515 \text{ coulombs.}$$

The value of the faraday derived from the atomic weight of silver and the defined electrochemical equivalent of silver is:

$$\frac{107.88}{0.00111800} = 96{,}494.$$

The mean value of the two is 96,504, but we recommend for general use the round number 96,500.

PLANT PHYSIOLOGY.—*Injury by smelter smoke in southeastern Tennessee.* GEORGE GRANT HEDGCOCK, Bureau of Plant Industry. Communicated by KARL F. KELLERMAN.

Observations were made on the condition of the vegetation in the region surrounding Ducktown and Copper Hill, Tennessee, in the neighborhood of the copper smelters during the month of September, 1913, before any frost injury had taken place. The area affected by the acute form of injury is probably larger than it was during 1905 and 1906 when J. K. Haywood[1] of the Bureau of Chemistry made studies of the effects of the smoke in this region. The actual damage by acute injury at present is possibly slightly less, owing to a greater area of smoke diffusion, but is

[1] U. S. D. A. Bur. Chem. Bul. 113, pp. 13, 1908.

still continuing in the same general directions as reported by Haywood, extending farthest to the north, 12 to 15 miles, and to the west 8 to 10 miles or even more. The acute injury to the south and east does not extend more than half the latter distance. No accurate estimate can be made of chronic injury which apparently extends much farther in all directions. Prevailing winds are the deciding factors as to the directions in which acute injury extends the farthest, and owing to the contour of the country all localities in any direction are not equally affected. In the worst affected area little herbage is found, and the hills look like a desert with a greatly eroded appearance. Beyond this area grasses have been able to maintain themselves owing to the greater dilution of the fumes. Various flowering plants, such as asters, goldenrods, and legumes begin to appear at a still greater distance than grasses, and along with them certain species of trees. Garden beans (*Phaseolus vulgaris*) are especially susceptible to the fumes, and are a good index of the SO_2 injury.

Deciduous trees appear to be more resistant to smoke than conifers in this region. The deciduous trees along the Ocoee River to the westward appear to be resistant in the following order, the most highly resistant being named first: *Quercus alba, Acer rubrum, Cornus florida, Nyssa sylvatica, Populus deltoides, Oxydendrum arboreum, Liriodendron tulipifera, Robinia pseudacacia, Platanus occidentalis*, and *Ulmus crassa*. On the uplands the most severe injury was found. It was most noticeable on slopes of hills facing the smelters. Of the Oaks the following order of resistance was noted: *Quercus alba, Q. prinus, Q. coccinea, Q. palustris, Q. digitata, Q. minor, Q. marylandica, Q. velutina*, and *Q. triloba*.

The element of the smoke that is the chief cause of injury is undoubtedly SO_2. Haywood ascribes the injury to this gas. The usual form of acute injury to deciduous trees consists of irregular, reddened areas of dead leaf tissue between the veins. The region in the immediate vicinity of the midrib and principal veins of the leaves is last to be affected. Repeated acute injury of this sort kills the twigs of the trees, and finally brings about the death of whole trees. Few conifers are found in the region of acute injury, and no observation of these was made.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHYSICS.—*The history of Ohm's law.* J. C. SHEDD and M. D. HERSEY. Pop. Sci. Mo., **83**, 599–614, December, 1913.

The earlier part of this paper gives an outline of the experimental development of Ohm's law in the hands of Cavendish and others using the static discharge; of Barlow, who, using the steady current from a voltaic pile, concluded that the resistance of a conductor varies with the square root of its length; of Cumming, who was led to this same conclusion; of Davy, who discovered that wires having the same ratio of length to cross-section offered the same resistance; of Becquerel, who was the first to show that the resistance of a wire varies directly as the length and inversely as the cross-section; and finally in the hands of Ohm himself, who, publishing first a radically incorrect relation, gradually arrived at the present complete form of the law which bears his name.

The latter part of the paper endeavors to trace the sequence of ideas in Ohm's mind, and also to explain the origin of the misconceptions regarding his work which prevailed for so many years among scientific men. M. D. H.

PHYSICS.—*The Pentane Lamp as a working standard.* E. C. CRITTENDEN and A. H. TAYLOR. To be published in the Bulletin of the Bureau of Standards and in the Transactions of the Illuminating Engineering Society.

The best standards of candlepower are electric incandescent lamps, but it is not always practicable to use them. Of the various flame standards the Harcourt 10-candle pentane lamp appears to be the best for general use. This lamp has the disadvantages of being large and not easily portable, of using fuel which is expensive and somewhat dangerous, and of requiring more air than ordinary ventilation will supply, but in spite of these faults its use is increasing rather rapidly.

The candle power is not usually exactly ten, and the exact value must be determined by a photometric test. The intensity is affected by atmospheric conditions, but when the proper corrections are made a given lamp will repeat its value very closely.

It is found that the pentane commercially obtainable increases in density rather rapidly by the fractional distillation which occurs in the lamp. The density (at 15°C.) should be between 0.6235 and 0.626, but it usually reaches 0.635 when a little over half of the liquid has been used. Beyond this point there is a marked increase in the intensity of the flame. For an approximate correction, the variation may be assumed to be linear and to be 1 per cent in candle power for each 0.01 in the density of the liquid.

When the lamps are operated in a well ventilated room the most important cause of variation is the humidity. Water vapor in the air lowers the intensity of the flame and variations due to that cause may exceed 15 per cent. Previous work at the Bureau of Standards[1] has indicated that 1 per cent. of water vapor in the air causes a decrease of 5.67 per cent. in the candle power of the flame, whereas the correction officially established in England is 6.6 per cent. The present paper gives further data based on about 75,000 individual photometer settings on 27 lamps, including all lamps tested in 1911 and 1912 whose tests have extended over a range of 0.5 per cent or more of water vapor in the air. The mean result is an exact check of the correction factor previously found at the Bureau.

To facilitate the reduction of observations to normal candle power a chart is given from which the departure of a lamp from normal value can be read directly when the barometric pressure and the readings of the wet and dry bulb thermometers of a ventilated hygrometer are known. The chart is plotted for a pentane lamp, but it may be applied to other flames without introducing serious errors. E. C. C.

GEODESY.—*Triangulation on the coast of Texas, from Sabine Pass to Corpus Christi Bay.* CHARLES A. MOURHESS. Special Publication No. 17, U. S. Coast and Geodetic Survey, 1913.

This publication contains the results of the triangulation of the U. S. Coast and Geodetic Survey and the Engineer Corps, U. S. Army, along a portion of the coast of Texas. The earliest observations involved in this work were made in Galveston Bay in 1850, and the most recent work was completed in 1912. The geographic positions of over 700 points, all correlated to the same geodetic datum, are given, together with a complete description of all permanently marked stations. A series of

[1] Rosa and Crittenden, Transactions Illuminating Engineering Society, **5**, 753, 1910.

sketches and an index of stations make it possible to find readily the data for any given locality. The triangulation is tertiary in character, which makes it reasonably certain that the length of any line in the main scheme is known with an accuracy as great as one part in ten thousand.

C. A. M.

BOTANY.—*Plants of the Alpine Club expedition to the Mount Robson Region.* PAUL C. STANDLEY. The Canadian Alpine Journal, special number, pp. 76–79, pl. 1–5. 1913.

The special number of the Canadian Alpine Journal, of which this paper is a part, contains a report upon an expedition undertaken by the Alpine Club of Canada in 1911 to explore Jasper Park, Yellowhead Pass, and the Mount Robson region in British Columbia and Alberta. The first three papers consist of a report upon the mammals, by Mr. N. Hollister, one upon the reptiles and batrachians by Mr. Hollister, and one upon the birds, by Mr. J. H. Riley.

The plants reported upon were collected by Mr. Hollister and Mr. Riley while engaged primarily in collecting mammals and birds, no attempt being made to secure a complete representation of the flora of the region. One hundred and forty-seven species are listed, five of them (*Cryptogramma acrostichoides, Vagnera pumila, Ophrys convallarioides, Orchis rotundifolia, Artemisia laevigata*) being illustrated by photographs. Four new species were described from the collections previous to the publication of the final report. Several of the species collected in the Mount Robson region represent notable extensions of range.

P. C. S.

ZOOLOGY.—*Two interesting mammals from the island of Tobago, West Indies.* AUSTIN H. CLARK. Annals and Magazine of Natural History, (8), **13,** no. 73, pp. 68–70, 1914.

In this paper are recorded specimens of *Marmosa tobagi* Thomas, and of *Dasypus novemcinctus hoplites* G. M. Allen from the island of Tobago.

The distribution of the species of the genera Marmosa and Dasypus in the West Indies is given, and it is suggested that, while probably endemic on Tobago, the mouse-opossum was possibly introduced into Grenada and the Grenadines by man.

A sketch of the history of our knowledge of these interesting forms is given, and it is pointed out that, while armadillos were reported from Tobago so long ago as 1658, and from Grenada in 1667, the animal occurring on Grenada was not specifically determined until 1911, while that on Tobago has up to the present time remained quite unnoticed by mammalogists.

A. H. C.

ZOOLOGY.—*Sopra una piccola Collezione di Onychophora da Australia.* Austin H. Clark. Zoologischer Anzeiger, **43,** no. 7, pp. 316–319. January 7, 1914.

This paper is based upon a small collection of onychophores sent to the author by Prof. R. Hamlyn Harris, the Director of the Queensland Museum, at Brisbane, Queensland.

The species represented in the collection are *Peripatoides gilesii* Spencer, *P. orientalis* (Fletcher) and *P. oviparus* (Dendy).

In an appendix is given a complete list of all the species of onychophores known from the Australian region (including New Britain, New Guinea and the Moluccas), with the habitat of each in detail. A. H. C.

TECHNOLOGY—*Surface insulation of pipes as a means of preventing damage by electrolysis.* Burton McCollum and O. S. Peters, Bureau of Standards. Technologic Paper No. 15. (In press.)

An investigation of the subject of surface insulation of pipes as a means of preventing damage to underground metallic structures by stray currents from electric railways has recently been completed at the Bureau of Standards. Tests were made of the various substances available for the purpose of insulation of underground structures, including paints, pitch and asphalt dips, pitch and paper and asphalt and felt wrappings, and so forth. Test specimens were made by lining shallow sheet iron cones with the material to be tested. Before being subjected to the final test each cone was filled nearly full of ten per cent salt ($NaCl$) solution and an alternating difference of potential of 80 volts (effective) applied across the coating for thirty seconds in order to be sure that it was continuous and without flaws. A milli-ammeter in series with the specimen indicated a defective coating by a kick of the needle. The electrical resistances of the perfect specimens were then approximately determined with a Wheatstone bridge. In the case of the paints these resistances were found to be of the orders of from 10^5 to 10^{11} ohms per square centimeter while for the wrappings they were much higher.

The final test of the specimens which survived the preliminary test consisted in allowing water and air alternately to come in contact with the coating while a direct potential difference of either 4 or 15 volts was applied across the coating. The value of the voltage applied depended on the thickness and other characteristics of the coating. In some of the specimens made up from each material the iron of the cone was made negative and in others positive, while in the case of the paints some of the specimens were subjected to the alternate action of air and water with no potential difference applied in order to check up the effect of the electric stress.

The alternating contact with the coating of air and water was obtained by filling the cone and allowing the water to evaporate which took about a week. Readings of the current flow were made at suitable intervals. The first appearance of current flow was taken as indicating the end of the useful life of the specimen as an insulating coating.

The average life of the paints was about one hundred and sixteen days, the maximum life obtained from any specimen being but little more than a year. No conclusive evidence was obtained that the low potential differences applied had any effect in hastening the initial failure of the coatings. The wrappings lasted longer than the paints and dips but none of them much more than four hundred days. It seems from the results that the failure of the coatings must be caused by absorption by them of water which in time penetrates to the iron, allowing current to flow and destroy the coating by electrolysis. After the first appearance of current flow the destruction of the coating was observed to proceed very rapidly.

The conclusion drawn from the results of the laboratory tests, i.e., that the protection against electrolysis which is obtained by wrapping or painting pipes or other metallic bodies for use underground is only temporary, is borne out by tests on insulated pipes buried in the ground under practical conditions, and also by correspondence with gas and water companies whose experiences lead to the same conclusion.

B. McC.

TECHNOLOGY—*Industrial gas calorimetry.* C. W. Waidner and E. F. Mueller. To appear as a Technologic Paper of the Bureau of Standards.

After reference to the more important types of calorimeters that have been applied to the measurement of the heating values of gases, the principle of the flow calorimeter is set forth, and an example is given showing the reductions of, and corrections to the observed data that are required in order to find the total and net heating values.

The results of an experimental investigation of laboratory gas meters, showing the errors to which such meters are liable, the precautions to be observed and the accuracy attainable in their use, are given at length. It is shown that an accuracy of about 0.2 per cent may be attained if the meter is calibrated in situ at the time of use, and that the calibration may be reproduced from time to time by making suitable adjustments, to an accuracy of about 0.5 per cent.

The results are given of an extended series of investigations of the various factors that may affect the accuracy of heating value determinations with flow calorimeters, such as: Completeness of combustion; accuracy of the temperature measurements; the magnitudes of the various heat losses from the calorimeter, particularly as affected by the volume of the entering air and of the products of combustion and by the atmospheric humidity; and the accuracy of measurements of the quantities of water and of gas. The effects of certain other factors, which depend on the nature of the gas tested and are particularly noticeable in the testing of illuminating gas, are briefly considered.

The results are given of an extended series of experiments with natural gas and with nearly pure hydrogen which show that, when the necessary corrections for losses of heat from the surface, for the effect of atmospheric humidity, etc., were applied to the observed heating values obtained with flow calorimeters of suitable design and construction, the total heating values thus found were in agreement to about 0.3 per cent with the total heating values obtained with calorimeters of the Berthelot bomb type, provided due allowance was made for the difference between the heat of combustion at constant pressure and the heat of combustion at constant volume. The results obtained with illuminating gas indicated that the heating values obtained with the Berthelot bomb type of calorimeter were probably in error, being too low (about 1 per cent), but further investigation will be required to determine the cause of the discrepancy found.

The summarized results are given of a critical investigation of eight flow calorimeters, representing types widely used in this country or abroad, and of one calorimeter of the comparison type.

The investigation has shown that several of the calorimeters that were investigated could be used, when proper precautions were observed and suitable corrections were applied to the observed heating values obtained with them, to determine the total heating values of most kinds of gases to an accuracy of about 0.3 per cent. Some of the calorimeters are, however, subject to constant errors that cannot be eliminated or be readily determined except by comparison with a standard instrument, such errors for one calorimeter amounting to nearly 2 per cent.

Examination of a very large amount of data obtained during the investigation indicates that with those calorimeters free from significant constant errors, total heating values should be determinable, under conditions obtaining in the practical testing of gas, to an accuracy of the order of 1 per cent.

C. W. W. and E. F. M.

TECHNOLOGY—*Some leadless fritted glazes.* E. T. MONTGOMERY. Bureau of Standards Technologic Paper. (In press.)

In the manufacture of American whiteware, china and porcelain and of English bone-china, a glaze composed of borosilicates of the alkalies, lime, lead and alumina maturing at a relatively low temperature (about cone 3, approximately 1100°C) is applied to a body previously fired to the desired maturing point for the given body, approaching vitrification more or less closely. It is essential in this process that the maturing point of the glaze be considerably below that of the vitrification temperature of the body in order to avoid, in the glost fire, undue softening of the body and consequent deformation and loss. To accomplish this purpose and at the same time to secure their inherent qualities of long temperature range, brilliancy and low viscosity, such low fusing glasses as borosilicates containing lead oxide are employed.

Chiefly on account of the poisonous nature of the lead compounds used in making these glazes, the subject of leadless glazes has aroused the interest and has received the serious attention of both technical ceramists and of manufacturers for many years. The present work was undertaken for the purpose of investigating the merits of the various types of leadless glazes thus far reported, of studying their properties and possibilities, of improving them if possible; and of making a general comparison from a technical standpoint, between lead and leadless glazes for whiteware and china at a glost heat of Segar cone No. 3 (approximately 1100°C).

To this end numerous series of glazes were made up, being so planned as to include a number of previously reported leadless glazes of merit, and all methodically arranged in such a way as to fully cover the range of composition which it was believed desirable to study. All of the glazes were tested over six standard underglaze colors of known composition and all of their properties were studied in direct comparison with a standard whiteware or china glaze made with lead, half of each trial being dipped in this standard lead glaze and half in the leadless test glaze.

The results of this investigation developed many interesting technical points both in regard to leadless glazes in themselves and in comparison with lead glazes. In general, we may say that while lacking some of the valuable characteristics and qualities of lead glazes, leadless glazes have a few distinct advantages of their own. On the other hand, it is the writer's opinion that it would be premature at the present time to say that we can make a leadless glaze for whiteware, china or porcelain which could be substituted for the present lead glaze. E. T. M.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

A special meeting of the Anthropological Society of Washington was held at 4.30 p.m. December 9, 1913, in the National Museum, the president, Mr. Stetson, in the chair. About fifty persons were present.

Dr. CHARLES B. DAVENPORT of the Carnegie Institution, director of the laboratory at Cold Spring Harbor, Long Island, addressed the Society on *Man from the standpoint of modern genetics*. He said that the problem of the origin of species has now become largely reduced to the problem of the origin and survival of the characters of the species. Since groups differentiated by a single character are called biotypes, the question of the origin of species is now that of the origin of biotypes. Man is a congeries of biotypes. If these do not exist as distinct elementary species it is because of the tremendous hybridization that is taking place between biotypes. These biotypes are most nearly realized in islands, peninsulas, and out-of-the-way places. The most distinct of the human races exist today in such places as Australia and Ceylon, the Japan Islands (Ainos), Cape Horn, and inside of the Arctic circle within the old and new world. But in small islands off the coast, where people have been long settled and little disturbed, they tend to approach a pure race or biotype.

Under the shelter of this isolation, incidentally, opportunity has been afforded for an adjusted race to spring up; but there is danger of deterioration thru too close inter-breeding. Hybridization, as stated, is constantly preventing the complete development of these biotypes. This hybridization has gone on with man since early times so that few biotypes are now actually realized. It is now going on faster than ever and even the rare fairly pure biotypes are fast disappearing from the globe. The work of the anthropologist of the future must be largely with these hybridized biotypes; his principal study will be the inheritance of the various differential traits.

The method of inheritance of some of these traits has already been studied. Thus we know that the brown iris is dominant over its absence, as seen in blue eyes. The skin color of the negro is complex, being due to two double (or four) factors; and these may work independently of one another, so that we have over two, three, or four pigment factors in the skin, producing the typical quadroon, mulatto, Sambo, and full negro skin coloration. Dark brown hair is dominant over blond hair; so that when both parents have only blond hair the children are all blonds. Two red-haired parents have only red-haired offspring. But two glossy black-haired parents may carry red hidden and so have red-haired children, as we so often see among the Irish. Kinky or curly hair is dominant over straight. Two straight-haired parents have, typically, only straight-haired children.

Many "hereditary diseases" depend on a "diathesis," a non-resistance that is clearly inherited, and if matings of like or of relations occur extensively we have the elements necessary for the production of a biotype. Among such diseases are Huntington's chorea, presenile cataract, and night blindness. Other diseases are inherited as sex-linked characters—such are color blindness and the "bleeding tendency." Very striking is the tendency to produce a real biotype of the imbecile class, because imbeciles tend to segregrate themselves and to inter-marry. This is the reason why we get such histories as the Nams of New York, the Hill Folk of Massachusetts, the Pineys of New Jersey, and the Jukes of New York. Any condition that favors consanguineous matings, or matings of likes, favors the formation of a variety of the human race, as Dr. Alexander Graham Bell (the Francis Galton of America) long ago pointed out. Thus most institutions which do not provide permanent custodial care tend to promote such marriages; for example, among the deafmutes, tubercular, nervous paupers, and even alcoholics and users of narcotics. On the other hand, in consequence of social stratification, fine near-biotypes, like the Lowells of Boston, the Dwight Woolseys of Connecticut, the Bayard-Jay-Livingston complex of New York, and the first families of Virginia have arisen. Actors tend to marry each other and so rapidly produce nearly pure strains of histrionic talent. This nation owes more than it recognizes to its strains of inventors, surgeons, commanders, statesmen, authors, artists, and financiers that have made her famous and given her the high standing she has attained in the family of nations.

Thus biotypes in man prove to be real things and their study is quite as much within the proper field of research of the anthropologist as are the commonly recognized races of men.

The paper was discussed by Doctor Hrdlička.

At the 470th regular meeting of the Society held December 16th, 1913, James Mooney, of the Bureau of American Ethnology, delivered an address on *The Gaelic factor in the world's population.* The speaker dealt chiefly with the Irish Gaels and drew a distinction between the Irish of native Gaelic stock and the unassimilated alien element massed in several of the northeastern countries as the result of the "Plantations" under James I and Cromwell. This alien element was of English and Lowland Scotch stock, with a slight Highland Gaelic infusion, Protestant in religion and mostly Unionist in politics, while those of the old native stock were as solidly Catholic and Nationalist. Speaking broadly, in Ireland the Catholics represent the original Gaelic stock; the Episcopalians, those of English stock; and the Presbyterians and Methodists, those of Scotch origin, constituting respectively about 74, 13, and 11 per cent of the total population. The present Gaelic race of Ireland is a blend of the Gael proper, a Keltic people who arrived in the country probably from northern Spain about 1000 B.C., and of all other races who preceeded or followed them up to the end of the thirteenth century, including the neolithic man, the unknown megalith builders, the dark haired Firbolg, the Picts, Danes, Normans, and Welsh. The Irish immigration to the American colonies previous to the Revolution was mainly of the alien Scotch and English element, known sometimes as Scotch-Irish. The Gaelic Irish immigrants did not begin to arrive in any great number until after the war of 1812, excepting in Maryland.

The wars growing out of the Reformation and the Stuart contests reduced the Irish race from an estimated 2,500,000 in 1560 to about 960,000 at the end of the Cromwellian war in 1652. In 1845 it reached its maximum estimate of 8,500,000. Then came the great famine of 1846–47. Within three years nearly 1,500,000 perished of hunger or famine fever. By the great flood of emigration Ireland has lost virtually one-half of its population within sixty years. In 1911 it stood at 4,390,219, the lowest point reached in over a century. Owing to governmental and economic conditions this decrease has been chiefly at the expense of the old native Gaelic stock rather than the Planter stock, the Gaelic percentage, as indicated by the religious statistics, having fallen from 83 to 74. In the sixty years ending March 31, 1911, according to the official British figures, 4,191,552 emigrants left Ireland, or nearly as many persons as are now living in the country. About 3,000,000 of these came to the United States, the total Irish immigration to this country from 1821 to 1900 being, officially, 3,871,253. From 1821 to 1850 the Irish constituted nearly one-half of all our immigrants. Previous to the Revolution the "Scotch-Irish" immigration was so great that in an official Parliamentary inquiry in 1778 it was asserted that nearly one-half the American Revolutionary Army was of Irish origin. Since 1870 the number of Irish-born in the United States has steadily decreased, by death and dwindling immigration. According to the census of 1910 there are now in the United States: Irish born, 1,352,155; American born of full Irish parentage, 2,141,577; American born, one parent born in Ireland the other in the United States (in most cases the result of an Irish immigrant marrying an Irish American), 1,010,628. Total of Irish birth or parentage, 4,504,360. This does not include any of the 811,000 non-French Canadians in the United States, of whom a large proportion are of Irish blood, or any of the 876,000 coming from England, of whom also a large number are of Irish origin. Neither does it include any of the 1,177,000 American born "of mixed foreign parentage," including such parentage combinations as Irish and German, which alone probably runs above fifty thousand. Among the states, New York stands first, with 1,091,000 of Irish birth or parentage; Massachusetts second, with 633,000; and Pennsylvania third, with 570,000. For all these figures it may be asserted that more than four-fifths are of Gaelic stock.

By the latest British census, 1911, the population of Ireland was

4,390,219, of whom all but 157,037 were native born. Of the native born about 74 per cent or 3,245,000 represent the old Gaelic stock. By the same census there were 375,325 persons of Irish birth then living in England and Wales, while an unofficial estimate puts those in Scotland at about 220,000, or nearly 600,000 for the whole island, which with the children of Irish parentage would probably total at least 1,500,000. The same census gives 139,434 Irish born to Australia, or perhaps 350,000 of Irish blood. South Africa and the other British colonies, exclusive of Canada, have 100,000 of the same stock, while Canada has in round numbers 990,000 of Irish birth or parentage, of whom about 750,000 are of Gaelic origin, as indicated by religious denomination. Outside the countries already named, Argentina has some 15,000 Irish born and the rest of Latin America possibly as many more, with perhaps another 15,000 or 20,000 scattered over the rest of the world. To sum up, the the total Irish-born population thruout the world is now about 6,875,000 or about 1,625,000 less than the population of the home country alone in 1845, while the whole number of unmixed Irish blood may be about seventeen million, of whom nearly fifteen million are of Gaelic stock. The total Gaelic population—Irish, Scotch and Manx—of fairly pure stock and racial identity, in every part of the world, probably numbers close to twenty million.

At a special meeting of the Society held on January 6, at the National Museum, Dr. Truman Michelson of the Bureau of American Ethnology, delivered an address, *Notes on the Fox Indians of Iowa.*—Their own native name is Meskwa'ki'Ag^{i}, "Red-Earths;" the French name, *les Renards*, is derived from the appellation of a single gens, Wāgō'Ag^{i}, "Foxes;" the English name "Foxes" is a translation of the French *les Renards*; the term "Outagamies" (and variants) is derived from the Ojibwa UtAgāmīg, "they of the other shore." Their closest linguistic relations are first with the Sauk, then the Kickapoo, then the Shawnee, and then the so-called Abnaki tribes. They are also comparatively close to the Menominee and Cree as compared with the Ojibwa, Ottawa, and Potawatomi. The thesis that the Foxes were once an Iroquoian people and subsequently took up an Algonquian dialect cannot be substantiated. There is presumptive evidence that the Foxes were once in the lower Michigan peninsula. However their proper history begins in the last half of the seventeenth century in Wisconsin on the Wolf and Fox Rivers. The long French wars broke out in the early part of the eighteenth century. Even the transportation of Kiala (that is, Kyanāw^{a}) by De Villiers to Montreal, and his subsequent exile to Martinique, did not break their spirit; and De Villiers paid for his overconfidence with his life. Soon there was peace with sporadic outbreaks till Beauharnois' recall, when war began again in earnest. However the Foxes assisted the French against the English. After the overthrow of French power in Canada the Foxes were favorable to the British interest. The fraudulent treaty of 1804 with the United States was probably responsible for the Foxes siding with the British in the war of 1812, and the subsequent troubles which culminated in the famous Black Hawk war. The Foxes claim that as a body they took no part in this. However owing to continued disturbances with Indians and the pressure of white settlers, the Sauks and Foxes sold their remaining lands in Iowa and agreed to remove to Kansas. Nevertheless small bands of the Foxes returned continually to Iowa, and it is even likely that a number of individual Foxes never did remove to Kansas. In 1856 the Iowa legislature passed a bill enabling the Foxes to settle in that state. Accordingly they purchased land with their own money, near Tama, Iowa. From time to time this has been added to till they now own about 3000 acres. The main body of the Foxes as a matter of fact did not leave Kansas till the outbreak of the Civil War when MAmīnwānigä[a], the Fox chief, was unwilling to sign a proposal to allot the Sauks and Foxes in Kansas. He was deposed from his chieftainship by the agent for this reason and he went to Iowa with nearly all the Foxes. In 1896 the state relinquished jurisdiction of the Foxes to the federal government, and at the same time certain claims of the Foxes against the Sauks were adjusted. There are some Foxes enrolled with the Sauks of Kansas and Oklahoma; the present population of those in Iowa is about 356.

As an abstract of Dr. Michelson's paper "Notes on the Social Organization of the Fox Indians," read at the recent meeting of the American Anthropological Association and largely incorporated in his present address, will appear in *Science*, the main facts of Fox sociology are here presented in but brief form. The tribe is divided into a number of exogamic gentes with animal names, which gentes perform certain courtesies for each other such as burial and acting as ceremonial attendants at clan-feasts. The tribe furthermore has a dual division in membership which is thus regulated: the first child, boy or girl, belongs to the side to which the father does, and so on alternately. The side the mother belongs to is immaterial. These divisions are not exogamic, and are not, as can be readily seen, in any fixed relation to the various gentes. The dual division figures prominently in clan-feasts, and not merely in rivalry in athletics, as has been thought. The folklore and mythology of the Fox Indians is rich. A comparative study shows the contact of two cultures, namely, that of the woodlands, and that of the plains. European elements also enter into them.

At the 471st meeting of the Society, held January 20, 1914, at the National Museum, Mr. WM. H. BABCOCK, its recent Secretary, addressed the Society on *The North Atlantic Island of Brazil.*

The speaker suggested that the Island of Brazil, which is conspicuous as a round figure in the Atlantic in the latitude of southern Ireland on many mediaeval maps, may be the projecting northeastern corner of America, which includes the Gulf of St. Lawrence.

He exhibited twenty lantern-slide maps, beginning with a recent map to show first the obstacles which defeated many attempts to reach Brazil until John Cabot made his way thru; secondly the structure of the American region above mentioned, which has islands in its included expanse of water, also a curved north and south water passage from the strait of Belle Isle to that of Cabot, dividing the land mass in two and leaving Newfoundland cut off in front, also the true position of islands, moved unduly far toward Europe on the mediaeval maps; also the three present Brazils—that in South America, dating from soon after 1500; that in Terceira of the Azores, from before 1351; and the still surviving tradition of the West-Irish peasantry of a great Brazil west of them, which goes back on the maps to 1325 and as a man's name beyond history.

The maps of Dalorta 1325, Dulcert 1339, the Atlante Mediceo 1351, the Pizigani 1367, the Catalan Atlas 1375, Pinelli 1384, Giraldi 1426, Beccaria 1435, Bianco 1448, a fifteenth century map, perhaps 1480, copied by Nordenskjold, Prunes 1553 and others were given to show the persistency of the tradition among geographers as to form and latitude. The Catalan map and another also show the island as including a sheet of water containing islands. The map copied by Nordenskjold and that of Prunes are instances of the island divided by the curved north and south channel. The former of these two shows also a second Brazil below Illa Verde, recognized as Greenland, which must mean Labrador, or Newfoundland or the region including them.

It is no doubt (like Bianco's map above) an instance of retaining two traditions in one showing. Sylvanus 1511, Cantino 1502, an anonymous Portuguese map 1502, and Schoner 1520 were presented as instances of bringing this region eastward on the maps and comparatively near to Ireland; Nicolay 1560 and Zaltieri 1566, as instances of shifting Brazil on the maps over into Newfoundland waters after the width of the Atlantic had become well known. Coppo, 1528, was given as an instance of American land masses interpreted as islands—especially Greenland, called Isola Verde. The Pizigani map records pictorially a disastrous Breton expedition to some region southwest of the circular Brazil and bearing the same name.

Outside of Ireland the word is first found in the expression "grana de Bresile"—grain of Brazil—of a list of commodities embodied in a commercial treaty dated 1193 between Ferrara and one of her Italian neighbors. In Ireland "Brazil" or "Breasail" is very ancient, having been borne by a prehistoric celebrity and a sixth century saint.

This latter fact and the correspondence in direction and geographical features of the North American region in question with the mediaeval map-island of Brazil make the suggestion of some very early visit to America by some one who spoke Irish well worthy of consideration.

DANIEL FOLKMAR, *Secretary.*

THE BOTANICAL SOCIETY

The 93d regular meeting of the Botanical Society of Washington was held at the Cosmos Club, Tuesday, January 6, 1914, with 42 members and 5 guests present.

Application for membership of Messrs. H. Pittier, Arno Viehoever, and Raymond B. Wilcox were read. Messrs. Charles Thom, Charles S. Ridgway, George D. Clark, Clarence W. Carpenter, William A. Dayton, Orlo A. Pratt, and Nathan R. Smith were elected to membership.

Mr. F. L. Lewton called attention to the discovery of the records of the Washington Botanical Club, a predecessor of this society from 1898–1902. He stated that these records were missing when the history of the society was written up a few years ago, and also gave a brief review of the club.

The scientific program was as follows:

Mr. Peter Bisset: *The James River Hybrid Walnut.* Lantern slides were shown of a walnut tree on the Rowe Farm, on the James River, opposite Lower Brandon, Va. The tree is 100 feet high, with a spread of 123 feet, altho until a recent storm the spread was 134 feet. At 4 feet from the ground the tree is 31 feet 3 inches in circumference, and at 6 feet from the ground is over 25 feet in circumference. At 12 feet from the ground it divides into 4 large branches, three of which are larger than any tree in the neighborhood. No one has any definite knowledge of the age of the tree, but as the old farm house was built about 200 years ago it is supposed that the seed was planted at that time. Its growth was probably rapid, judged from seedlings which attained a height of 5 feet 10 inches in one season, as compared with 3 feet in seedlings of *Juglans nigra* which grew beside them. A seedling planted nearby about 1860 is now $2\frac{1}{2}$ feet in diameter and of the height of the parent tree. The characters of the leaves and nuts are such as to suggest a possible hybrid origin. The pubescence of the branches and leaves agree with *Juglans cinerea* and the fruit and other leaf characters suggest *Juglans regia* instead of *J. nigra*. The nuts are of low vitality and very thick shell.

Dr. G. G. Hedgcock: *Smelter Injury in Southeastern Tennessee* (with lantern), published elsewhere in this Journal.

Dr. D. N. Shoemaker: *Some Chinese Horticultural Brassica Species* (with lantern). Horticultural Forms of Chinese Brassicas in the United States at present are:

Three well marked varieties of Mustard, *Brassica juncea*. These are well established in the American Seed Trade.

Four types of non-pungent Brassicas, of uncertain specific relations:

1. The heading forms, Chinese name *Pai Tsai*. These make long heads resting on the surface of the ground, and present many varieties. 2. A form with long broad petioles, and long light green leaf blades, the veins of which are quite prominent. 3. A form with very broad short flat petioles, and dark green leaf blades. These usually send up swollen seeding stems. 4. A very loose-leafed round-petioled form, used by the Chinese as a summer vegetable.

P. L. Ricker, *Corresponding Secretary.*

THE CHEMICAL SOCIETY

The 233d Meeting was held on Monday, December 22, 1913, at the Cosmos Club. Prof. Earle B. Phelps, of the Hygienic Laboratory, lectured on *Recent advances in sewage chemistry.* The chemistry of sewage has been developed by a process of evolution from the older water chemistry, but with our present conception of the purposes of sewage disposal and of the objections to stream pollution, the older scheme of sewage analysis has failed to yield results commensurate with the labor involved. In place of the nitrogen cycle of water chemistry we are substituting a carbon cycle with special reference to the oxygen relations. The difficulty of dealing analytically with the reactions that are involved in the oxidation of sewage under artificial or natural conditions makes it necessary to employ indirect methods for this purpose.

"The oxygen requirement" of a sewage or effluent is defined as the amount of oxygen which will be eventually consumed by the organic matter when that sewage or effluent is brought into equilibrium with oxygen-saturated water. The "relative stability" of a given effluent or polluted stream is similarly defined as the relation between the available oxygen in the mixture in the form of free dissolved oxygen, nitrites, and nitrates, and the total oxygen requirement of the organic matter as defined above. This establishes a practical working method for the determination of the degree of purification of a sewage or of the degree of pollution of a stream.

The actual determination of relative stability is made by the use of methylene blue as an indicator for the oxygen-zero point. By the application of the methods of physical chemistry the reaction has been shown to be of the first order and from the time required to decolorize methylene blue one determines the relative stability ratio. A more direct and generally applicable method is the actual determination of dissolved oxygen before and after a period of incubation. These data give directly the velocity of the reaction and its probable future course. By the application of these newer methods the study of stream pollution is being placed upon a quantitative scientific basis (Author's abstract).

Discussion: In reply to inquiries by Sullivan, Gore, S. T. Powell, and Bunzel, the following points were brought out: The deficiency in oxygen is the factor which harms fish in streams. The effect of sewage on oysters is entirely a hygienic, not a chemical question. "Available oxygen" includes free oxygen, nitrites, and nitrates, but no other sources of oxygen. Acidity and alkalinity also enter as factors in the rate of reaction.

Medical Director Ames, U.S.N., who was a visitor at the meeting, discussed the question of coöperation between municipal chemists and sanitarians and manufacturers whose byproducts pollute streams, as well as various projects for utilization of sewage. Professor Phelps stated that our present knowledge of methods is in advance of our practice, because of the great expense of sewage disposal. The question of saving the sewage for agricultural purposes was discussed by Ames, Schreiner, Sullivan and Yoder. It was shown that the great dilution of modern American city sewage makes it almost impossible to utilize it for fertilizer, and that the concentrated sludge obtained by certain methods of concentration is also not utilizable; in China the sewage is very largely utilized, and in Hong Kong its disposal is a source of revenue to the city.

The 234th meeting was held on Thursday, January 8, 1914, at the Cosmos Club. The president appointed the following committees: Committee on Communications: H. C. GORE, Chairman, A. SEIDELL, E. C. SHOREY, W. BLUM, and J. JOHNSTON. Entertainment Committee: A. N. FINN, Chairman, J. G. RILEY, J. W. TURRENTINE, E. A. INGERSOLL, and J. C. HOSTETTER. The Secretary's and Treasurer's reports were read.

Dr. WILLIAM DUANE of Harvard University was presented by the chairman, and spoke briefly and informally on radium and the radium emanation, showing samples of both and illustrating their effect in producing phosphorescence in willemite.

The papers on the regular program were as follows:

L. F. KEBLER, of the Bureau of Chemistry: *Chemical investigations in tablet medication.* Medication by tablets has so many advantages that it has come into wide use, altho the invention is of comparatively recent date (1843). The speaker sketched the history of the patents and the development of modern rapid machinery for making various types and forms. A study has been made of the variations in weight of various tablets due to the kind of machine used. A variation of not over 2 per cent in the number made from a batch of given weight is claimed for some machines and materials. Satisfactory tablets should not vary more than 10 per cent. Fifty-four kinds of tablets made by single punch machines showed 44 per cent exceeding a 10 per cent total weight variation, and the rotary machine gave nearly the same results. The tablet triturates however showed best results by the single punch machine. Molded tablets (compressed by hand) showed 79 per cent with a total weight variation of 10 per cent or over. Variations in composition as determined by analysis (324 samples, 449 analyses) sometimes ran very high, 20 to 40 per cent variations, (usually below declaration) being fairly common. Nitroglycerin tablets showed the widest variation.

Discussion: In reply to inquiries by Yoder and Foster, it was stated that the filling of the molds is by volume only, and that each of the analyses reported on represents from 10 to 25 tablets as a sample.

WIRT TASSIN: *Metallography applied to inspection.* Failures of engineering structures whose members have passed all ordinary tests on sample pieces have frequently occurred, and have been usually laid to "fatigue" of the material due to repeated stresses. The failure of test pieces really to represent the properties of the structural member is becoming recognized as a frequent cause. The speaker described improvements in the apparatus which he exhibited before this Society at the meeting of February 13, 1913, and which is now being regularly used for examining directly large structural pieces in the foundry or shop. Slides illustrating the effects of various heat and mechanical treatments were shown and discussed.

ROBERT B. SOSMAN, *Secretary.*

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 729th meeting was held on November 8, 1913, at the Cosmos Club, Vice President Eichelberger in the chair; 38 persons present. The minutes of the 728th meeting were read and approved.

Mr. R. B. Sosman presented a paper, illustrated by lantern slides, giving the results of an investigation by himself and Mr. A. L. Day on *A method for determining the expansion of liquid metals.* After reviewing existing and rather conflicting data on the change in volume on fusion of various rocks, the apparatus designed for such volume determinations of metals and of solid and liquid silicates from 250° to 1600° was described. The fundamental constant is the expansion coefficient of artificial graphite given by formula $10^6\beta = 0.55 + 0.0016t$. Volume measurements on quartz up to 1600° show a dilatation which increases rapidly as the inversion point of 575° is approached. Above this temperature quartz contracts slightly. At about 1300° there begins a second and (under these conditions) irreversible dilatation. Granite has a curve of similar form. The volume of diabase glass was determined up to 1250° and compared with Barus' well-known values. A simple explanation of some of the conflicting features of his observations has been found.

The paper was discussed by Mr. Burgess.

Mr. A. W. Gray then spoke on *Some peculiarities of invar.* He described some of the results obtained by himself and previous observers in measuring the thermal expansion of invar. Numerous lantern slides were exhibited to show various peculiarities of the alloy, method and apparatus used by the speaker in determining expansivities, the precision obtained in measuring elongations by the use of both freely suspended and upwardly stretched wires, and the uniformity of temperature easily secured in an electric furnace of the type used for most of the work. One most striking feature is that at temperatures above about 170° invar may follow with considerable regularity either of two different expansion curves, without ever jumping from one to the other except, perhaps, when close to this critical temperature. Further above about 220° for the upper curve and about 280° for the lower one, the expansivity of invar appears to be identical with that previously found for a specimen of Bessemer steel. Under some conditions the same piece of invar may, at high temperatures, expand noticeably faster than Bessemer steel. Comment was made upon progressive shortening produced by repeated alternations of temperature between 20° and 150°.

J. A. Fleming, *Secretary.*

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ASTROPHYSICS.—*The solar constant of radiation.* C. G. Abbot.[1] Smithsonian Institution.

We live in a world warmed by the sun. While it is not to be expected that everybody will devote himself to the measurement of solar radiation, yet it is not surprising that many have concerned themselves with measuring the quantity on which all lives depend. So far as I am aware, this subject was not pursued by the ancients to such a point as to obtain measurements worth much present consideration. This is a great pity, for thus we lack proof whether the sun's radiation has changed progressively. Beginning about a century ago investigations of solar radiation were pursued with great assiduity by various observers. The need was almost immediately perceived of reducing the observations to represent conditions outside the earth's atmosphere, as for example, on the moon, so as to be independent of the haze and water vapor, and even of the gaseous constituents of the air. It is required to know the measure of solar radiation in free space as an index of the condition of the sun, quite apart from its influence on terrestrial affairs, but secondly it is of great importance and interest to apply this knowledge to promote meteorological inquiries.

Sir John Herschel, who was a pioneer in solar radiation work, proposed to express solar radiation in terms of a unit which he called the actine, which is based on the melting of ice. But by general consent, the gram calorie has been adopted as the unit of measurement, and we say that the "solar constant of radiation" is the number of calories per square centimeter per

[1] Address of the retiring president delivered before the Philosophical Society of Washington, January 3, 1914.

minute which would be produced by the complete absorption of the solar radiation in free space at the earth's mean solar distance.

Preparatory researches of great interest were made in the eighteenth century by Bouguer, Lambert, DeSaussure and Leslie. Determinations of the solar constant of radiation, however, may be said to have begun about eighty years ago with the investigations of Sir John Herschel, Principal Forbes, and Pouillet. The problem comprises two parts: First, to measure the intensity of the solar radiation at the earth's surface; second, to estimate the loss it has suffered in passing through the atmosphere. It will be convenient to consider the atmospheric influences briefly before taking up the methods of measuring the solar radiation, and then to return to a more thorough discussion of the atmospheric transmission.

Atmospheric transmission. The determination of the transmission of the atmosphere rests primarily upon the hypothesis of Bouguer, first put forward in 1729 and elaborated in Bouguer's posthumous work published in 1760. The late Dr. Langley has placed this matter in so very clear a light in his paper on the Amount of the Atmospheric Absorption[2] that I cannot do better than to quote from his statement.

> If a beam of sunlight enters through a crevice in a dark room, the light is partly interrupted by the particles of dust or mist in the air, the apartment is visibly illuminated by the light laterally reflected or diffused from them, and the direct beam, having lost something by this process, is not so bright after it has crossed the room, as before. In common language, the direct light, to an observer in the path of the beam, has been partly "absorbed," and the problem is, to determine in what degree. If a certain portion of the light (suppose one-fifth) were thus scattered, the beam after it crossed the room would be but four-fifths as bright as when it entered it; and, if we were to trace the now diminished beam through a second apartment altogether like the other, it seems, at first, reasonable to suppose that the same proportion (i.e., four-fifths of the remainder) would be transmitted there also, and that the light would be the same kind of light as before, and only diminished in amount (in the proportion $\frac{4}{5} \times \frac{4}{5}$). The assumption originally made by Bouguer and followed by Herschel and Pouillet, was that it was in this manner that our solar heat was absorbed by our atmosphere, and that by assuming such a simple progression the original heat could be calculated.

[2] Amer. Jour. Sci., third series, **28**: September, 1884.

If A_0 be the intensity of the original beam before entering the transparent medium whose transmission is to be investigated, then after the passage through the first stratum of unit thickness let us suppose a fraction of the original, represented by p, has passed through, so that what was A_0 becomes A_0p. Then since a second stratum identical with the first in constitution and thickness must, according to Bouguer's assumption, have an identical effect, the ray which was A_0 will emerge from the second stratum A_0p^2, and so on. The fraction p transmitted by the unit of thickness is the common ratio of a geometric progression, so that after passing through a thickness m of the medium, the intensity of the light which was formerly A_0 will become A_0p^m.

As the height to which the atmosphere extends in appreciable density is very small compared with the radius of the earth, the thickness of the layer traversed by a solar beam of a zenith distance not exceeding 70° is approximately proportional to the secant of the zenith distance of the sun at the time of observation. If we regard unit thickness as that corresponding to a barometric pressure of 760 mm. of mercury, then p in our formula corresponds to the vertical transmission coefficient of the atmosphere above sea-level, and for any station where the barometric pressure is B the intensity of the ray from the sun as it reaches the earth's surface, which we call A, may be expressed by the formula.

$$A = A_0p^{\frac{B}{760}\sec z}.$$

Some writers have preferred to use the formula as a formula of "absorption" rather than of transmission. In that way the expression reduces to a somewhat different form, but its fundamental principles are the same. The investigations of Herschel, Forbes, Pouillet and others up to the time of Langley had reference to this exponential formula, based upon the hypothesis of Bouguer, which was to the effect that successive equal layers of transparent material transmit equal fractions of the incident ray.

A convenient method of applying the atmospheric transmission formula is to take logarithms of both members of the equation so as to reduce the expression to the form of the equation of a straight line. Thus

$$\log A = \frac{B}{760} \sec z \log p + \log A_0$$

By this equation the intersept of the best straight line on the axis of ordinates is the logarithm of the intensity of solar radiation outside the atmosphere, and the inclination of the line to the horizontal is the logarithm of the atmospheric transmission for vertical rays.

The reader must bear in mind that the simple expression thus obtained is given only in illustration of the work of the earlier investigators, and it must be hedged about with certain conditions and limitations in order to apply it, as we shall see later, to the determination of the solar constant of radiation by the most approved methods.

Instruments. Herschel's actinometer: This instrument consists of a thermometer with a large cylindric bulb, containing a deep blue fluid (the ammoniacal sulphate of copper) and enclosed in a wooden case blackened interiorly and covered with a piece of plate glass. The thermometer has a very large bulb, and it is adjusted in volume by means of a screw, so as to regulate the position of the column of liquid on the thermometer scale. Herschel introduced what is termed the dynamical method of observing the solar radiation, for he obtained not the total rise of temperature of the instrument when long exposed to the sun, but its initial rate of rise, corrected for the cooling or warming of the thermometer due to external conditions when the sun is shaded. The determination of the cooling correction is done by observing the rise or fall of the temperature for a certain time interval before exposing to the sun, and again determining the rise or fall after such exposure to the sun is completed. The mean rate of warming or cooling, due to the surroundings, is applied as a correction to the rate of warming due to the exposure to the solar radiation.

Pouillet's pyrheliometer: A flat metal box, blackened on the front, and filled with water, has a thermometer inserted at the rear, extending away from the direction of the sun. The instrument, like that of Herschel, was exposed to the influence of the surroundings while shaded for a certain interval of time, the shade was then removed for a similar interval so as to allow the solar radiation to fall upon the blackened box, after which the instrument was again shaded. In practice it was found that the water within the box could not be well enough stirred in order to allow the average temperature of the water to be well ascertained. The instrument was greatly improved by Tyndall, who substituted mercury for water, and, in order to contain the mercury used iron in the making of the box.

Crova alcohol actinometer: A large spherical bulb thermometer containing alcohol, is enclosed in a nickel pated metal chamber with a vestibule for the entrance of the rays. The stem of the thermometer runs back, directly away from the sun, and is enclosed in a nickel plated tube with a side opening for reading the thermometer. A short mercury thread is introduced in the alcohol column at a suitable point for observing. The method of observing is the same as that adopted by Herschel and by Pouillet.

Violle actinometer: A large spherical double walled enclosure filled with water is kept at a known constant temperature. A spherical blackened bulb thermometer lies at the center of the enclosure, and the sunlight is introduced to it through a suitable vestibule in the double walled chamber. Violle's method of reading was static, as opposed to the dynamic methods we have just considered. He observed the total rise of the thermometer and its fall after the cutting off of the sun rays, noting the position of the column at fixed intervals after exposure and after closure. The theory of the instrument as developed by Violle is simple and elegant. As a standard the instrument is open to the objection that the water equivalent of the bulb of the thermometer is very small, and difficult to measure, and that several corrections, rather difficult of determination, should be applied. It was used by Dr. Langley in his expedition to Mount Whitney in 1881.

Ångström electrical compensation pyrheliometer: This instrument has had the most extensive adoption in recent years of any form of instrument for measuring solar radiation. It was invented about the year 1895. Two metal strips exactly similar to one another, and blackened upon the front, are exposed alternately to heating by the sun. Arrangement is provided for passing an electrical current through the strip which is not at the moment being heated by the sun. Thermo-elements, fastened to the back of each strip, indicate when the temperature of the exposed strip is equal to that of the strip which is electrically heated. Under these circumstances it is assumed that the energy of the electric current is equal to the energy received from the sun. About 160 copies of this electrical compensation pyrheliometer have been sent out from Upsala to different parts of the world.

Several other kinds of pyrheliometers have been used in recent years, among them two forms which have been devised by the writer. We shall have occasion to speak of these later.

Early observations. Forbes observed with the Herschel actinometer in 1832 at Brientz and the Faulhorn. He showed that the transmissibility of sun rays continually increases as the length of path of the ray in air increases. Forbes rightly attributed this to the non-homogeneity of the solar radiation, and the inequality of transmission of the different component parts of it. Under such circumstances Bouguer's formula of course cannot apply. Forbes concluded that equal barometric columns of air give equal transmission, whether taken from the high or low station. In this he was wrong. He formed an empirical curve to represent all his observations at both stations, employing air masses as abscissae and actinometer readings as ordinates. Instead of extrapolating this curve directly to air mass zero he preferred to find its tangents and thus derive the subsidiary curve of tangents from which he derived a formula for extrapolating his observations. In this way he obtained results corresponding to the value 2.85 calories per square centimeter per minute for the solar constant. Thus Forbes cut loose entirely from Bouguer's exponential formula of atmospheric transmission.

Pouillet observed in the years 1837 and 1838 at Paris. His work was published before that of Forbes, although done later.

He found transmission coefficients by means of Bouguer's formula. He apparently did not investigate the defects of this formula as thoroughly as Forbes did. His result for the solar constant of radiation is 1.7633 calories per square centimeter per minute. This value, on account of the non-homogeneity of the solar rays, is necessarily too low.

Quetelet observed with a Robinson actinometer, similar in form to Herschel's, at Brussels, from 1843 to 1853. These experiments might well repay a critical examination now, not for their value in determining the absolute measure of the solar constant of radiation, but in connection with the variation of the average intensity of the solar radiation from year to year as influenced by volcanic eruptions.

Desains employed a thermopile, and compared the transmissibility of the rays of the sun through a water cell at different stations. He found the transmissibility of solar rays through the water cell always increased by a long preliminary course through moist air. This result is essentially the same as that of Forbes, although obtained in a different manner.

Violle observed at many different stations, including Mont Blanc. His instrument apparently read much too high, as noticed by Langley in the report of the Mount Whitney expedition. He used a somewhat complicated empirical formula of extrapolation, as he was fully cognizant of the defect of Bouguer's formula, as indicated by Forbes. He obtained the following values:

	OUTSIDE ATMOSPHERE	MT. BLANC	GRAND-MULET	BOSSONS	PARIS
Altitude.........		4810	3050	1200	60
Barometer.......		430	533	661	758
Calories.........	2.54	2.39	2.26	2.02	1.74

These values should be reduced about one-fourth to make them comparable with observations made in recent years at high elevations by many observers. In such a case the value outside the atmosphere would become about 1.9 calories.

Crova made many observations at Mont-Pellier with his alcohol actinometer standardized against the Tyndall pyrheliometer.

He made some attempts to extrapolate his observations to the limit of the atmosphere, but these, like other solar constant values obtained by pyrheliometry alone, are not definitive. Great value, however, attaches to the long series of direct observations continued from 1883 to 1900 at Mont-Pellier. These show plainly the influence of the volcano Krakatau and others.

K. Ångström observed with the electrical compensation pyrheliometer at several stations at different altitudes on the island of Teneriffe in the years 1895 and 1896. Some of his measurements were made at the altitude of 3700 meters, and give direct readings of solar radiation as high as 1.63 calories per square centimeter per minute. Ångström declined to determine from these a value of the solar constant of radiation, recognizing that this demanded observations of the solar spectrum as well as pyrheliometric work. In later years he prepared spectro-bolometric apparatus for this purpose, and made many solar constant measurements therewith at Upsala. These measurements are still being continued there by his successors. It is hoped that this long and interesting series will soon be published.

Passing from this work of Ångström, which belongs in a later period, and omitting mention of valuable pyrheliometric observations by numerous observers in Italy, Switzerland, and Russia, which I regret that space forbids me here to discuss, attention must now be directed to the work of Langley, which marked an epoch in this kind of investigation.

Langley's observations. Prior to Langley's observations, there had been numerous attempts to determine the solar constant, which are well summed up in the excellent little book of Radau, entitled Actinometrie. It is shown that nearly all observers were in comparative agreement, so far as their actual observations go, and if the transmission of radiation by the atmosphere be estimated by the simple formula $A = A_0 p^{\frac{B}{760} \sec z}$ which was employed by Pouillet and many others, the value of the solar constant would be found in the neighborhood of 1.75 calories.

But Forbes, Desains, Violle, Crova and others showed convincingly that this equation does not accurately express the diminution of radiation attending the decline of the sun from zenith to horizon, or the descent of the observer from a high altitude to a lower one. Accordingly several empirical formulae of more complexity were proposed, which owing to their more numerous constants, could be made to fit the observed variation of the total intensity of radiation under different conditions more closely. By the aid of such empirical formulae higher values of the solar constant have been obtained. Some of these in our own time have gone as high as 4 calories. Radau however says "it is clear that the intensity of the solar radiation outside the atmosphere cannot be certainly obtained from experiments which have been made [prior to 1878] for the result depends essentially on the manner of calculation." This conclusion is still applicable to pyrheliometer measurements not supported by spectrum observations.

The tendency toward high values of the solar constant was powerfully stimulated by the publication of the report of the Mount Whitney expedition by Langley in 1884. As Forbes and Radau had stated, so Langley emphasized and acted upon the fact that the formula $A = A_0 p^{\frac{B}{760} \sec z}$ applies only to a homogenous bundle of rays in a pure atmosphere; and the intensity of solar radiation outside the atmosphere can be exactly determined only when the atmospheric transmission coefficients of the rays of all wave lengths, which go to make up the complex beam of the sun, are separately determined and allowed for. Langley was the first to determine and apply atmospheric transmission coefficients for numerous rays of different wave lengths in the solar spectrum. For this purpose he invented the bolometer, a delicate electrical thermometer, and observed with it the variation of the intensity of each ray of the spectrum from low sun to high. He found it impracticable to determine the transmission coefficients in the water vapor bands of the infra-red, but assuming that there were no water vapor bands in the solar spectrum outside our atmosphere, he avoided this difficulty by smoothing the spectrum energy curve, which he computed from his bolometric observations to represent the distribution of solar radiation outside the atmosphere, so as to leave no water vapor bands in it at all. Had Langley stopped with these steps accomplished, he would have left us as the result of the Mount Whitney expedition, 2.060 calories, the mean value as determined by high and low sun observations at Lone Pine, or 2.220 calories, the mean value similarly determined from observations at Mountain Camp. But, by the train of reasoning given on pages 142–144 of his report, he convinced himself that the exponential formula does not hold for the earth's atmosphere, even for a strictly homogeneous ray. He therefore altered his results by two different procedures, one of which he states was of a kind to give too low a value of the solar constant, and the other too high. By this means he obtained the values 2.630 and 3.505. The mean of these, 3.068, or in round numbers 3.0 calories per square centimeter per minute he adopted as the solar constant. But in fact, both procedures were calculated to give too high results, and the most probable results of Langley's observations lies below either of them, and is in fact 2.22, or 2.06 calories, according as the work at Lone or Mountain Camp is regarded as the better. In order to recognize this, it is necessary to examine the argument which led him to doubt the accuracy of the exponential formula, as applied to the transmission of homogeneous rays through the earth's atmosphere, but first let us consider the basis of the formula.

We have seen that Bouguer's formula rests on the fundamental assumption that the light is not changed in its nature in passing from one layer to another, so that equal layers take out equal fractions. This is not the case except for homogeneous rays. It is therefore necessary to divide the beam up into parts, each containing rays of approximately homogeneous transmissibility. For this purpose it is necessary to observe the spectrum of the sunlight by the aid of the bolometer or other satisfactory delicate heat-measuring instrument. Even so, it is not possible to observe the transmission of the atmosphere at every wave length, so as to determine the coefficients of transmission in the fine lines of absorption by water vapor and oxygen which are introduced by the earth's atmosphere. These lines are mainly grouped in the great bands made up of these fine lines which occur in the red and infra-red spectrum, and for them a special procedure must be adopted, as was introduced by Langley. In general, however, the bolometer suffices to give us atmospheric transmission coefficients in sufficient number to deal with the gradually changing transparency of the air for rays of nearly adjacent wave-lengths. The proof of the formula for atmospheric transmission for homogeneous rays follows. It will be seen that the formula is one of extrapolation solely, and is not applicable to computations of the transparency at different barometric pressures, unless it be the fact (which is not usual) that the quality of the air from the different stations to the limit of the atmosphere is approximately identical. This indeed may be the case at very high elevations of 4000 meters and over, but is not the case for ordinary observing stations, so that in the use of the formula of transmission it is generally erroneous to introduce the barometric pressure in the exponent as was done by Pouillet.

Proof of formula for transmission. Imagine the atmosphere to be made up of n concentric layers so chosen in thickness as to produce separately equal barometric pressures, and let the number n be so great that the transparency of any single layer is sensibly uniform, although the layers may differ from each other in transparency by any gradual progression. The index of refraction of air is so near unity that there will be no sensible regular reflection in passing from one layer to the next, and the transmission of each layer may be expressed exponentially by Bouguer's formula, but with different coefficients of transmission for the several layers.

Thus, suppose E_0 to be the original intensity of a beam of light incident upon the outermost layer at the angle whose secant is m.

Then after passing successive layers the remaining intensities become

$$E_1=E_0a_1^{m_1}, \quad E_2=E_0a_1^{m_1}\cdot a_2^{m_2}, \quad E_n=E_0a_1^{m_1}a_2^{m_2}\cdot\cdot\cdot\cdot a_n^{m_n}. \quad (1)$$

The value of the secant of the angle of incidence will change slightly in passing from layer to layer from two causes: First, the curvature of the earth; second, the refraction of the beam in air. These causes produce opposite effects, the first tending to increase the angle of incidence, the second tending to diminish it as the beam approaches the earth's surface. Their combined effect is dependent on the height to which the temperature exercises absorption and on the distribution of density with the height. But it is generally supposed that the absorption of the air above 40 miles from the earth's surface is negligible, and, remembering that the atmospheric density diminishes with the height, it appears that for zenith distances less than 70° the effect of change of the secant of the angle of the incident beam from the outermost to the innermost layer of the atmosphere will not introduce error greater than 1 per cent. Accordingly for zenith distances less than 70° we may write approximately

$$E_n = E_0(a_1 a_2 \; . \; . \; . \; . \; a_n)^m \tag{2}$$

The symbols a_1, a_2 . . . . a_n denote constants (providing no change of transparency occurs during the interval of time in question), and their values are slightly less than unity. We may substitute for their product a single constant, a, itself a proper fraction, and remembering that E_n is the intensity at the earth's surface, above denoted simply by E, we have

$$E = E_0 a^m \tag{3}$$

Limitations of formula. No mention is made in this expression, of the barometric pressure, but it is easy to see that an alteration of barometric pressure would signify, under the conventions adopted in deriving the formula, a change in the number of layers, n. This would cause an alteration of the quantity a, which is the continued product of the transmission coefficients of the layers, by introducing additional multipliers a_{n+1}, a_{n+2} . . . . or by the withdrawal of some a_{n-1}, a_{n-2}. . . . . Since we have no means of determining the value of the terms so introduced or taken away, there is no means of correcting for change of barometer in the use of the expression (3) and it would, for instance, be impossible to compute, from knowledge of the values of E, E_0, a, and m for one station, what would be the value of E at some station of different barometric pressure.[3]

From this we see that the unit of air mass to be taken for each station is the air mass traversed by beams from zenith celestial objects *between the station itself and the outer limit of the atmosphere*, not from sea-level.

The determination of the solar constant of radiation, based upon the demonstration which has just been given, depends upon the following assumptions:

1. In a homogeneous medium, a homogeneous ray loses a fixed proportion of its intensity in every equal length of its path.
2. The earth's atmosphere may be considered as made up of a great number of layers concentric with the earth, each approximately homogeneous in itself over the area swept through by the solar beam between zenith distances of 70° and 30° during the time required for this sweep of the beam.
3. Surface reflection of the outer boundary of the atmosphere, or the boundaries of its internal layers, is negligible.
4. Except in the known red and infra-red atmospheric bands, the transparency varies gradually from wave length to wave length, or if atmospheric absorption lines exist, the energy they absorb is inconsiderable.
5. Atmospheric bands do not exist in the solar spectrum outside the atmosphere.
6. The quantity of solar energy beyond $\lambda = 0.3\mu$ in the ultra-violet and beyond $\lambda = 3.0\mu$ in the infra-red is inconsiderable.

The soundness of these assumptions is best proved by the results of a great number of observations made at sea-level and at high altitudes during the last ten years by different observers, but mainly by the staff of the Astrophysical Observatory of the Smithsonian Institution.

Discussion of Langley's solar constant value. We may now perceive why the high solar constant value of Langley ought not to be accepted. For, consider lines 26 to 43 of page 144 of the Mount Whitney report, which detail the precise method em-

[3] This demonstration applies only to homogeneous rays.

ployed in obtaining what Langley regarded as a minimum value, namely 2.63 calories per square centimeter per minute:

> We now proceed to determine from our bolometer observations, a value which we may believe from considerations analogous to those just presented, to be a *minimum* of the solar constant, and one within the probable truth. All the evidence we possess shows, as we have already stated, that the atmosphere grows more transmissible as we ascend, or that for equal weights of air the transmissibility increases (and probably continuously), as we go up higher. In finding our minimum value we proceed as follows, still dealing with rays which are as approximately homogeneous as we can experimentally obtain them. Let us take one of these rays as an example, and let it be one whose wave length is 0.6μ and which caused a deflection at Lone Pine of 201. The coefficient of transmission for this ray as determined by high and low sun at Lone Pine and referred to the vertical air mass between Lone Pine and Mountain Camp is 0.976. From the observations at Lone Pine then, the heat of this ray upon the mountain should have been $201 \times 1000 \div 976 = 206.0$, but the heat in this ray actually observed on the mountain was 249.7, therefore multiplying the value for the energy of this ray outside the atmosphere, calculated from Mountain Camp high and low sun observations (275) by the ratio $\frac{2497}{2060}$ we have 333.3, where 333.3 represents the energy in this ray outside the atmosphere as determined by this second process. In like manner we proceed to deal with the rays already used, thus forming column 8 in Table 120.

It is evident that the transmission coefficient determined for the wave length 0.6μ by the aid of high and low sun observations at Lone Pine, represented the mean transmission of a ray of this wave length through a mass of air containing all the kinds of strata between Lone Pine and the limit of the atmosphere. Such a transmission coefficient would certainly be greater than that which would have been found if the air had all been like that between Lone Pine and Mountain Camp, because the lower layers are least transparent.[4] Therefore the value 0.976 could be known, *a priori*, *not* to represent the transmission of the air between Lone Pine and Mountain Camp, but to be certainly greater than the true transmission coefficient for the air between these stations. Accordingly the discrepancy between the computed and observed intensities at Mountain Camp is only what should be expected, and implies no failure of the formula of Bouguer at all; for that formula was used in the computation of the

[4] See Table 118 of the Mount Whitney report.

intensity at Mountain Camp just quoted with a coefficient p which was certainly wrong. The argument on which Langley acted may be stated in a plausible form as follows: If Bouguer's exponential formula with the transmission coefficient obtained by high and low sun observations at Lone Pine gives too low a value of the intensity of homogeneous solar radiation for a station within the atmosphere like Mountain Camp, as was shown by actual observation, much more will it give too low a value outside the atmosphere. An equally plausible, and equally fallacious argument is the following: It is said that the density of water decreases with increasing temperature at the mean rate of about 0.00041 per degree from 0° to 100°, but observations at 4° prove that water is actually denser at this temperature than at 0°, therefore the supposed decreased density at 100° is a delusion.

Solar constant work of the Smithsonian Astrophysical Observatory. The earlier years of the work of the Astrophysical Observatory were devoted to the improvement of the bolometer and the use of it for the determination of the positions of lines in the infra-red solar spectrum. About 1902 attention began to be devoted to measurements of the solar constant of radiation. We approached these measurements with a very much better instrumental equipment than that which had been Langley's in the Mount Whitney expedition of 1881. Soon after the Astrophysical Observatory was founded, about the year 1890, Langley introduced the automatic registration of the galvanometer in connection with the spectro-bolometer, and in the subsequent years the difficulties connected with the use of the recording spectro-bolometer were so far overcome that the solar spectrum could be observed from the extreme ultra-violet end of the spectrum at about 0.3μ to a wave length of about 3μ in the infra-red with great ease and accuracy, in an interval of seven minutes of time. Drift of the galvanometer, which in Langley's expedition to Mount Whitney he has told me often amounted to a meter a minute on the scale, was now so far reduced that a centimeter an hour would be unusual. In fact the bolometer, despite its great sensitiveness, is about as easy to use for this work as an ordinary thermometer is for measuring the temperature of the air.

Our first measurements of the sun's radiation as a whole were made with the Crova alcohol actinometer, and in order to standardize this instrument we constructed a modified Tyndall pyrheliometer consisting of a copper box filled with mercury and having a cylindric bulb thermometer inserted radially into the box. Owing to the difficulty of keeping the small thread of mercury at the proper point for reading purposes in the Crova actinometer, we found it more desirable to develop the pyrheliometer for our purpose. Soon a solid disk of copper with a radial hole large enough to enclose the thermometer bulb was substituted for the box filled with mercury, the use of mercury being limited to insuring a good heat connection between the bulb of the thermometer and the copper of the disk. Some of these copper disk pyrheliometers are still in use on Mount Wilson. About 1909, however, the further improvement was introduced of using silver in place of copper for the disk. A thin steel lining is provided for the hole where the thermometer is inserted, so as to prevent the mercury from alloying with the silver. In these silver disk instruments the thermometer stem, which is introduced radially in the disk, is bent outside the chamber at right angles so as to point towards the sun. The whole instrument is mounted equatorially with a device for moving it by hand to follow the sun from moment to moment. These disk pyrheliometers, either of copper or silver, have now been in use since 1906 with great satisfaction. Their constancy over long periods of time leaves nothing to be desired, and the accuracy of observation reaches a small fraction of 1 per cent.

As the disk pyrheliometer is a secondary instrument, it was necessary to develop a standard primary instrument to compare it with. As early as 1904 experiments were begun to produce a pyrheliometer based upon the hollow chamber "black body" type, with a flowing liquid to carry off the heat produced by the absorption of the solar rays within such a chamber. After numerous experiments, and long trial, the water-flow standard pyrheliometer was fully developed in 1910. Later still, another hollow-chamber instrument in which the chamber was bathed with stirred water was employed to check the results of the standard water-flow instruments. In each of these types of standard instruments it is possible to introduce electrically known quantities of heat for testing purposes, and in many experiments it has been proved that the test quantities of heat thus introduced may be recovered to within 1 per cent. Accordingly it is believed that the standard scale of radiation has been thoroughly established. The silver disk instruments are standardized by comparing them with such standard instruments, and the standard scale of radiation so produced, which is believed to be accurate to at least one-half of 1 per cent, has been diffused generally over the world by the Smithsonian Institution. About twenty-five copies of the silver disk pyrheliometer have been standardized and sent out to Europe, North America, and South America for this purpose. The Smithsonian instruments read about 3.5 per cent above those of Ångström.

Measurements of the solar constant of radiation were begun in Washington in 1902 and have been continued at Washington or elsewhere in every succeeding year until the present time. In 1903 it was noticed that the values of the solar radiation outside the atmosphere obtained in Washington were variable within the limits of about 10 per cent, and as some of the changes appeared to occur between days which were of the highest order of excellence, it was thought possible that these changes might occur in the sun, and not be caused by alterations of the transparency of the earth's atmosphere. To test this possibility, a station was established on Mount Wilson, California, in 1905 by invitation of Director Hale of the Mount Wilson Solar Observatory. The station proved to be very favorable for the work, and in 1908 a permanent structure of cement was built there for the use of the Smithsonian Astrophysical Observatory. In the years 1909 and 1910 spectro-bolometric observations for the determination of the solar constant of radiation were also made on the extreme summit of Mount Whitney in California at an altitude of 4420 meters. At the same time observations were being made at Mount Wilson at an altitude of 1730 meters.

The results from these two stations reduced to outside the atmosphere at mean solar distance, like those which had formerly been obtained simultaneously at Washington and Mount Wilson, were identical within the limit of the accuracy of the determinations. The accuracy of the work at Mount Wilson and Mount Whitney was so great that the average divergence between the observations of the same days was only 1 per cent. At Washington, the sky conditions being less perfect, the average divergence from simultaneous solar-constant results of Mount Wilson was about 3 per cent.

Evidences of solar variability of short irregular periods. Numerous observations of several years at Mount Wilson indicated a fluctuation in the solar-constant values having a range of about 10 per cent. The fluctuations seemed to occur irregularly, sometimes running their course of 10 per cent or less within the period of a week or ten days, and at other times keeping nearly constant. It had been shown by the observations made simultaneously at Mount Wilson and at Mount Whitney that the results, as reduced outside the atmosphere, appear to be independent of the altitude of the observing station, on days when the sky conditions appeared to the eye to be excellent. The march of the apparent fluctuation of the solar constant values at Mount Wilson has not been of a haphazard character. I mean by this that the values progress in a definite direction, as for instance from a low value to a high value by steps through several successive days, and then as definitely progress in the opposite direction through other successive days, and do not fluctuate widely from high values to low, as would be the case if the irregularities were due merely to instrumental error. Since, then, it appeared that the fluctuations were neither of an accidental instrumental character, nor of a character associated with the altitude of the observing station, it appeared most reasonable to conclude that these fluctuations were due to changes in the sun's emission.

To test this important conclusion it appeared necessary to establish a second station, equally favorably situated with regard to sky conditions as Mount Wilson, but so far remote from Mount Wilson that local influences could not be expected to alter the results at both stations in the same direction on the same day. Such a station was established at Bassour, Algeria, in the years 1911 and 1912. Seventy-five days of simultaneous measurement at Mount Wilson and at Bassour were obtained, and of these days about fifty were so far free from the occurrence of clouds, or other disturbing influences, at both stations, as to be retained for purposes of comparison. The result of the comparison shows that when high values are obtained at Bassour, high values are obtained also at Mount Wilson, and *vice versa*. Thus the fluctuations which have been found, appear to be truly existing in the solar radiation outside the earth's atmosphere, for the solar constant values obtained at two stations separated by about one-third the circumference of the earth unite in showing them.

Value of the solar constant. During the whole solar constant campaign from 1902 to 1913, about 700 measurements of the solar constant of radiation have been obtained, all but three of the values ranging between 1.80 calories and 2.10 calories. The range of these numbers is mainly attributable to the actual fluctuation of the sun itself, though part, especially in Washington work, is due to accidental errors of measurement. The mean value from 690 measurements is 1.933 calories per square centimeter per minute. It is believed that this number represents the average value of the solar constant of radiation for the epoch 1902 to 1913 within 1 per cent. There is still the possibility, however, that an appreciable quantity of solar radiation beyond the wave length of 0.3μ in the ultra-violet has been absorbed by ozone in the higher atmosphere of the earth, and has been impossible of determination at the stations employed. However, from the consideration of the form of energy curve of the sun's spectrum it is improbable that this lost ultra-violet radiation can exceed 1 or 2 per cent.

Solar variability associated with sun-spots. Besides the short irregular fluctuation of solar radiation above mentioned as having been shown by the simultaneous measurements at Mount Wilson and Bassour, Algeria, it appears that a long period fluctuation is associated with the sun-spot numbers. This connection is brought out by taking the mean monthly values of the solar constant measurements at Mount Wilson from the year 1906 on, and comparing them with the mean monthly sun-spot numbers of Wolfer for the same period. From such a comparison it appears that the greater the number of sun-spots the higher will be the solar constant of radiation, and that an increase of a hundred sun-spot numbers corresponds to an increase of about 0.07 calories per square centimeter per minute in the solar radiation outside the earth's atmosphere. This is a very curious circumstance, when it is recalled that the temperature of the earth is generally lower at sun-spot maximum than at sun-spot minimum, notwithstanding that, if the above result be true, the solar radiation is more intense at sun-spot maximum than at sun-spot minimum. On the other hand, the result is in line with the irregular variability of the Myra type of variable stars.

Atmospheric transmission. In connection with the measurements which have been made of the solar constant of radiation, there have been some interesting by-products. Among these we may mention first the determination of the transmission coefficients of the earth's atmosphere for light of all wave-lengths, including the ultra-violet and the infra-red spectrum, and ranging from wave-length 0.3μ in the ultra-violet to wave length 2.5μ in the infra-red. These transmission coefficients have been obtained by the Smithsonian observers at Washington, Mount Wilson, Mount Whitney, and Bassour. It is very interesting to compare them with the transmission of the atmosphere as computed according to the theoretical considerations of Rayleigh on the cause of the light of the sky. It is found that by means of these transmission coefficients the value of the number of molecules in the atmosphere may be obtained almost as accurately as by the use of the more common laboratory methods for determining the number of molecules per cubic centimeter of a gas of known density. It is found that the theory of Rayleigh connecting the change of transmission with the wave-length is closely confirmed by the observations at Bassour, Mount Wilson, and Mount Whitney. Similar measurements of atmospheric transmission for more limited regions of the spectrum have been made by other observers at high altitudes, and these also are found to agree closely with the theory of Rayleigh, and with our own observations.

Not less interesting is the determination of the distribution of energy in the sun's spectrum, and thereby of the probable temperatures existing in the sun. The solar temperatures may be inferred also from the value of the solar constant of radiation itself, and the two methods agree substantially in giving the probable solar temperatures as between 6000° and 7000° absolute Centigrade.

Recent balloon experiments. Notwithstanding the satisfactory state of the theory of solar constant measurements by the method of Langley, depending upon spectro-bolometric observations at high and low sun combined with measurements by the pyrheliometer, and notwithstanding the close agreement between results obtained by this method for many years at stations of differing altitude from sea-level to 4420 meters elevation, there still exists the possibility that if we could, indeed, go outside the atmosphere altogether, we should obtain values differing materially from those above given. So long as we observe at the earth's surface, no matter how high the mountain top on which we stand, the atmosphere remains above us, and some estimate must be made of its transmission before the solar constant can be determined. Different persons will differ in the degree of confidence which they will ascribe to measurements of the atmospheric transmission such as have been considered, and there are still some who totally disbelieve in the accuracy of the results thus far obtained, even though they be confirmed by observations at such differing altitudes. Accordingly it has seemed highly desirable to check the results by a method of direct observation by the pyrheliometer, attaching the instrument for this purpose to a balloon and sending it to the very highest possible altitudes. By a cooperation between the Smithsonian Institution and the United States Weather Bureau, experiments for this purpose were made in July and August of the year 1913.

The instruments employed were modified in form from the silver disk pyrheliometer, which has been described above. As the apparatus could not be pointed at the sun, the disk was placed horizontally, and the thermometer was contrived to record its temperature by photography upon a moving drum. The receiving disk was alternately exposed to the sun and shaded by the intervention of a shutter, operated intermittently by the clock work which rotated the drum under the stem of the thermometer. Five instruments of this kind were sent up on successive days. While it was well known that the temperature of the higher air would go as low as $-55°C.$, it was believed that a blackened disk, exposed half the time to the direct sun rays, would certainly remain above the temperature of $-40°$, which is the freezing point of mercury. This expectation was disappointed. Accordingly, owing to the freezing of the mercury in the thermometer, the highest solar radiation records obtained during the expedition were at the altitude of 13,000 meters, although the balloons in some instances reached the altitude of 33,000 meters.

The results obtained, while they have not the same degree of accuracy as those obtained by direct reading of the silver disk pyrheliometer, are yet of considerable weight. All the measurements unite in indicating values of the solar radiation at altitudes of 10,000 meters and higher, which fall below the value of the solar constant of radiation as obtained by other methods, and above the value of the radiation at the summit of Mount Whitney as obtained by different observers with pyrheliometers. It is expected in the coming year to repeat the observations with balloons under much improved circumstances. By aid of electrical heating apparatus it is expected to keep the surroundings of the disks at approximately the freezing temperature, even though exposed to the air at temperatures as low as $-55°C.$ In this way it is hoped to obtain good pyrheliometer measurements as high as it is possible for sounding balloons to go, and possibly to an altitude of 40,000 meters. As the atmospheric pressure at such altitudes is less than 1 per cent of that prevailing at sea-level, the experiments, if successful, may be expected to remove reasonable doubt of the value of the solar constant of radiation.

MINERALOGY.—*Variations in the compositions of minerals.* EDGAR T. WHERRY, U. S. National Museum.[1] Communicated by Waldemar T. Schaller.

With the advance of scientific knowledge it becomes necessary from time to time to revise some of our most fundamental conceptions and definitions. In chemistry, for instance, the old view is being abandoned that mixtures differ from compounds in that the former can be separated into their constituents by "mechanical means" while the latter cannot.[2]

Most of our text-books of mineralogy are largely based on Dana's System of 1892, and ignore the important advances which have taken place since that time. In particular, the writer believes that the conception of mineral species which permeates them is in need of revision, for, in the light of recent work, variability of composition must apparently be recognized as a fundamental principle of mineralogical chemistry. It is therefore proposed that a species be defined as *a natural inorganic substance whose chemical and physical properties are constant only within certain limits*, these limits varying widely from one case to another. The possible ways in which variations in the chemical composition of minerals can occur are through adsorption, isomorphous replacement, and solid solution.

Adsorption. While most minerals exemplify the crystalloidal state of matter, colloids are also not infrequently represented. As has been pointed out by several writers,[3] all minerals appearing wax- or gum-like, or with botryoidal, dendritic, globular, mammillary, nodular, reniform, or stalactitic structures, and at the same time showing an amorphous character under the microscope, are to be regarded as gels, or solid colloids.

[1] Read at the Rochester meeting of the American Chemical Society, September, 1913.

[2] W. Lash Miller, Science, **34**: 257 1911.

[3] F. Cornu, Centr. Min. Geol., **1909**: 324; R. Marc. Fortschritte Min. Kryst. Petr., **3**: 11; A. Himmelbauer, ibid., **3**: 32 (including a 6-page bibliography), 1913.

My excuse for treating this subject so fully at this place is that American mineralogists appear to have underestimated the importance of these contributions: in six recent text-books I have been unable to find the word colloid.

One of the most striking features possessed by gels is their power of adsorbing foreign substances. For instance, the ability of the sesquioxides, when precipitated with ammonia, to take up considerable amounts of phosphoric acid, boric acid, etc., has long been recognized, and analytical methods modified in the presence of these substances. The amounts so adsorbed bear in general no relation to the molecular weights of the substances concerned—that is, the law of definite proportions is not obeyed—except that "the composition of many [natural] gels agrees frequently quite exactly with the corresponding formulas of crystallized minerals."[4]

The extent to which adsorption causes variations in the compositions of colloid minerals becomes evident when the analyses of bauxite, psilomelane, wad, the clays, chrysocolla, etc., are inspected. It is not so certain, however, which constituents should be regarded as united and which as adsorbed in these minerals. Is an amorphous clay containing silica, alumina and water to be regarded as an adsorption product of SiO_2 gel, Al_2O_3 gel, and water, or as kaolinite gel ($H_4Al_2Si_2O_9$) containing an excess of one or the other constituents adsorbed? It will be necessary to develop methods for the proximate analysis of colloidal minerals—staining, fractional solution, plotting dehydration curves, etc.—before such questions can be settled, a problem that will keep mineralogical chemists busy for some time to come. But meanwhile we should face the issue squarely, and in stating the composition of such minerals admit their variable character instead of attempting to assign them definite formulas, as is done in text-books.

Then there is a whole series of minerals whose superficial appearance is that of colloids, but whose fibrous or foliated internal structure betrays their crystallinity, such as chalcedony, limonite, malachite, serpentine, dufrenite, etc. As there appears to be no single descriptive term[5] in use for these, the word *meta-colloid* is here proposed. A *meta-colloid* is to be defined as *a substance which, though originally colloidal in character, has be-*

[4] Cornu, op. cit., p. 336.

[5] Himmelbauer, op. cit., p. 39, calls them "gealterte Gelen."

come more or less crystalline, for this has evidently been the history of most of this class of minerals.

If the original colloids have compositions approaching those of definite crystallizable compounds, then the change to a meta-colloid may be regarded as a simple molecular rearrangement. But if adsorbed constituents are present in excess over the requirements for such compounds, what becomes of them? Observations bearing directly on this point are lacking, but some analyses of meta-colloid minerals are certainly on record in which the presence of foreign material is shown. It is only necessary to turn to garnierite (Dana, System, p. 677), chloropal (ibid., p. 701) and dufrenite (ibid., p. 797), all of which often look crystalline (cryptocrystalline) and homogeneous under the microscope, to find examples of this. It would therefore seem that in some cases, at least, adsorption may occur even in meta-colloids, so that *it can not be regarded as safe to consider crystallinity alone of minerals, whose features are those of meta-colloids, as a certain proof of their definiteness of composition.*

Solid solution. Especially in substances appearing in distinct crystals it is quite generally assumed that, except for isomorphous replacement,[6] the composition is fixed, constant, and definite. Yet even here there is evidence that some variation may occur. Two cases have recently been discussed elaborately: nephelite, which often contains 2 per cent more SiO_2 than is required by its simple formula without evident effect on its crystallographic constants, optical properties, or any other features;[7] and pyrrhotite, in which the amount of sulphur can vary from 36.3 per cent corresponding to FeS, to over 40 per cent, with only slight changes in axial ratio and specific gravity, and without loss of crystallinity or characteristic properties.[8]

But other well crystallized minerals have yielded analytical results exhibiting even greater variability in the amounts of con-

[6] The subject of isomorphous replacement is fully treated in the text-books, and need not be discussed here. In one sense it is, of course, only a special case of solid solution, but this term is here used only for non-isomorphous combinations.

[7] Foote and Bradley, Amer. Jour. Sci., **31**: 25, 1911; **33**: 439, 1912.

[8] Allen, Crenshaw, Johnston and Larsen, Amer. Jour. Sci., **33**: 169, 1912.

stituents, especially the columbates, tantalates and titanates, but also some sulfo-salts (binnite, tetrahedrite), halides (fluocerite, yttrocerite), oxides (strüverite, uraninite), silicates (some pyroxenes and amphiboles, to account for the composition of which the conception of isomorphous replacement has to be made unreasonably broad), etc.

It is customary at the present time to consider this variability as due to "solid solution." Of course, the mere giving a phenomenon a name does not explain it, but whatever may be its significance its existence cannot be denied and should not be overlooked. Consequently, *even crystallinity cannot fairly be regarded as a certain criterion of the absence of "solid solution" or accordingly of the definite chemical composition of a mineral.*[1]

In conclusion, it may be urged that in future text-books and writings dealing with the establishment of mineral species, notice be taken of these relations, and that there be included along with the simple, essential formula of each mineral, in so far as one can be recognized, a statement of the extent to which variations in its composition occur.

BOTANY.—*A hybrid between Tripsacum and Euchlaena.* G. N. Collins and J. H. Kempton, Bureau of Plant Industry.[2]

In connection with studies in the heredity of maize and re ated plants a fertile hybrid has been secured between *Tripsacum dactyloides* L. and *Euchlaena mexicana* Schrad.

Euchlaena mexicana or teosinte is an annual grass, native in Mexico, often grown for forage. The variety grown in the United States requires a long season to mature and the only place where seed is produced is in southern Florida. *Tripsacum dactyloides* is a perennial grass, native in many parts of eastern United States. The plant is of no economic importance.

The genera Euchlaena and Tripsacum are placed in separate groups of the tribe Maydeae and the plants are so different that

[1] This is in no way intended as a denial of the definite molecular structure of crystals; and that it is quite possible to reconcile the latter conception with the existence of solid solution will be shown in a later paper.

[2] Presented before the Botanical Society of Washington, February 3, 1914.

it is difficult even to contrast the characters. The following is an attempt to formulate the more conspicuous differences:

Tripsacum	*Euchlaena*
Plants perennial.	Plants annual.
Male and female flowers in the same inflorescence.	Male and female flowers in different inflorescences.
Lateral inflorescences not enclosed in bracts.	Lateral inflorescences enclosed in bracts.
Fruit trapezoidal.	Fruit nearly triangular.
Order of flowering of pistillate flowers from above downward.	Order of flowering of pistillate flowers from near the bottom upward.
Staminate spikelets in pairs, both sessile.	Staminate spikelets in pairs, one sessile, the other pediceled
Leaves averaging about 50 times as long as wide.	Leaves averaging about 10 times as long as wide.

Euchlaena and Tripsacum are the only American genera associated with Zea in the tribe Maydeae. Euchlaena and Zea cross readily and a complete series of intermediates is known.[3]

Although the possibility of securing a hybrid between such diverse plants seemed very remote, the paucity of wild relatives encouraged us in repeated attempts to secure hybrids between Tripsacum and Zea or Euchlaena. Until the present instance these attempts have always given negative results.[4]

The pollen parent of the present hybrid belonged to a Mexican variety of Euchlaena, the seed of which was received from Mr. H. V. Jackson of Durango, Mexico. This variety is earlier than the Florida teosinte and many of the plants show indications of contamination with maize. Among the most common maize-like characters occurring in the teosinte from this region are the development of a central spike in the staminate inflorescence, the greater prominence of the primary culm, and the formation of a rudimentary cob in the pistillate inflorescence.

[3] For a discussion of the characters of Euchlaena and Zea, see Collins, G. N., *The origin of maize*, Journ. Wash. Acad. Sci. **2**: 520–530, 1912.

[4] In view of the great disparity in the length of the stigmas, there may be a mechanical difficulty in making the reciprocal cross, using Tripsacum as the pollen parent.

The maximum elongation of the pollen tube in fertilizing Tripsacum flowers would never exceed 2 cm., while the fertilization of an ovule of Zea or Euchlaena could not be accomplished without an elongation of at least 10 cm.

Owing to the fact that the plant which supplied pollen for the hybrid was grown in the greenhouse where all teosinte plants behave abnormally, it was impossible to determine whether this particular plant would have possessed many or few of these maize-like characters had it grown normally in the open. As it developed in the greenhouse it was much reduced in stature, being only about 2 feet high. A number of pistillate flowers were produced in the terminal inflorescence, the branches of which were much reduced. But there was no tendency to form either a cob or a central spike in the terminal inflorescence.

The plant of Tripsacum used as female parent of the hybrid was an offshoot from a plant grown at Lanham, Maryland. In February, 1913, a number of offshoots were removed from the plant at Lanham and planted in the greenhouse at Washington. Probably as a result of being grown in the greenhouse the staminate portion of the first inflorescences that appeared were aborted. The female flowers of one of these aborted inflorescences were pollinated by Euchlaena, producing the hybrid under discussion. As soon as pollinated the inflorescence was enclosed in a paper bag. This was an unnecessary precaution, for the stigmas were dry before any Tripsacum pollen was produced and there were no other flowering plants of Tripsacum in the greenhouse at that time. As a result of this pollination four seeds were secured.

The four hybrid seeds were planted on April 8, 1913, but only one germinated. As soon as the seedling appeared above the ground the soil was removed so as to expose the seed, allowing us to make sure that the plant was growing from the Tripsacum seed and not from the seed of some other grass accidentally occurring in the soil.

All possibility that the plant was other than a true hybrid was removed at an early date. As soon as the nature of the seedling could be determined it was found to resemble the male parent Euchlaena in all discernible characters. This resemblance continued throughout the life of the plant.

The abnormal characters of the particular plants used as parents, induced by the greenhouse conditions, made impossible any accurate comparisons of the hybrid with its individual parents, but it can be said that the hybrid plant more nearly resembled normal teosinte grown in the open than did any of the greenhouse grown teosinte plants themselves. With respect to all the differences listed above, the hybrid resembled Euchlaena. The only suggestion of a Tripsacum character was that the main stalk matured some days in advance of the branches or suckers. This might be taken as a slight indication of a tendency toward perennial habit. On the other hand this tendency may exist in Euchlaena, which has not been carefully examined with this character in mind. Seed was produced in abundance and was indistinguishable from that of pure teosinte. Some of this first generation hybrid seed has been planted and a number have germinated showing the hybrid to be fertile.

The chief points of interest in this hybrid may be summarized as follows:

1. The hybrid is bigeneric, and the parent types differ in profound morphological characters.

2. One of the parents is strictly annual, the other perennial, requiring several years to mature.

3. None of the characters of the female parent appeared in the first generation; that is, the hybrid is completely patroclinous.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

BOTANY.—*Mexican grasses in the United States National Herbarium.* A. S. HITCHCOCK. Contr. U. S. Nat. Herb. **17**: 181–389. 1913.

This paper includes a list of 615 species of Mexican grasses, 23 of which are described as new, represented by specimens in the U. S. National Herbarium. There is a key to the genera, and, preceding each genus, a key to the species. Under each species are given the more important synonyms, the type locality, the range, and an enumeration of the specimens from Mexico arranged by states. One new genus, Triniochloa, is described. This includes three species, one, from Chihuahua, collected by the author, being new, the others transferred from Avena. One of the latter, the type species, *T. stipoides*, was first described as Podosaemum and later transferred to Muhlenbergia and to Avena.

The more important collections available in the present study are those of Palmer, Pringle and the author, who have explored botanically nearly all the states of Mexico. There are cited also many duplicates of the early collectors, such as Bourgeau, Liebmann, Schaffner, Botteri and Müller. A. S. H.

PHARMACOLOGY.—*Individual variation in the alkaloidal content of belladonna plants.* A. F. SIEVERS. Journal of Agricultural Research **1**: 129–146. 1913.

In a systematic study of the alkaloidal content of the leaves of a large number of belladonna plants, some important facts have been established. The leaves were assayed at five distinct stages of growth from early in May to late in October and the results indicate that the flowering stage is the most advantageous time to pick the leaves. A higher percentage of alkaloids is found later in the season but the leaves are then too small and sparse for profitable harvesting. The physical characteristics of the plant have thus far shown no relationship to the alkaloidal content of the leaves. Luxuriant growth is no criterion of the medicinal value of the plant.

The individual plants show a remarkable variation in the alkaloidal content. It is found that many plants rich in alkaloids throughout the season are equally rich in following seasons. The same is true of plants that are unusually poor in alkaloids. This indicates that the relative production of alkaloids in these plants is largely due to the inherent characteristic of the individual and not entirely to the varying external influences. A. F. S.

PLANT PHYSIOLOGY.—*Environmental influences on the physical and chemical characteristics of wheat.* J. A. LeClerc and P. A. Yoder. Journal of Agricultural Research **1**: 275–291. 1914.

Previous work (Bureau of Chemistry Bulletin 128) showed that the composition of wheat and its physical characteristics, such as the weight per thousand, weight per bushel, and flintiness are not to any great extent hereditary; that both the chemical composition and the physical characteristics above enumerated are dependent upon the environment (climate and soil) in which the wheat grew. In the present paper the authors describe investigations carried on in Maryland, Kansas, and California in which small plots of soil from each of three localities were interchanged. This experiment was continued during 1909–10–11–12. Each year the crop from each plot was harvested and analyzed for the usual chemical constituents and physical properties. From these results it is seen that the wheat grown in any one locality is very uniform in composition and in appearance, but quite different from the same wheat grown on the same soils in the other two localities, showing that the climatic conditions prevailing during the period of growth exerts the major influence in affecting both the chemical composition and the physical characteristics of wheat. The wheat grown on the check plot in each locality was identical, physically and chemically, to that grown on the imported soils. J. A. LeC.

PHYTOPATHOLOGY.—*A bacterium causing the disease of sugar-beet and nasturtium leaves.* Nellie A. Brown and Clara O. Jamieson. Journal of Agricultural Research **1**: 189–210. 1913.

The paper deals with an organism causing a spot-disease on leaves of nasturtium and sugar-beet. The spotting was noticed on these plants in the same year, occurring in widely separated areas—the nasturtium leaf-spot in Virginia, and the sugar-beet leaf-spot in Utah.

The cause of the disease, a bacterium, was isolated from each host, and the organism isolated was proved up in each case by means of inoculations. As it was supposed that two distinct diseases were being dealt with, work was carried on independently for two years, when, through comparison of cultural and morphological tests and by cross-inoculations, it was proved that the organisms causing the leaf-spot disease on both hosts were identical. The same organism also produces spots on bean leaves and pods, also on leaves of lettuce, pepper, and eggplant.

The organism is called *Bacterium aptatum*. It belongs to the green fluorescent group of bacteria, and has been shown to be different from *Bacterium xanthochlorum*, an organism in this group pathogenic to potato; and from *Pseudomonas tenuis*, which has been given the same group number in the descriptive chart of the Society of American Bacteriologists. It is also different from *Bacterium phaseoli*, although both organisms produce the spotting of bean leaves and pods.

N. A. B.

PHYTOPATHOLOGY.—*The foot-rot of the sweet potato*. L. L. Harter. Journal of Agricultural Research **1:** 251–273. 1913.

The foot-rot, a new disease of the sweet potato, is caused by the fungus *Plenodomus destruens*. It was found in Virginia for the first time during the summer of 1912 and caused extensive damage that season and in 1913. In some fields as much as 95 per cent of the plants were killed. The organism kills the plants primarily by the destruction of the cortex of the stem, although occasionally it may be found on the vines several feet from the hill. Numerous inoculations have proven the parasitism of this fungus. Experiments have shown that it will grow from diseased roots into the slips produced therefrom; also from diseased slips into the roots. The fungus lives over the winter on dead vines in the field and probably on the roots used for seed. The disease occurs in the hot bed, so that it is likely that the sale or exchange of slips and seed potatoes is largely responsible for its distribution. Sanitary methods and careful selection of only sound healthy potatoes for seed are recommended as means of control. L. L. H.

PHYTOPATHOLOGY.—*The anthracnose of the mango in Florida.* S. M. McMurran. U. S. Department of Agriculture Bulletin 52, pp. 15. 1914.

An investigation of the mango anthracnose or blight was conducted in Florida during the seasons of 1912 and 1913 with a view to determining (1) the cause of the disease, (2) the control of the disease, and (3) the broader question of the suitability of the southeast coast of Florida for the production of the mango on a commercial scale.

Infection experiments by the writer and others have shown that the blighting of the mango blossoms, the tear staining and scabbing of the fruit, and the spotting of the leaves is due to *Colletotrichum gloeosporioides* Penz.

The experiments on the control of the disease indicate that the blossom blight form of the disease cannot be controlled by spraying with Bordeaux mixture during seasons which are rainy at blooming time, but that the fruit may be protected from fungus invasions and carried through to maturity in a clean and disease-free condition by spraying.

In regard to the third proposition, observations in Florida indicate that a set of fruit cannot be expected unless the weather is dry at blooming time. This coincides entirely with the opinions expressed by writers on the mango from Porto Rico, Jamaica, and Hawaii, and forces the conclusion that the main limiting factor of the mango is the condition of the weather at blooming time. Given clear, dry weather, a good crop of fruit may be expected. Given, on the other hand, rainy weather at blooming time, i.e., suitable conditions for fungus infection, a failure is practically certain.

The main bloom of the mango occurs in March. The weather records for Miami show that the months of March in 1912 and 1913 were unusually rainy, but that the mean number of rainy days for March based on a record of 16 years is only 4.56 days, and that in 8 years out of the 16 the number of rainy days fell below this mean. From this it would appear that the chances for success are quite good, the hazard being probably no greater than in most of the peach growing sections of the North. S. M. M.

PHYTOPATHOLOGY.—*Polyporus dryadeus, a root parasite on the oak.* W. H. Long. Journal of Agricultural Research **1**: 239–250. 1913.

A brief history is given of this fungus since Bulliard first described it in 1789 as *Boletus pseudo-igniarius.* Attention is called to Hartig's error in assigning to *Polyporus dryadeus*, the rot produced by *P. dryophilus*. Several synonyms for *P. dryophilus* are also given and the rot produced by it compared to the rot produced by *P. dryadeus*. The disease was found in the forests of Arkansas, Texas, Oklahoma, Maryland, and Virginia. The first evidence of the disease is a reddish brown discoloration of the inner bark and cambium; in the final stage of the rot the color becomes white or creamy white. In all the uprooted trees examined, the disease began in the lower portion of the roots and spread upward toward the stool of the tree. The rot was found in the roots of *Quercus texana*, *Q. nigra*, *Q. alba*, *Q. velutina*, *Q. minor*, *Q. rubra*, and *Q. prinus*. The following conclusions are presented:

1. *Polyporus dryadeus* is a root parasite of the oak producing a white sap rot and heart rot in the roots.
2. In all the trees examined this rot did not extend upward into the tree as a true heart or sap rot of the trunk, but was limited to the underground parts of the tree.
3. The rot and sporophore described and figured by Robert Hartig do not belong to *Polyporus dryadeus* but to *P. dryophilus*.
4. In the majority of cases only old or much suppressed trees or trees growing under very unfavorable conditions are attacked by this disease.
5. The disease does not seem to spread readily to adjacent trees.
6. The disease is widely distributed both in America and Europe and is probably found in these countries throughout the range of the oak. W. H. L.

PHYTOPATHOLOGY.—*An underscribed species of Gymnosporangium from Japan.* W. H. LONG. Journal of Agricultural Research **1**: 353–356. 1914.

Attention is called to the introduction into this country of a new species of Gymnosporangium on *Juniperus chinensis* from Japan. The three types of teliospores in the genus Gymnosporangium which have characters of specific value are described.

Taxonomic descriptions are given of three species, *Gymnosporangium chinense*, *G. japonicum* and *G. haraeanum*, all from Japan and on the same host, *Juniperus chinensis*. The value of taking into consideration at least two of the types of teliospores, the thin and thick-walled ones found in each species of Gymnosporangium, is shown. W. H. L.

PHYTOPATHOLOGY.—*Three undescribed heart-rots of hardwood trees, especially of oak.* W. H. Long. Journal of Agricultural Research **1:** 109–128. 1913.

Of the twenty heart-rotting fungi found in oak only the following seven were present to any extent in the trunks and tops of the trees: *Hydnum erinaceus*, *Polyporus sulphureus*, *P. dryophilus*, *P. berkeleyi*, *P. frondosus*, *P. pilotae*, and *Fomes lobatus*.

Of the 2100 felled oak trees studied in the Ozark National Forest 64.8 per cent were affected with butt rots. Tables are given for the following fungi: *Hydnum erinaceus*, *Polyporus pilotae*, *Polyporus sulphureus*, *Polyporus berkeleyi*, and *Polyporus frondosus*, showing the various heights of rot produced by each in the trees.

Polyporus pilotae was found in the following species of trees: *Quercus alba*, *Q. velutina*, *Q. texana*, *Q. coccinea*, *Castanea pumila*, and *C. dentata*. The macroscopic and microscopic characteristics of this rot for each host are given. It is a delignifying rot in which long white strands of cellulose are usually the most prominent feature.

A string and ray rot of oaks caused by *Polyporus berkeleyi* is a rot in which the wood fibers are first delignified and then absorbed, leaving more or less intact the medullary rays and the vessels. In a later stage all the elements are gradually destroyed until only a brown mass of very rotten wood and fungus hyphae is left in the stool of the tree.

Polyporus frondosus is also a delignifying fungus. It was found in only 12 trees out of 1968 white oaks examined. It has been found on various species of oak and also on chestnut throughout the United States and Canada, and also in Europe. W. H. L.

PATHOLOGY.—*Cysticercus ovis, the cause of tapeworm cysts in mutton.* B. H. Ransom. Journal of Agricultural Research **1:** 15–58. 1913.

The discovery by inspectors of the Bureau of Animal Industry that sheep slaughtered under Federal supervision were not infrequently infested with cysticerci located in the musculature, led to an investigation as to their identity. They were evidently the same parasite as that named *Cysticercus ovis* by Cobbold in 1869, which has generally been considered identical with *Cysticercus cellulosae*, the pork-measle parasite, the intermediate stage of *Taenia solium* of man. Some authors, however, have looked upon it as an aberrant form of *Cysticercus tenuicollis*, the intermediate stage of *Taenia hydatigena* (also known as *T. marginata*), a dog tapeworm. By means of feeding experiments it was definitely proved that *Cysticercus ovis* is neither *Cysticercus cellulosae* nor *C. tenuicollis*. Like the latter it is the intermediate stage of a dog tapeworm, but of a species heretofore unrecognized in its adult stage. The name of this species is *Taenia ovis* (Cobbold, 1869). Dogs become infested as a result of devouring measly mutton, and sheep as a result of swallowing the eggs of the tapeworm in food or water contaminated by the feces of infested dogs. There is no reason to suppose that the parasite is transmissible to man; in fact no tapeworm infestation occurred in a human subject (the writer) after the ingestion of live cysticerci. *Cysticercus ovis* may attain its full development in sheep in less than three months after infection and in the dog the tapeworm may reach egg-producing maturity in seven weeks after the ingestion of the Cysticercus. *C. ovis* is practically limited to the intermuscular connective tissue, and thus differs from *C. tenuicollis* which occurs in more or less intimate relation with serous membranes. Unlike the latter it apparently does not pass through the liver in its migrations from the alimentary tract to its final location.

Cysticercus ovis has been found occasionally in England, France, Germany, Algeria, German South West Africa, and New Zealand. Its presence has been determined in seven of the western United States. As yet no infestation has been found in sheep from the eastern United States. Wolves, probably, as well as dogs, may serve as hosts of the adult tapeworm. The Cysticercus may occur in goats.

Over 17,000 of the sheep slaughtered under Federal supervision during the year 1912, prior to December 1, were found to be infested with *Cysticercus ovis*. So far as the sheep in the western United States are concerned the number actually infested probably exceeds 2 per cent.

A full discussion of *Cysticercus ovis* is given under the headings of historical summary, life-history investigation, zoological description, remarks on morphology and comparison with other species, macroscopic appearance, distribution in body, degeneration, diagnosis, geographic distribution, prevalence, age of infested sheep, economic importance, significance in meat inspection, survival after death of host, and prophylaxis. B. H. R.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BOTANICAL SOCIETY OF WASHINGTON

The 94th regular meeting of the Botanical Society of Washington was held in the Assembly Hall of the Cosmos Club, Tuesday, February 3, 1914. Messrs. Raymond B. Wilcox, Arno Viehoever, and Henry Pittier were elected to membership.

The scientific program was as follows:

Brief notes and reviews of literature. Dr. David Griffiths reviewed a prospectus of a stock company which has been organized in Australia for the purpose of eradicating the cactus, which is there considered a serious pest. Mr. S. C. Stuntz called attention to the return from Brazil of Mr. A. D. Shamel, who has been there with Messrs. Dorsett and Poponoe, who are studying methods of tropical fruit culture and introducing the varieties that may be of value in this country. Mr. Shamel brought back over 1100 photographs which have thus far been taken by them, and prints of these will soon be available for study at the Office of Foreign Seed and Plant Introduction for those who are interested.

Dr. R. H. True: *A report on the Atlanta meeting of the Botanical Society of America.* Dr. True gave a report on the attendance at the meetings and number and character of the papers read before the different sections, with special notes regarding those of a botanical character.

Dr. H. Hasselbring: *The relation between transpiration and the absorption of inorganic constituents by plants.* (Published in Bot. Gaz. **57**: 72–73. January, 1914.)

Mr. G. N. Collins: *A hybrid between Tripsacum and Euchlaena* (with lantern). (See this Journal, p. 114.)

Dr. Walter H. Evans: *An attempt at revegetation on Kodiak Island, Alaska.* The conditions on Kodiak Island following the eruption of Mount Katmai in May, 1912, were described and an account was given of experiments in restoring the meadows and pastures of the experiment station on that island.

The level land was covered with the ash, or, more correctly, the débris from the explosion, to a depth of 12 to 14 inches, and practically all vegetation was destroyed. The only natural revegetation was where hummocks of earth brought the original soil nearer the surface or where plants came through cracks that formed in the deposit during the summer season. In these places fireweed, *Epilobium angustifolium*, and

Alaskan redtop, *Calamagrostis langsdorfii*, have come up abundantly. In some instances where the deposit fell in the edge of marshes it sunk in such a way that the grass came through and is growing luxuriantly. On the hills and steeper slopes the rains have washed the ash to the bottoms along the creeks or into the sea.

At the experiment station, in order to furnish pasture and forage for the live stock, experiments in revegetating the more level tracts have been begun. Soon after the eruption had ceased manure was spread on the land, which was then disked and seeded to rye. This gave some winter pasture and a light crop the following year. In the spring of 1913 experiments were undertaken on an extensive scale. Land was manured and commercial fertilizers were applied and a large amount of grass and leguminous seed was sown with oats as a nurse crop. Wherever nitrogen either in manure or as nitrate of lime was applied, good growth was secured. Less growth followed where only Phosphoric Acid and Potash were used and where no fertilizer was applied the seed germinated, grew slowly, and finally died unless the roots were able to penetrate the layer of ash and reach the soil below.

In gardens and wherever an especial effort was made to mix the deposit with the underlying soil, better growth was reported than normal, the ash appearing to have been of benefit, probably by reason of the improved physical condition of the soil.

P. L. Ricker, *Corresponding Secretary.*

THE PHILOSOPHICAL SOCIETY

The 730th meeting was held on November 22, 1913, at the Cosmos Club, Vice President Fischer in the chair; 55 persons present. The minutes of the 729th meeting were read and approved.

Mr. W. W. Coblentz made an *Exhibition of extreme forms of thermopiles*, showing four forms. They are of bismuth-silver giving an e.m.f. of 80 microvolts per degree and of bismuth-bismuth tin alloy having a thermal e.m.f. of 127 microvolts. The novelty in these thermopiles is the receiver, which is a completely opaque curtain which can be adapted to many forms. The forms shown were: point receiver or stellar thermopile, surface receiver to be used in place of the single thermal element in an Ångström pyrheliometer, receivers in series parallel reducing resistance one fourth, and the receivers in a U-shaped trough for physiological work.

Mr. L. A. Bauer then spoke on *Results of a first analysis of the Sun's general magnetic field.* The chief results are: (1) The magnetic axis determined from the published data between parallells 60° N. and 60° S. January, 1912, to February, 1913, is found to be inclined for the sun, 9° to 12° to the axis of rotation, practically the same as that of the Earth; (2) the Sun's magnetic field is asymmetrical about the equator in much the same manner and direction as is that of the Earth; (3) the analysis determined four instants distributed over a year when north end of Sun's magnetic axis was on the central meridian; since a whole number of rotations must have occurred during the intervals, it was possible to determine a period of rotation applying, perhaps, to the Sun as a whole, the preliminary synodic period thus found was nearly 33 days; (4) the solar magnetic field is as complex as that of the Earth and the distorting systems which are superposed upon a primary, simple magnetic field follow laws very similar to those disclosed in the study of the Earth's field. The paper was illustrated by lantern slides. Mr. Burgess discussed the question of magnetic state under high temperature and pressure; Messrs. Swann and White also discussed the paper.

Mr. W. F. G. Swann then gave an illustrated paper on *The atmospheric potential gradient and a theory as to its connection with other phenomena in atmospheric electricity.* The application of the ordinary theory of conduction of electricity in gases to the atmosphere shows the mere existence of an atmospheric potential gradient of the kind found carries with it the following requirements: (1) the ratio of number of positive ions per cc. at the Earth's surface to the number of negative ions shall be greater than unity; (2) the above ratio shall increase with potential gradient; (3) neither the number of positive ions per cc. nor the number of negative ions per cc. at the Earth's surface are the same thing as the numbers which would, if the atmospheric field were absent, exist in order to result in a balance between recombination and formation; (4) the atmospheric potential gradient, in a homogeneous atmosphere, shall decrease with the height in the neighborhood of the Earth's surface; (5) there should be an apparent, but not necessarily true, increase of the rate of ionization with the height. The problem of the conduction of electricity between parallel plates immersed in a gas shows that the usual solution is quite inapplicable when the rate of formation of ions is small and the plates are a finite distance apart; accordingly, a new calculation is given. The paper was discussed by Messrs. Bauer, Marvin, Sosman, and Humphreys, particularly in reference to the present rather primitive state of the science of atmospheric electricity.

The 731st meeting was held on December 4, 1913, at the Cosmos Club, being a joint meeting with the Washington Academy of Sciences. President Tittmann, of the Academy, in the chair; about 150 persons present.

Professor Jean Perrin, of the University of Paris, spoke on *Brownian movement and molecular reality.* The paper gave a brief review of the history of the subject and of the author's work, and was illustrated by cinematographic photographs showing three experiments to illustrate the Brownian movement.

The chair called for a rising vote of thanks to the speaker for his very interesting and instructive address.

The 732d meeting, 43d annual meeting, was held on December 20, 1913, at the Cosmos Club, President Abbot in the chair; 28 persons present. The minutes of the 42d annual meeting were read. The report of the Secretaries was read by Mr. Humphreys, showing an active membership of 146, a net gain of 8 over last year. Fifteen regular meetings have been held. The report was ordered accepted and placed on file. The Treasurer's report, dated December 16, 1913, was read by Mr. Sosman, showing total receipts of $983.44 for the year; total expenditures of $1677.49, including cost of additional investment for $1000 registered bond of the Cleveland Illuminating Company; total investments $11,000; cash in hand $527.15. The report was ordered accepted and placed on file. The report of the Auditing Committee, consisting of Messrs. Paul, White, and Whitten, was read by Mr. Paul. This report showed statements in Treasurer's report were correct and that the arrears in dues are $57.00. The report was ordered accepted and placed on file. The reading of the names of members entitled to vote was omitted by unanimous consent. Messrs. Hersey and Faris were appointed tellers.

The following officers were duly elected for the ensuing year: *President*, L. A. Fischer; *Vice Presidents*, W. S. Eichelberger, Wm. Bowie, G. K. Burgess, W. J. Humphreys; *Treasurer*, R. B. Sosman; *Secretaries*, J. A. Fleming, P. G. Agnew; *General Committee*, L. J. Briggs, E. G. Fischer, N. E. Dorsey, R. L. Faris, R. A. Harris, F. A. Wolff, E. Buckingham, D. L. Hazard and M. D. Hersey.

During the election the question of more suitable quarters for meetings was informally discussed. A rising vote of thanks for his long, faithful and cheerful service was extended the retiring Secretary, Mr. Humphreys. The Secretary was instructed to determine as to whether the present is the forty-second or forty-third annual meeting and to correct minutes, if necessary. The rough minutes of the meeting were read, corrected and approved. After adjournment a buffet luncheon was served.

The 733d meeting was held on January 3, 1914, at the Cosmos Club, Vice President Eichelberger in the chair; 46 persons present.

The evening was devoted to the address of the retiring President, Mr. C. G. Abbot, on *The solar constant of radiation* (see this Journal, p. 89).

The chair expressed to the speaker the thanks of the Society members and friends for the interesting and illuminating paper.

J. A. Fleming, *Secretary*.

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PHYSICS.—*The brightness of optical images.* P. G. Nutting, Eastman Kodak Research Laboratory.

The relative brightness of an object and its image formed by a lens may be calculated by certain well known formulae when the relative aperture of the lens is small and the object distance great. Experimental determinations of relative brightness have been made but not with sufficient precision to permit of a satisfactory deduction of the light lost during transmission through the lens.

In this article are given first an extension of the theory to lenses of all apertures and focal lengths and to all object distances. A method is described of measuring relative illumination with a precision as high as that reached in the best ordinary photometry. Both investigations were initiated and carried out at the research laboratory of the Eastman Company. The unabridged paper (to appear elsewhere) contains the complete mathematical theory and experimental data.

The theoretical investigation leads to an expression for the flux density I of radiant power, in watts per unit area, entering the image, relative to that (I_0) leaving the object. This expression is in terms of radius of effective aperture R of the lens, distance of object u and image v measured from the nodal point of the lens. The formula is simplified if we substitute magnification m for the ratio v/u of image distance to object distance, and introduce the symbol $a = R/F$, the ratio of the radius of effective aperture to equivalent focal length F. The complete formula is

$$\frac{I}{I_0} = \pi M \left[M \log \frac{1+S}{1+T} - \frac{T}{1+T} \right]$$

in which $M = \dfrac{1}{1-m^2}$ $S = \dfrac{a^2}{(1+m)^2}$ and $T = m^2 s$

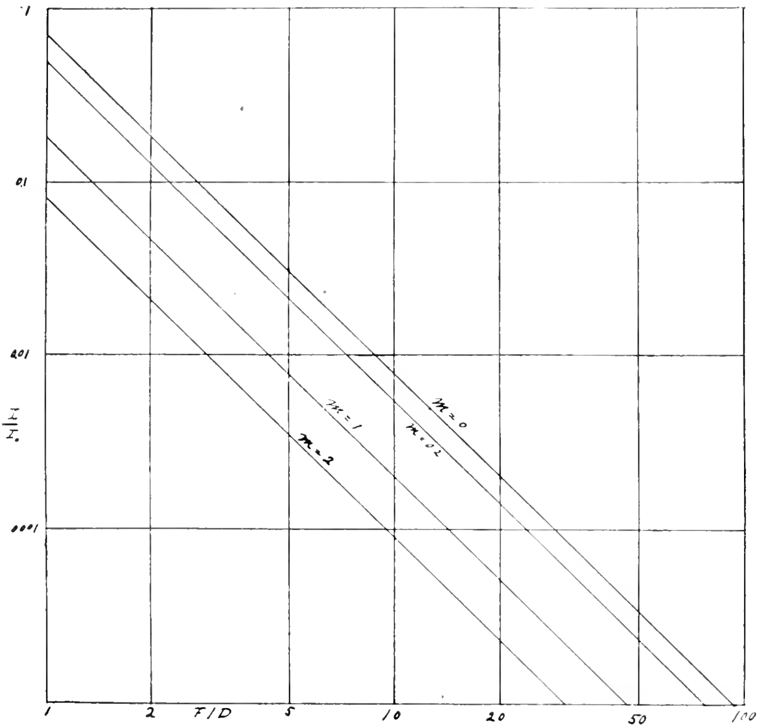

Fig. 1

In the special case of a very distant object, this expression simplifies to $\pi \log (1+a^2)$ or for narrow apertures to the ordinary formula $I = I_0 \pi a^2$. When image and object are at equal distances $(m=1)$,

$$\frac{I}{I_0} = \frac{1}{2} \pi a^2 \frac{8 + a^2}{(4 + a^2)^2}$$

The relative brightness of image and object, computed by the above formulae for any lens aperture F/D and any magnification $m = v/u$ is given in the following table:

APERTURE	$m = 0$	$m = .1$	$m = 2$	$m = .5$	$m = 1$	$m = 2$
1	.704	580	.521	.333	.179	.0775
2	.1902	.1580	.1321	0864	.4091	.0210
5	.0312	0255	0219	.01296	.00785	.00347
10	.00785	.00625	.00553	.00349	.00197	.000870
20	.00196	.00162	.00134	000878	.000490	.000217
50	.000314	000259	.000216	.000135	.000078	.0000346
100	.000878	.000065	.000051	.000044	.000019	.0000086

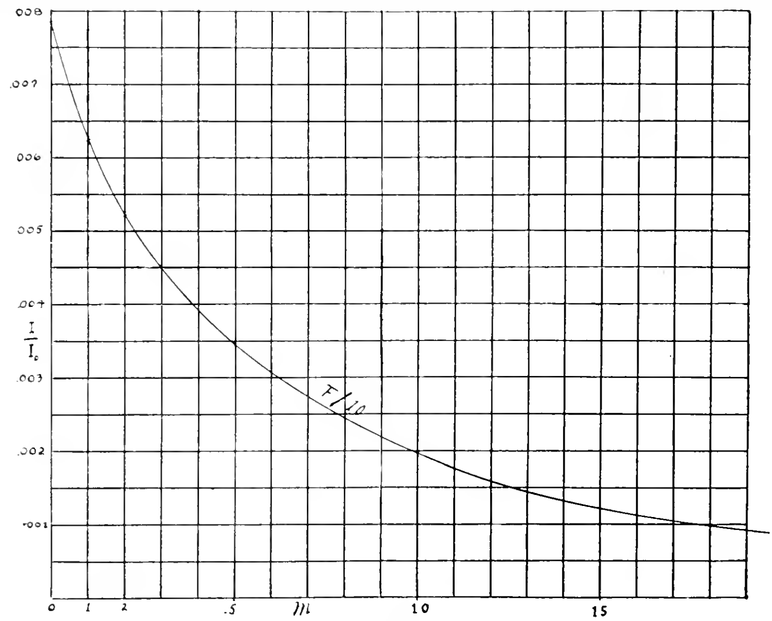

Fig. 2

Figure 1 shows relative brightness plotted against relative apertures, both on logarithmic scales. The curves are sensibly straight lines.

Figure 2 shows the variation of relative brightness with relative distance of image and object, v/u. Relative brightness decreases rapidly at first, then slowly and steadily to zero for great magnifications.

In measuring relative illuminations the arrangement finally adopted was that shown in figure 3. The test object was a sheet of opal glass S, 14 inches square, forming the front face of a cubical box containing a tungsten lamp of 1500 candle power. Opposite the source, 5 meters distant, was a white magnesia block

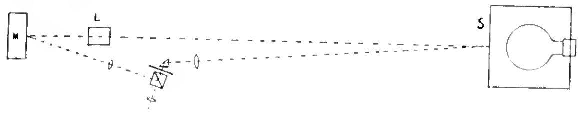

Fig. 3

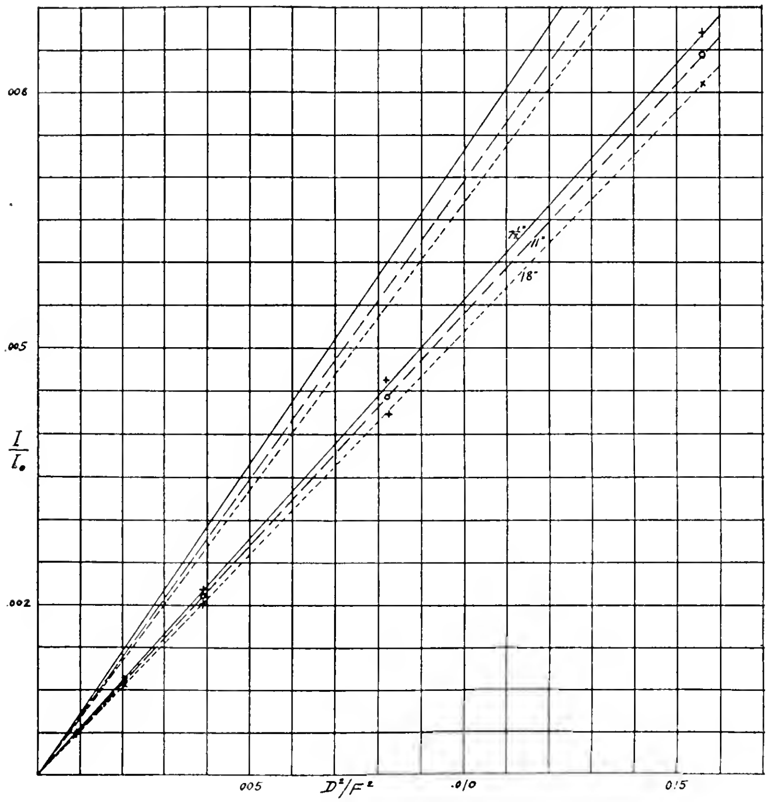

Fig. 4

M upon which an image of the source could be thrown by the lens L under test. The brightness of this image was compared with that of the same spot with the lens removed by means of a modified Beckstein illuminometer.

The relative brightness of block (without lens) and source $I_1:I_0$ is the area of the source divided by the square of the distance to the *edge* (not center) of the source to within 0.1 per cent error. Relative brightness of image and block without lens is the measured ratio $I_2:I_1$, hence the desired relative illumination of image and object $I_2:I_0$ is obtained by multiplication. Since the comparison screen of the photometer is illuminated directly by the source, there is no curve due to fluctuations in the source by mat-black walls, and the remainder is measured and corrected for.

The results obtained on the different lenses are tabulated below. For each test are given the numerical aperture at which the text was made, the relative brightness I_1/I_0 of source and receiving block, relative distance m of image and object, observed relative brightness I_2/I_0, the same quantity computed—neglecting losses by reflection and absorption (B)—and finally the ratio of observed to computed brightness T which is the percentage transmission of the lens.

LENS	NO.	SERIES	EFL	AP.	$I_1:I_0$	m	$I_2:I_0$	B	T
Cooke Process...	32051	V	18″	F/8	.00475	.0865	.00820	.01058	.78
Cooke Process.....	31796	V	11″	8	.00475	.0675	.00841	.01085	.78
Cooke Process.....	33991	V	7½″	8	.00475	.0417	.00870	.01136	.77
B. & L.-Z. Tessar.	1320682	1C	6″	4.74	.00494	.0309	.0249	.0328	.76
Cooke............	40399	1C	8″	4.72	.00499	.046	.0237	.0321	.74
Fuess Tel. Objective............			6″	5.3	.00494	0.33	.0257	.0278	.92
B. & L.-Z. Tessar.	95933	1C	40 mm.	4.94			.0172	.0322	.54
Cooke Cine........			2″	3.67			.0393	.0585	.67
Zeiss-Krauss Tessar..............			75 mm.	3.69			.0330	.0579	.57
Zeiss-Krauss Tessar...........			150 mm.	4.71			.0234	.0355	.66

If there be no absorption of light within a lens, a transmission of .76 corresponds, for 6 air glass surfaces, to a mean refractive index of about 1.55; hence the higher observed transmissions are quite up to theoretical possibility.

The first five lenses in the above list were used at various measured apertures. Data are given in the following tables, and in the curves of figure 4.

STOP	18 INCH COOKE SER. V			11 INCH COOKE SER. V			7½ INCH COOKE SER. V		
	Obs.	Comp.	Trans.	Obs.	Comp.	Trans.	Obs.	Comp.	Trans.
F 8	.00820	.01058	.774	.00841	.01085	.776	.00870	.01136	.766
11	.00374	.00459	.816	.00441	.00570	.774	.00463	.00600	.770
16	.00206	.00264	.783	.00210	.00270	.779	.00202	.00283	.714
22	.00108	.00140	.773	.00116	.00143	.781	.00115	.00150	.766
32	.00524	.000661	.792	.00051	.00067	.762	.00050	.00071	.72
45	268	336	.796						
64	156	166	.94						
90	100	083	.83						

The Tessar and Cooke F/4.5 lenses gave results as follows:

STOP	B.-L.-Z. TESSAR 1c.			STOP	8 INCH COOKE SERIES II		
	Obs.	Comp.	Trans.		Obs.	Comp.	Trans.
F 4.74	.0249	.0328	.758	F/4.72	.0237	.0321	.739
5.66	.0184	.0238	.724	5.68	.0172	.0232	.744
8	.00890	.0115	.766	8	.00836	.0112	.749
11	.00476	.00610	.765	11	.00425	.00595	.715
16	.00231	.00288	.804	16	.00210	00282	.664
22	.00115	.00152	.765	22	.00117	.00149	.800
32	.00054	.00072	.750				

These tables show a fair constancy of transmission T as the stop is varied. It may be noted further that the departure of actual from indicated aperture ratio is the same in the high speed lenses of different makes.

PHYSICS.—*The production of temperature uniformity in an electric furnace.* ARTHUR W. GRAY. To appear in full in the Bulletin of the Bureau of Standards.

In the present paper certain improvements of the electric furnace described several years ago by the writer[1] are presented; experimental evidence shows that it is possible in the new furnace to heat a region of considerable length to any desired temperature up to about 700° C. so uniformly that irregularities in the temperature distribution will be less than the effect of heterogeneity

[1] Journ. Wash. Acad. Sci. 2: 250. 1912.

in thermoelements of the best quality, and probably less than the uncertainties at present existing in our knowledge of the temperature scale itself. The method has been applied to a furnace designed to heat uniformly bars under measurement for thermal expansivity; but the application of it clearly is not limited to problems of this general character.

The iron tube of the trial furnace,[2] together with its contents, is retained without essential alteration. The principal change consists in removing the heating coil from the tube upon which it had formerly been wound and substituting two independent concentric heaters to supply heat uniformly for the entire length of the interior. In the experiments so far made air has formed the insulation, filling the small annular space separating the original tube from the first heater, and also the larger space between the heaters, except for some layers of mica and of asbestos cloth, in all about 4 mm. thick, wrapped tightly around the ribbon of the inner heater. The outer one is covered in the same way, and the space between this and the casing of the whole furnace is filled with asbestos-magnesia compound. The end plugs consisting of two thick blocks of a good heat conductor separated by a thick layer of a poor conductor are attached to large insulating heads filling the entire cross-section of the casing. In most of the experiments heat was supplied to the plugs by means of coils filling the grooves turned in the outer conducting blocks, just as in the former furnace; but recently considerable improvement was effected by cutting these coils out of action, and substituting flat coils of the same diameter as the outer heater, against the ends of which they bear.

The concentric heaters are of nichrome ribbon wound longitudinally, instead of helically, upon iron pipes. A flat mat is made of the resistor ribbon and strips of micabeston[3] woven together in basket fashion. This is wrapped about the heater tube (previously covered with a layer of micabeston), and the opposing ends of each insulating strip are lapped for a short distance

[2] For an illustrated description see the communication cited above.

[3] An insulating preparation of mica flakes and a resinous cement pressed into large, thin, flexible sheets.

and tucked under alternate lengths of the ribbon. Then follows another layer of micabeston and, finally, a wrapping of asbestos cloth. As each layer is applied it is drawn down firmly by a tight helical bandage of cotton tape, which is removed as soon as the layer has been cemented in place by warming and then cooling the tube. The final wrapping of asbestos cloth is secured by a bandage of nichrome ribbon. The lengths of ribbon bounding each edge of the mat and the two on either side of the middle are left long enough at one end to serve as electrical terminals. When the heater is wound, these terminals come out at opposite ends of a diameter at one extremity of the tube, and they connect the two halves of the winding in parallel.

This method of winding possesses the following advantages: (1) Any irregularities in the resistance of the heating ribbon are distributed in such a way as to produce a minimum effect upon the longitudinal distribution of temperature. (2) The winding is non-inductive. (3) The maximum difference in electrical potential that can occur between adjacent portions of the winding is limited to the drop in a length of ribbon twice as long as the furnace. This makes the danger of arcing by accidental contact considerably less than in the ordinary form of inductive winding. (4) If adjacent windings should accidentally touch, only a short length of ribbon could be short-circuited. (5) Spaces for the side openings down which the length-defining wires are suspended can be provided without affecting the heat supplied per unit length of the furnace tubes. (6) The location of the terminals combines both convenience and safety.

A furnace of the type here described requires considerable time to attain thermal equilibrium. The lag, however, causes no great inconvenience, because in any precise expansion determinations sufficient time should be allowed for the specimen to reach mechanical equilibrium, that is to say, for all unbalanced internal stresses to disappear. The gain in temperature uniformity and constancy more than counterbalances any time lost from avoidable lag. Nevertheless, it seems likely that a furnace amply sufficient for most purposes could be made with considerably less lag. In this connection it might be mentioned that the principal use of the inner concentric heater is to hasten the attainment of approximate thermal equilibrium. Experience has shown that when the proper adjustment has been secured, the steadying action of the insulation within the outer heater is sufficient to wipe out fluctuations in both losses and supply of heat.[4]

The temperatures and temperature distributions were determined by two thoroughly protected Pt-Pt Rh thermoelements of the best quality in connection with a Diesselhorst potentiometer. The sensitivity was such that one millimeter change in the galvanometer deflection indicated a change in temperature of between 0.058° and 0.086°, depending on the temperature.

Even before the flat end-heating coils were substituted for the coils in the outer conducting blocks of the plugs, fair uniformity throughout the central 30 cm. for which the furnace was designed could be easily obtained by proper adjustment of the heating currents. Good performance was not limited to some particular temperature, as is the case with furnaces in which adjustment of the distribution is attempted by the ordinary cut-and-try method of crowding the windings near the ends. For example, at 667° C. the mean temperature throughout the full 30 cm. was 0.37° lower than the temperature at the center, with a maximum drop of one degree at the extreme ends of the interval; at 145° the mean temperature over the same region was 0.08° lower than at the center, with a maximum drop of 0.25° at the extreme ends.

As an indication of the constancy attainable, it might be mentioned that during the twenty minutes that passed while the observations at 667° were being made the temperature at the center rose 0.067°, or at the rate of 0.2° per hour. During this period no attention whatever was paid to regulation of the heating currents.

[4] The use of two concentric heaters bears some resemblance to the cascade furnace described by Harker (Proc. Roy. Soc. A **76**: 237. 1905), for reaching a temperature of about 2000°C in a heater-tube made of the same material as Nernst lamp glowers. To avoid the necessity of having contacts on this tube capable of carrying relatively large currents, and the consequent severe stress on the parts, it was surrounded by a coil of nickel wire heated by an independent circuit to about 1000°, and insulated from the inner tube by a layer of zirconia. No precaution seems to have been taken to secure uniformity of temperature within.

Greater uniformity of temperature in the central region than had been secured by other experimenters after repeated attempts to adjust properly the crowding of windings was regularly obtained at widely differing temperatures even when heat losses through the ends were reduced merely by the action of the double plugs without supplying any heating current whatever to the coils in the end blocks. Adjustment of the temperature gradient was considerably facilitated by the installation of the flat coils covering the ends of the outer heater tube described above. This change also made it rather easy to produce fair uniformity for the entire length of the heater tubes—32 cm. longer than the bars the furnace was designed to heat.

That no unusual effort is required to obtain moderate uniformity of temperature is shown by the table below, which represents sixteen consecutive runs made while determining the expansivity of a bar of invar. Alongside the temperature observed at the center is recorded

Temperature Distribution in Consecutive Trials of an Electric Furnace

TEMPERATURE	CORRECTION	TEMPERATURE	CORRECTION
390°	−0.16°	233°	−0.10°
393	−0.13	214	−0.05
278	−0.03	344	−0.05
271	+0.03	314	−0.10
242	+0.13	445	−0.25
170	−0.04	294	−0.05
188	+0.04	262	+0.03
207	−0.10	175	+0.15

the correction that must be added to obtain the mean temperature throughout the 30 cm. occupied by the bar. In many of the runs the heating currents required to maintain the desired temperature were estimated and switched on late in the afternoon. The furnace was then left to itself over night. The temperature distribution found the following morning was explored and used. Reference to the table shows that in only one case (and that under known unfavorable conditions) did the mean temperature differ by more than 0.16° from that at the center.

ZOOLOGY.—*Nocturnal animals.* AUSTIN H. CLARK, National Museum.

In the discussion of zoögeographical problems, and especially in the reconstruction of hypothetical land bridges over which animals are assumed to have migrated from one region into another, comparatively little attention has been paid to analyzing the data upon which sweeping generalizations are based.

We are tempted to consider as a homogeneous unit all of the animals collectively occurring in any one locality, speaking of this unit as the "fauna" of this locality, and forgetting that in reality it is a heterogeneous collection of animal forms derived from all of the more adaptable and virile types in all the faunal complexes which from the distant past to the present day have swept over the region.

Since in reality the terrestrial animals of any given locality collectively form a heterogeneous faunal complex, instead of a homogeneous entity, it becomes essential that we should endeavor to find some criterion by which this complex may be separated into its original constituents, or at least whereby a beginning may be made in this direction.

On land, abundance of light alternates with a more or less complete absence of light, and we therefore find many animal types which are strictly diurnal, like most birds, many which are strictly nocturnal, like the bats, and many which are indifferently one or the other, like most insects.

Nocturnal animals, properly speaking, are animals which, while capable of performing all their normal functions in the day time, and not dependent upon other nocturnal animals, are active only at night.

Thus none of the amphibians come within the category of nocturnal animals, for the amphibians are active whenever the humidity is high enough so that they are in no danger of dermal desiccation, whether at night or during rains; similarly, though active chiefly or entirely at night, none of the terrestrial crustacea or molluscs are properly nocturnal.

Many of the herbivorous mammals are most active at night, at which time they often make long journeys for water; this is done to avoid overheating and loss of too much water from the body, and, in many places, to avoid certain insects, such as the species of *Simulium*, *Glossina*, the Tabanidae, etc., which, larger and more dangerous than any nocturnal insects, always breed in or near water and bite only in the daytime.

The predacious mammals and birds are active chiefly (though not by any means entirely) at night for the reason that, following the path of least resistance, they always conform to the habit of taking their prey when it is least able to defend itself, and therefore they must be considered as fortuitously, not as truly, nocturnal.

The day is physiologically the most favorable time for the performance of the normal functions of animals, and at the same time it is the period of greatest meteorological and thermal diversity. Therefore it would seem that new types of animals would always first arise as diurnal species.

If a new animal type arose as a diurnal form, and proved virile and adaptable, it would soon populate all available situations, and would increase so that there would be no room for further additions to its numbers.

But a type sufficiently virile and adaptable to attain such a condition would most assuredly give rise to crepuscular, and finally to nocturnal, forms. It is at this developmental stage that we find, for example, the rodents and the lepidoptera of the present day.

A new type of subsequent origin, of the same habits but economically more efficient, would follow the same course, and therefore would extirpate the diurnal species of the preceding less efficient type long before it had any effect upon the nocturnal species, so that, when the second type had become fully established, we would find it consisting of diurnal and crepuscular species, while the older type would consist of strictly nocturnal species, hiding by day and encroaching upon their more efficient rivals' food supply at night.

This is exactly the process by which the deep sea fauna has been formed from the littoral fauna.

The strictly nocturnal mammals are the elephants, the hippopotamus, the tapirs, the rhinoceros, the sloths, Galeopterus (Cynocephalus), the anteaters, the aard-varks, the armadillos, the pangolins, the bats, the opossums, the solenodons, the lemurs (except in Madagascar), and the monotremes (except the aquatic species); among the birds the kiwis and the owl-parrots (Stringops) are nocturnal, and among the reptiles the geckos; among the invertebrates the most striking and isolated nocturnal types are the onychophores and the millipeds.

A glance at this list of strictly nocturnal types brings out many points of interest.

Among the birds and mammals the average size is much greater than that of the diurnal types.

Most of the nocturnal mammals have long palaeontological records, and, collectively, the included groups are considered as much more ancient, primitive and aberrant than the diurnal types.

Taken as a whole the nocturnal animals of the globe indicate zoögeographic affinities very different from those indicated by the diurnal animals; for instance, the nocturnal fauna of America shows a close affinity to that of Africa, and also an affinity with that of Australia, while the occurrence of tapirs, otherwise confined to the Malayan region, is of interest; but the affinity indicated by overwhelmingly the greater part of the diurnal fauna of America is with eastern Asia.

The two fundamental differences in the conditions under which the nocturnal animals live as contrasted with the diurnal are (1) the much lower and more uniform temperature, and (2) the more or less complete absence of light.

It is precisely these two differences which delimit the conditions under which the abyssal marine animals live as contrasted with the littoral marine animals, and we are therefore not surprised to find that the nocturnal fauna of the land corresponds in its relation to the diurnal fauna exactly to the abyssal fauna of the oceans in its relation to the littoral fauna.

This comparison enables us to understand how a given type (as for example the bats), exclusively nocturnal in the tropics, may become more or less diurnal in the cold northern regions, just as an organism confined exclusively to the abysses in the tropics may become sublittoral, or even littoral, in the antarctic or in the arctic; for the coëfficient of virility and adaptability necessary to enable an animal type to thrive under nocturnal conditions in the tropics, or in the deep sea, is equivalent to that necessary to enable it to exist in unnaturally cold surroundings, or in unnaturally great diurnal temperature variations.

In this short paper no attention has been paid to the innumerable intergrades between the intertidal fauna, and the faunas of the land and of fresh water, or to the singularly instructive faunas of deserts, wet belts, saline lakes, caves, or of abnormal situations in general, nor to isolated island faunas, nor to the characters presented by burrowing animals collectively considered; nor has attention been given to the singular fact that, parallel to the abstract similarity between the nocturnal terrestrial fauna and the abyssal fauna of the oceans, the fresh water fauna is actually more closely allied to that of the deep sea than either is to the littoral fauna from which both have been derived, but in which the ancestral types have been supplanted by more efficient types of subsequent origin which as yet have not intruded either into the fresh water or into the deep sea; though these points, and many others, have a very intimate bearing upon the problem of the nocturnal terrestrial fauna.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

AGRICULTURAL CHEMISTRY.—*Selective adsorption by soils.* E. G. PARKER. Journal of Agricultural Research **1**: 179–188. 1913.

Soils not only have the power of adsorbing dissolved salts from solutions but also of adsorbing one ion at a greater rate than another.

The presence of bases of the soil (Ca, Mg, etc.) in solution after shaking certain salt solutions with or percolating them through a soil is probably not due to a direct chemical reaction of the salt in solution with the silicates of the soil, but to a reaction of free acid, resulting from a selective adsorption of the cation, with the mineral components of the soil. The rate of adsorption of chlorin ions from a solution of potassium chlorid by soils is much less than of potassium ions. The selective adsorption of potassium from a potassium-chlorid solution by a soil increases in amount with the concentration up to a certain point and then remains practically constant. In general, the smaller the soil particles the greater the selective adsorption of potassium from a potassium-chlorid solution. The presence of sodium nitrate decreases the adsorption of potassium from a solution of potassium chlorid by a soil up to a concentration of about 37.5 grams of potassium chlorid per liter and then increases it. The presence of monobasic calcium phosphate does not change appreciably the adsorption of potassium from a potassium-chlorid solution.

Finally, if a mineral fertilizer be applied to a soil and exposed to the rain and thus dissolved and carried through the soil in solution, these substances will be adsorbed (an entirely physical phenomenon) either as a whole or selectively from the solution by the vast surface of the soil particles and will be held there by this same physical force until the plant or subsequent leaching removes it.

The presence of other mineral substances added to the soil may or may not increase or decrease the rate at which this adsorptive phenomenon takes place. E. G. P.

ENTOMOLOGY.—*The Calliephialtes parasite of the codling moth.* R. A. CUSHMAN. Journal of Agricultural Research **1**: 211–237. 1913.

This parasite was introduced into California from Europe in 1904. The start on the work discussed was made with specimens secured from the California State Insectary.

The adult female is about half an inch long, exclusive of the ovipositor, which about equals the body in length. It is long and slender, black with red legs. The male is somewhat shorter and more slender than the female. There is considerable variation in size depending on the larval food supply.

The codling moth is attacked in the larval stage after it has spun its cocoon, the parasite first killing the host by stinging and then depositing a single egg within the cocoon. The egg is white and smooth, 1.5 mm. long and about one-fifth as wide at the widest part, rounded at the cephalic end and tapering toward the caudal end. The incubation period was found to average slightly over two days.

The newly hatched larva is yellowish in color with the head large and distinct. After the first molt the form changes to the normal larval habitus of insects of this class. It feeds externally on the host, entirely consuming the fluid contents. This requires on the average about 7 days, after which the larva spins its cocoon. About 10 days later for females and 7.5 days for males, pupation takes place. The act of pupation requires about 15 minutes for males and 35 to 41 minutes for females, the difference being due to the fact that after exuviation the ovipositor increases greatly in length. The average pupal period for females was about 11 days and for males about 9 days. The average time spent in the cocoon by females was 21.5 days and by males 17.7 days.

Transformation to the adult took place about a day before the emergence from the cocoon. The average total developmental period for females was about 30 days and for males about 25 days.

There were found to be two complete and a partial third generation during the breeding season, a part of the third and all of the fourth constituting the hibernating brood. Hibernation takes place in the full-grown larval stage. The males appear in the spring about 10 days ahead of the females. R. A. C.

ENTOMOLOGY.—*The Occurrence of a cotton boll weevil in Arizona.* W. DWIGHT PIERCE. Journal of Agricultural Research **1**: 89–96, figs. 1–9. 1913.

A new variety of the cotton boll weevil, *Anthonomus grandis thurberiae*, has been found to occur in a state of nature on the co-called Arizona wild cotton, *Thurberia thespesioides*, in mountain canyons of the Santa Catalina, and Santa Rita Mountains of Arizona.

The weevil breeds in the buds and bolls of this plant at altitudes of 4000 to 5000 feet. It can hardly have more than two full generations a year because of the late blooming season of the plant. The species hibernates as an adult in the bolls, remaining in the pupal cell often until September 1, although the majority probably emerge in August.

Attack on the buds begins about August 15. The egg is usually inserted in the lower part of the bud, and this soon drops to the ground. The larva develops and pupates in the fallen bud and emerges in a few weeks. The second generation is probably almost entirely on the bolls.

At Victoria, Texas it has been found that the Arizona variety can breed in cotton and that it can interbreed with the genuine cotton boll weevil.

The greatest significance of the discovery of this weevil lies in the fact that the westward extension of cotton culture has brought cotton production to within twenty miles of one of the canyons where the weevil was actually found.

The apparently greater adaptability of the Arizona form to extremes of climate may also indicate the possibility that this form could successfully endure the severe climate of the western Texas cotton areas where the boll weevil has never succeeded in establishing itself. W. D. P.

ENTOMOLOGY.—*Descriptions of twenty-three new genera and thirty-one new species of Ichneumon-flies.* HENRY L. VIERECK. Proceedings of the U. S. National Museum **46**: 359–386. December 31, 1913.

Describes the new genera Eristernaulax, Macroneuroides, Trachagathis and Zadiolcogaster in the Braconidae, and in the Ichneumonidae the following as new: Aglaojoppidea, Cryptanuridimorpha, Cryptophion, Cryptopterigimorpha, Digonocryptus, Epiopelmidea, Joppocryptus, Lamprocryptidea, Monogonocryptus, Phaenolabrorychus, Photocryptus, Polyaenidea, Polycyrtidea, Polycyrtimorpha, Thymarimorpha, Zaglyptomorpha and Zamastrus from South America, and Diaglyptidea and Photoptera from Java. The new species described are mostly from South America. J. C. CRAWFORD.

ENTOMOLOGY.—*Miscellaneous contributions to the knowledge of the weevils of the families Attelabidae and Brachyrhinidae.* W. DWIGHT PIERCE. Proceedings of the U. S. National Museum **45**: 365–426. May 23, 1913.

In the portion of this paper dealing with the family Attelabidae the author treats only of the subfamily Rhynchitinae which he divides into two new tribes, giving a key to the species of the genus Eugnamptus, to which most of the North American species belong. In the family Brachyrhinidae the author proposes a new classification in which he describes five new subfamilies, twenty-six new tribes, the new genera Amydrogmus, Hadromeropsis, Bradyrhynchoides, and Glaphyrometopus, and the new subgenera Panscopidius and Neopanscopus, together with twenty-four new species and nine new varieties. J. C. CRAWFORD.

ENTOMOLOGY.—*New potato weevils from Andean South America.* W. DWIGHT PIERCE. Journal of Agricultural Research **1**: 347–351, figs. 1–3, pls. 39–41. January 10, 1914.

During 1913, shipments of potatoes for propagation by the Department of Agriculture from various points on the western slope of South America were found infested by live weevils when received at Washington, D. C.

Three species of weevils were found in these various shipments. Their manner of attack was such that it was extremely difficult to detect infestation in lightly infested potatoes. The larval feeding cell is not usually very large and is entirely within the tuber, although near the surface. Advices from Peru indicate that infested potatoes are not uncommonly served at the table, because of the difficulty of detecting the injury externally.

The species *Rhigopsidius tucumanus* Heller occurs in Argentina, Peru, Bolivia, and Chile.

The other species, both representing new genera are found in Peru. These species are described as *Premnotrypes solani*, n. sp. and *Trypopremnon latithora*, n. sp. W. D. P.

REFERENCES

Under this heading it is proposed to include, by author, title, and citation, references to all scientific papers published in or emanating from Washington. It is requested that authors coöperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

PALEONTOLOGY

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EVOLUTION

COLLINS, G. N. and KEMPTON, J. H. *Inheritance of waxy endosperm in hybrids of Chinese maize.* IV^e Conférence Internationale Génétique, Paris, **1911**: 347-357. 1913.

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BRITTON, N. L. and ROSE, J. N. *Studies in Cactaceae,—I.* Contributions from the U. S. National Herbarium **16**: 239-242, pl. 66-73. April 10, 1913. (Includes descriptions of 7 new species in Echinocactus, Epiphyllum, Hylocereus, Nyctocereus, Opuntia, and Wittia.—W. R. M.)

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COOK, O. F. *The abortion of fruiting branches in cotton.* Bureau of Plant Industry Circular 118: 11-16. March 22, 1913.

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ENTOMOLOGY

ALEXANDER, C. P. *A revision of the South American dipterous insects of the family Ptychopteridae.* Proceedings of the U. S. National Museum **44**: 331–335. February 20, 1913. (Includes description of a second South American species, *Tanyderus patagonicus*.—J. C. C.)

ALEXANDER, C. P. *A synopsis of part of the neotropical craneflies of the subfamily Limnobinae.* Proceedings of the U. S. National Museum **44**: 481–549, pls. 65–68. April 30, 1913. (Treats of the tribes Eriopterini and Limnophilini and describes thirty-seven new species and three new subspecies. The author gives keys to the genera and species included.—J. C. C.)

BRUNER, L. *Results of the Yale Peruvian expedition of 1911. Orthoptera (Acridiidae-short-horned locusts.* Proceedings of the U. S. National Museum **44**: 177–187. February 11, 1913. (Two new genera, Cumainocloidus and Urubamba, are described, together with six new species and one new variety.—J. C. C.)

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CRAWFORD, J. C. *Descriptions of new Hymenoptera,—No. 8.* Proceedings of the U. S. National Museum **46**: 343-352. December 23, 1913. (Describes Perilampidea, Xenomymar and Neoymar (new genera) and ten new species, mostly from Trinidad, in the Chalcidoidea and three new species in the Serphidoidea.—J. C. C.)

COCKERELL, T. D. A. *New parasitic Hymenoptera of the genus Eiphosoma.* Proceedings of the U. S. National Museum **46**: 61-64. August 23, 1913. (Describes four new species and gives a table to the species occurring in North and Central America.—J. C. C.)

DYAR, H. G. *Descriptions of new species of Saturnian moths in the collection of the United States National Museum.* Proceedings of the U. S. National Museum **44**: 121-134. February 20, 1913. (Deals with the genus Hylesia, gives a key to the species, and describes thirty new species mostly from South America.—J. C. C.)

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KENNEDY, C. H. *Notes on the Odonata, or dragonflies, of Bumping Lake, Washington.* Proceedings of the U. S. National Museum **46**: 111-126. September 30, 1913.

KNAB, F. *Gad-flies (Tabanidae) of the genus Stibasoma.* Proceedings of the U. S. National Museum **46**: 407-412. December 23, 1913. (Includes a key to the American members of this genus and descriptions of one new species.—J. C. C.)

KNAB, F. *New moth-flies (Psychodidae) bred from Bromeliaceae and other plants.* Proceedings of the U. S. National Museum **46**: 103-106. August 23, 1913. (Describes four new species of the genus Psychoda, bred from water found at the bases of the leaves of Bromeliaceae and in flower bracts of Calathea. —J. C. C.)

MALLOCH, J. R. *The genera of flies in the subfamily Botanobiinae with hind tibial spur.* Proceedings of the U. S. National Museum **46**: 239-266, pls. 23-24. December 6, 1913. (Gives keys to the four genera included and to the species of the genus Hippelates, ten of which are new; includes also descriptions of the new genera Prohippelates and Pseudohippelates.—J. C. C.)

Malloch, J. R. *A Synopsis of the genera of Agromyzidae, with descriptions of new genera and species.* Proceedings of the U. S. National Museum **46**: 127–154, pls. 4-6. December 6, 1913. (Gives keys to the subfamilies, tribes, genera and to the American species of some of the genera; describes Paraleucopis, Paramilichia and Euchlorops, new genera; proposes Paramadiza, new name for Madiza of authors, not of Fallen; describes eleven new species.—J. C. C.)

Malloch, J. R. *Notes on some American Diptera of the genus Fannia, with descriptions of new species.* Proceedings of the U. S. National Museum **44**: 621–631, pl. 77. April 30, 1913. (Describes five new species and gives a key to the species of one group of the genus.—J. C. C.)

Malloch, J. R. *Descriptions of new species of American flies of the family Borboridae.* Proceedings of the U. S. National Museum **44**: 361–372. February 20, 1913. (Describes ten new species in several genera.—J. C. C.)

Malloch, J. R. *Two new species of diptera in the United States National Museum collection.* Proceedings of the U. S. National Museum **44**: 461–463. February 20, 1913.

Malloch, J. R. *Three new species of Anthomyidae (Diptera) in the United States National Museum collection.* Proceedings of the U. S. National Museum **45**: 603–607. June 11, 1913.

Morgan, A. C. *New genera and species of Thysanoptera, with notes on distribution and food plants.* Proceedings of the U. S. National Museum **46**: 1–55. August 23, 1913. (Describes the new genera Rhipiphorothrips, Microthrips, and Horistothrips, nineteen new species, and one new variety, mostly from North America.—J. C. C.)

Rohwer, S. A. *A synopsis and descriptions of the nearctic species of sawflies of the genus Xyela, with descriptions of other new species of sawflies.* Proceedings of the U. S. National Museum **45**: 265–281, text fig. 1. May 22, 1913. (Describes the new genus Allantopsis in the family Tenthredinidae and twenty-one new species in various genera.—J. C. C.)

Rohwer, S. A. *New parasitic Hymenoptera belonging to the tribe Xoridini.* Proceedings of the U. S. National Museum **45**: 353–361. May 22, 1913. (Describes eleven new species.—J. C. C.)

Rohwer, S. A. *Descriptions of thirteen new species of parasitic Hymenoptera and a table to certain species of the genus Ecphylus.* Proceedings of the U. S. National Museum **45**: 533–540. June 4, 1913.

Rohwer, S. A. *Results of the Yale Peruvian expedition of 1911. Hymenoptera, superfamilies Vespoidea and Sphecoidea.* Proceedings of the U. S. National Museum **44**: 439–454. February 20, 1913. (Describes fourteen new species. —J. C. C.)

Viereck, H. L. *Results of the Yale Peruvian expedition of 1911. Hymenoptera-Ichneumonoidea.* Proceedings of the U. S. National Museum **44**: 469–470. February 20, 1913. (Describes three new species.—J. C. C.)

Viereck, H. L. *Descriptions of six new genera and twelve new species of Ichneumon-flies.* Proceedings of the U. S. National Museum **44**: 639–648. April 18, 1913. (Describes the new genera Amyosoma, Arichelonus, Diachasmimorpha, and Shirakia in the family Braconidae, and Eripternimorpha and Zaparaphylax in the family Ichneumonidae.—J. C. C.)

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MINERALOGY.—*Supplementary note on the crystal form of hodgkinsonite.*[1] C. Palache, Harvard University. Communicated by W. T. Schaller.

Through the kindness of Mr. McGovern of Franklin Furnace the writer has been supplied with specimens of a second occurrence of the new mineral hodgkinsonite. These are in the form of veins from 3 to 7 cm. in width consisting of a granular mixture of hodgkinsonite and willemite; the veins cut the normal franklinite ore with well defined boundaries.

The material of the veins is in large part compact but at quite irregular intervals there occur tiny cavities upon whose walls are implanted excellent crystals of hodgkinsonite. The crystals do not exceed 2 mm. in length but they are clear and brilliant and give measurements so much better than any obtained on the first-found specimens that the elements have been recalculated and a new table of angles is here presented containing the new data. It will be seen that the forms include the better ones of the first list together with several new ones; the habit is however entirely similar to that first described, the acute pyramids formed by combination of two prisms and two pyramid faces, *m* and *r*, having their summits more or less modified by the other planes. The forms previously described as etch forms have not been found on these crystals and they may well be dropped from the form series of the mineral. Nine crystals were measured and gave a

[1] Hodgkinsonite, a New Mineral from Franklin Furnace, N. J. C. Palache and W. T. Schaller, this Journal, **3**: 474. 1913.

very consistent set of observations which together with the calculated angles and new elements are shown below.

HODGKINSONITE

$p_0=0.7201$ $q_0=1.1025$ $\mu=84°\ 35'$ $a:b:c=1.538:1:1.1075$ $\beta=84°\ 35'$

		Calculated φ	Calculated ρ	Measured φ	Measured ρ	Limits φ	Limits ρ	No. of faces
c	(001)	90° 00′	5° 25′	90° 00′	5° 27′		5° 18′– 5° 36′	8
m	(110)	33° 09′	90° 00′	33° 09′	90° 00′	33° 05′–33° 13′		19
l	(210)	52° 33′	90° 00′	52° 33′	90° 00′			1
s	(011)	4° 54′	48° 01′	4° 54′	48° 01′	4° 43′– 5° 04′	47° 58′–48° 03′	16
o	(021)	2° 27′	65° 44′	2° 30′	65° 42′	2° 27′– 2° 37′	65° 38′–65° 45′	12
v	($\bar{4}$03)	−90° 00′	41° 01′	−90° 00′	40° 50′		40° 43′–40° 57′	2
w	($\bar{2}$01)	−90° 00′	53° 30′	−90° 00′	53° 28′		53° 20′–53° 37′	8
t	($\bar{4}$01)	−90° 00′	70° 20′	−90° 00′	70° 20′		70° 14′–70° 25′	4
p	(111)	36° 27′	54° 00′	36° 35′	54° 04′			1
r	(221)	34° 50′	69° 40′	34° 49′	69° 41′	34° 47′–34° 51′	69° 37′–69° 47′	12
n	($\bar{3}$11)	−61° 55′	66° 58′	−62° 00′	67° 00′	61° 58′–62° 03′		2

GEOLOGY.—*The transportation of débris by running water.*[1] G. K. GILBERT, based on experiments made with the assistance of EDWARD CHARLES MURPHY.

Scope. The finer débris transported by a stream is borne in suspension. The coarser is swept along the channel bed. The suspended load is readily sampled and estimated, and much is known as to its quantity. The bed load is inaccessible and we are without definite information as to its amount. The primary purpose of the investigation was to learn the laws which control the movement of bed load, and especially to determine how the quantity of load is related to the stream's slope and discharge and to the degree of comminution of the débris.

Method. To this end a laboratory was equipped at Berkeley, Cal., and experiments were performed in which each of the three conditions mentioned was separately varied and the resulting variations of load were observed and measured. Sand and gravel were sorted by sieves into grades of uniform size. Determinate discharges were used. In each experiment a specific

[1] Abstract of U. S. Geological Survey Professional Paper 86. (In press.)

load was fed to a stream of specific width and discharge, and measurement was made of the slope to which the stream automatically adjusted its bed so as to enable the current to transport the load.

The slope factor. For each combination of discharge, width, and grade of débris there is a slope, called competent slope, which limits transportation. With lower slopes there is no load, or the stream has no capacity[2] for load. With higher slopes capacity exists; and increase of slope gives increase of capacity. The value of capacity is approximately proportional to a power of the excess of slope above competent slope. If S equal the stream's slope and σ equal competent slope, then the stream's capacity varies as $(S—\sigma)^n$. This is not a deductive, but an empiric law. The exponent n has not a fixed value, but an indefinite series of values depending on conditions. Its range of values in the experience of the laboratory is from 0.93 to 2.37, the values being greater as the discharges are smaller or the débris is coarser.

The discharge factor. For each combination of width, slope, and grade of débris there is a competent discharge, κ. Calling the stream's discharge Q, the stream's capacity varies as $(Q—\kappa)^o$. The observed range of values for o is from 0.81 to 1.24, the values being greater as the slopes are smaller or the débris is coarser. Under like conditions o is less than n; or, in other words, capacity is less sensitive to changes of discharge than to changes of slope.

The fineness factor. For each combination of width, slope, and discharge there is a limiting fineness of débris below which no transportation takes place. Calling fineness (or degree of comminution) F and competent fineness ϕ, the stream's capacity varies with $(F—\phi)^p$. The observed range of values for p is from 0.50 to 0.62, the values being greater as slopes and discharges are smaller. Capacity is less sensitive to changes in fineness of débris than to changes in discharge or slope.

The form factor. Most of the experiments were with straight channels. A few with crooked channels yielded nearly the same

[2] *Capacity* is defined for the purposes of this paper as the maximum load of a given kind of débris which a given stream can transport.

estimates of capacity. The ratio of depth to width is a more important factor. For any combination of slope, discharge, and fineness it is possible to reduce capacity to zero by making the stream very wide and shallow or very narrow and deep. Between these extremes is a particular ratio of depth to width, ρ, corresponding to a maximum capacity. The values of ρ range, under laboratory conditions, from 0.5 to 0.04, being greater as slope, discharge, and fineness are less.

Velocity. The velocity which determines capacity for bed load is that near the stream's bed, but attempts to measure bed velocity were not successful. Mean velocity was measured instead. To make a definite comparison between capacity and mean velocity it is necessary to postulate constancy in some accessory condition. If slope be the constant, in which case velocity changes with discharge, capacity varies on the average with the 3.2 power of velocity. If discharge be the constant, in which case velocity changes with slope, capacity varies on the average with the 4.0 power of velocity. If depth be the constant, in which case velocity changes with simultaneous changes of slope and discharge, capacity varies on the average with the 3.7 power of velocity. The power expressing the sensitiveness of capacity to changes of mean velocity has in each case a wide range of values, being greater as slope, discharge, and fineness are less.

Mixtures. In general, débris composed of particles of a single size is moved less freely than débris containing particles of many sizes. If fine material be added to coarse, not only is the total load increased but a greater quantity of the coarse material is carried.

Modes of transportation; movement of particles. Some particles of the bed load slide; many roll; the multitude make short skips or leaps, the process being called saltation. Saltation grades into suspension. When particles of many sizes are moved together the larger ones are rolled.

Modes of transportation; collective movement. When the conditions are such that the bed load is small, the bed is molded into hills, called dunes, which travel downstream. Their mode of advance is like that of eolian dunes, the current eroding their upstream faces and depositing the eroded material on the downstream faces. With any progressive change of conditions tending to increase the load, the dunes eventually disappear and the débris surface becomes smooth. The smooth phase is in turn succeeded by a second rhythmic phase, in which a system of hills travel upstream. These are called antidunes, and their movement is accomplished by erosion on the downstream face and deposition on the upstream face. Both rhythms of débris movement are initiated by rhythms of water movement.

Application of formulas. While the principles discovered in the laboratory are necessarily involved in the work of rivers, the laboratory formulas are not immediately available for the discussion of river problems. Being both empiric and complex, they will not bear extensive extrapolation. Under some circumstances they may be used to compare the work of one stream with that of another stream of the same type, but they do not permit an estimate of a river's capacity to be based on the determined capacities of laboratory streams. The investigation made an advance in the direction of its primary goal, but the goal was not reached.

Load versus energy. The energy of a stream is measured by the product of its discharge (mass per unit time), its slope, and the acceleration of gravity. In a stream without load the energy is expended in flow resistances, which are greater as velocity and viscosity are greater. Load, including that carried in suspension and that dragged along the bed, affects the energy in three ways. (1) It adds its mass to the mass of the water and increases the stock of energy pro rata. (2) Its transportation involves mechanical work, and that work is at the expense of the stream's energy. (3) Its presence restricts the mobility of the water, in effect increasing its viscosity, and thus consumes energy. For the finest elements of load the third factor is more important than the second; for coarser elements the second is the more important. For each element the second and third together exceed the first, so that the net result is a tax on the stream's energy. Each element of load, by drawing on the supply of energy, reduces velocity and thus reduces capacity for all parts of the load. This principle affords a condition by which total capacity is limited. Subject to this condition a stream's load at any time is determined by the supply of débris and the fineness of the available kinds.

Flume transportation. In the experiments described above—experiments illustrating stream transportation—the load traversed a plastic bed composed of its own material. Other experiments were arranged in which the load traversed a rigid bed, the bottom of a flume. Capacities are notably larger for flume transportation than for stream transportation, and their laws of variation are different. Rolling is an important mode of progression. For rolled particles the capacity increases with coarseness, for leaping particles with fineness. Capacity increases with slope and usually with discharge also, but the rates of increase are less than in stream transportation. Capacity is reduced by roughness of bed.

Vertical velocity curve. The vertical distribution of velocities in a current is controlled by conditions. The level of maximum velocity may have any position in the upper three-fourths of the current. In loaded streams its position is higher as the load is greater. In unloaded streams its position is higher as the slope is steeper, as the discharge is greater, and as the bed is rougher.

Pitot tube. The constant of the Pitot velocity gage—the ratio between the head realized and the theoretic velocity head—is not the same in all parts of a conduit, being less near the water surface and greater near the bottom or side of the conduit.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

ASTROPHYSICS.—*The non-selective transmissibility of radiation through dry and moist air.* F. E. Fowle, Astrophysical Journal **38**: 392. 1913.

The change in the transmissibility of radiation associated with atmospheric water-vapor between the wave-lengths 0.371μ and 1.74μ was first determined; this rendered possible the evaluation of the transmissibility of radiation by dry air vertically above Mount Wilson (1730 meters). In the following table are given, for a few selected wave-lengths, the coefficients of transmission for dry air, $a_{a\lambda}$, the factor for the change produced by atmospheric water-vapor when the amount of precipitable water is 1 cm., $a_{w\lambda}$, and the theoretical values for dry air computed from the theory of molecular scattering.

WAVE-LENGTH	μ 0.370	μ 0.400	μ 0.430	μ 0.460	μ 0.500	μ 0.600	μ 0.750	μ 1.000	μ 1.500
$a_{w\lambda}$	0.957	0.962	0.967	0.971	0.976	0.977	0.988	0.990	0.988
$a_{a\lambda}$ (observed)	0.683	0.757	0.808	0.851	0.885*	0.916*	0.977	0.987	0.990
$a_{a\lambda}$ (computed)	0.680	0.755	0.808	0.850	0.890*	0.946*	0.977	0.987	0.986

* Places of selective transmission.

The corresponding values of a_λ for air containing w cm. of precipitable water-vapor would be $a_{w\lambda}^{w} \cdot a_{a\lambda}$.

The transmission coefficient for dry air was then used for the determination of the number of molecules, N_0, per cc. of a gas at 760 mm. pressure and at 0°C. The result was

$$N_0 = 25.6 \times 10^{18},$$

found to correspond very closely with the present best value from other methods, 27 billion billion (Millikan). This mode of analysis shows that for dry air, except where selective absorption accurs, the depletion of the beam from the sun or other celestial body, as observed in

1910 and 1911 at Mount Wilson was caused almost wholly by molecular scattering. From 0.36μ to 0.50μ the depletion is practically wholly of this nature. Then come the great selective absorption bands, which except near the D lines, have been eliminated from this discussion. Even in the infra-red between these water-vapor bands, molecular scattering accounts for the observed depletion of radiation by the atmosphere.

The same analysis applied to atmospheric aqueous vapor shows that the observed absorption is very much too great to be accounted for by the number of water molecules present. The transmission coefficients found by various observers for liquid water, however (0.21μ to 0.50μ), are such as would be expected from this amount of water in vapor form. This leads to the inference that its absorption in liquid form in this region results from molecular scattering. The number of molecules, N_0, computed from the transmission coefficients of liquid water is about

$$N_0 = 28 \times 10^{18}.$$

The increased absorption connected with atmospheric water-vapor and the departure of the transmission coefficients from strict proportionality to the inverse fourth power of the wave-length in the sense that the coefficients for smaller wave-lengths are too high, leads to the inference that the vapor is loaded with something greater in size than molecules. This loading could be due to dust or iron, although there is not definite evidence why these should be proportional to the amount of water-vapor present. The presence of nuclei, formed by the action of the ultra-violet light of the sun on the moisture present in the air, seems perhaps the most satisfactory explanation.

In the above study the amount of water-vapor present in the air was measured by the depths of three calibrated selective absorption lines in the infra-red. The effect of scattering, which varies slowly and continuously with the wave-length, was eliminated. It has been shown in an earlier paper (*Astrophysical Journal*, **37**: 359. 1913) that the mean results of such determinations of the amount of aqueous vapor in the atmosphere agree with the mean results of estimates of it from observations with kites and balloons. F. E. F.

PHYSICS.—*Standard density and volumetric tables, 4th edition.* Bureau of Standards Circular No. 19. (In press.)

In this circular the following tables are included: Table 1 gives the density of water (according to P. Chappuis) at every tenth of a degree from 0°

to 40°C. Tables 2 to 8, inclusive, are standard density and specific gravity tables for ethyl alcohol. They are based on work done at this Bureau and published in Vol. 9, No. 3, of the Bulletin of the Bureau of Standards (Reprint No. 197). Tables 9 to 11, are similar tables for methyl alcohol. They are based on the work of Doroshevskii and Rozhdestvenskii. Tables 12 and 13 are density tables for sugar solutions. Tables 14 and 15 are density tables for sulphuric acid solutions. Tables 16 to 19 give the relation between specific gravity and degrees Baumé, in use in the United States. Table 20 is for changing the density basis of hydrometers and picnometers. Table 21 gives the weight of a liter of air at various pressures and temperatures. Table 22 gives the difference between the weight of 1 cc. of water in vacuo and in air at various pressures and temperatures. Table 23 gives the apparent weight of various volumes of water at various temperatures when weighed against brass weights in air. Table 24 gives the temperature correction for glass volumetric apparatus. Tables 25 to 37 give the corrections to be applied to the weight of water, in air, to give the capacity of glass volumetric apparatus. Table 38 gives the density of water (according to Thiesen) at temperatures from 0° to 102°C. Tables 39 and 40 are master scales for the graduation of hydrometers to indicate percentages of ethyl alcohol by weight and by volume and percentages of "Proof Spirit." G. K. B.

GEOLOGY.—*The Noatak-Kobuk region, Alaska.* PHILIP S. SMITH. U. S. Geological Survey Bulletin 536. Pp. 160, with maps and illustrations. 1913.

Practically all of the Noatak-Kobuk region lies north of the Arctic Circle, and as a whole is a mountainous region. The rocks from which the geology of the region has been inferred have been separated into two main divisions, namely, sedimentary and igneous. The sedimentary rocks have been divided into thirteen groups as follows: Unconsolidated deposits consisting of recent stream gravels; recent beach deposits; beach and outwash deposits; Tertiary deposits; the Mesozoic rocks separated into the Bergman, Koyukuk, and Anaktuvuk groups; the Paleozoic rocks subdivided into the Lisburne limestone, Noatak sandstone, Devonian limestone, Silurian limestone, undifferentiated Paleozoic limestones, and undifferentiated Paleozoic metamorphic schists. The last two divisions of Paleozoic rocks may possibly include some rocks of pre-Paleozoic age. The igneous rocks have been subdivided into four main groups: Basaltic effusives, granitic intrusives, early intrusives and effusives, and greenstones. P. S. S.

GEOLOGY.—*Iron-ore deposits of the Eagle Mountains, California.* E. C. Harder. U. S. Geological Survey Bulletin 503. Pp. 81, with maps, views and sections. 1913.

The Eagle Mountain iron ores are located in the northern part of the Eagle Mountains, Riverside County, California. The broad structural feature of the northern third of the Eagle Mountains—that is, of the portion consisting of sediments and intrusive granite and where the iron ores occur—is an oval dome, extending in a general east-west direction across the range. The iron ores with associated metamorphic minerals occur as replacements in dolomite. Locally, as at the east end of the area, they have replaced the entire series of dolomite lenses, leaving the associated quartzite but little altered. Elsewhere they occur within the dolomite lenses or beds in bands or as irregular masses roughly parallel to the bedding. The ore is predominantly hematite, but here and there consists of masses of magnetite. Much of the hematite contains disseminated magnetite, making it slightly magnetic, but probably less than 10 per cent of the entire quantity of ore is magnetite.

The succession of geologic events in Eagle Mountain region is as follows: (1) Deposition of sandstone, siliceous shale, and dolomite. (2) Intrusion of porphyritic granite into the sediments. (3) Alteration of granite porphyry to augen gneiss and the sediments to schists and crystalline limestone. (4) Erosion interval followed by submergence and deposition of a great thickness of quartz sandstone; then the deposition of arkosic sandstone, followed by the formation of beds and lenses of dolomite and quartz sandstone, and, lastly, of beds of sandstone and conglomerate. (5) Intrusion of quartz monzonite in two main sills. (6) The heat and pressure accompanying the intrusion recrystallized and consolidated the sediments and perhaps locally developed metamorphic minerals. (7) During the latter part of the intrusion, or shortly after it, iron ores and metamorphic minerals were introduced by deep-seated solutions replacing the dolomite and to a slight extent the quartzite. (8) Doming of the sediments and intrusives, accompanied by great faulting. (9) Erosion exposing all the rock formations, accompanied by the sculpturing of mountains and followed by the development of great outwash aprons around the mountains.

A. H. Brooks.

GEOLOGY.—*Geology and ore-deposits of the Phillipsburg quadrangle, Montana.* W. H. EMMONS and F. C. CALKINS. U. S. Geological Survey Professional Paper 78. Pp. 271, with maps, views, and sections. 1913.

The consolidated sedimentary rocks range in age from Algonkian to late Cretaceous. The Algonkian Belt series is represented by about 20,000 feet of shale, sandstone and impure limestone. It is overlain, with an unconformity that is locally conspicuous, by the Flathead quartzite of Cambrian age, which constitutes the base of a Palaeozoic series about 4500 feet thick, which consists mainly of limestones, but whose uppermost strata, are quartzitic. These rocks were covered by several thousand feet of Jurassic and Cretaceous sandstone and shale, the latest that survive being of Colorado or Montana age. No structural unconformities are apparent in the Palaeozoic and Mesozoic series, but several epochs are unrepresented by deposits.

Intrusive igneous rocks occupy a large proportion of the surface. With the exception of a few diabasic and dioritic sills, the important intrusive masses are of irregular or dome-like form and are probably of early Tertiary age. Most of them belong to the granite and diorite families. The Phillipsburg batholith, one of the most important economically, is petrographically similar to the Boulder batholith, but less alkalic. The most unusual intrusives are pyroxene aplites, associated with granodiorites or quartz monzonites, some of which contain primary scapolite.

The rocks already described are overlain with marked unconformity by Tertiary tuffs and lavas in small amount, and by stream and glacial deposits of Tertiary and Quaternary age. There is clear evidence of two widely separated glaciations. Remnants of Tertiary erosion surfaces of low relief are well preserved, and the glacial sculpture of the high mountains is striking.

The structure of the pre-Tertiary sedimentary rocks is highly complex. The most remarkable structural features are overthrusts which have pushed Algonkian rocks several miles eastward over rocks as late as Jurassic and which have been folded. These overthrusts are thought to have a close relation with the similar ones in the Rocky Mountains further north and further south, described by Willis, Richards and others. The igneous rocks and the Tertiary gravel deposits have suffered some deformation, but much less than the older strata.

The ore deposits are classified according to mode of occurrence as follows: A. Deposits filling fissures. (1) Silver-bearing veins in granite, (2) Gold-bearing veins in granite, (3) Silver-bearing veins in quartzite,

(4) Gold-bearing veins and sheeted zones in quartzite. B. Replacement deposits related to fissures or to bedding planes. (1) Silver-bearing replacement veins in sedimentary rocks, (2) Silver deposits in bedding-planes of calcareous rocks, (3) Gold-bearing replacements veins in sedimentary rocks. C. Replacement deposits of contact metamorphic origin. (1) Gold-copper deposits, (2) Magnetite deposits. D. Gold placers.

All the important deposits in place are in or near the intrusive bodies. They were deposited by ascending solutions, and it is regarded as probable that these solutions were given off from the intrusives now exposed or from deeper ones that are still concealed. F. C. C.

GEOLOGY.—*Geology of the Nome and Grand Central quadrangles, Alaska.* Fred H. Moffit. U. S. Geological Survey Bulletin 533. Pp. 140, with maps and views. 1913.

The Nome and Grand Central quadrangles are situated in the south-central part of Seward Peninsula, Alaska.

Along the southern border of the area is a narrow coastal plain, sloping gently upward from Bering Sea to the foot of the hills a tew miles inland while on the north side are the Kigluaik Mountains, whose highest peaks within the quadrangle are about 3,000 feet. The rest of the area is a dissected upland with hills reaching a maximum elevation of about 2600 feet and showing smooth rounded contours.

The oldest rock formation is the Tigaraha schist, the topmost member of the Kigluaik group, which consists of biotite gneisses, coarsely crystalline limestone, biotite schist, and siliceous graphitic schist. The Tigaraha schist is exposed in the most northern part of the area and has a general southerly dip. It is intruded by dikes and sills of granite, diorite and diabase. Overlying the Kigluaik group and occupying nearly all the remainder of the mapped area is the Nome group of formations, made up chiefly of chloritic and feldspathic schists and altered limestones with many greenstone and a few granite intrusives. The age of the Kigluaik and the Nome groups is unknown. They probably range from Paleozoic or pre-Paleozoic to middle Paleozoic. The Quaternary unconsolidated deposits of the area include sands and gravels of marine and of fluvial origin, glacial deposits, and the mantle of unassorted debris due to weathering.

Within the coastal plain five or six of the old beaches have been discovered and these give direct evidence of changes in the relative heights of land and sea. They range in elevation from 34 feet below sea level to 70 or 79 feet above sea level, and except where removed or uncovered by erosion are buried under later gravel deposits, having a maximum thickness of 120 feet. F. H. M.

GEOLOGY.—*Nitrate deposits.* HOYT S. GALE. U. S. Geological Survey Bulletin 523. Pp. 36. 1912.

This paper consists of a short summary of the natural occurrences of nitrate salts known in the United States. The descriptions are chiefly compiled from the references to such occurrences found scattered throughout geologic and other literature, the use of such deposits as a source of nitrate for the manufacture of powder during war time having been a frequent source of comment. Some new descriptive data by the author and analyses from materials collected in the field are also included. The article contains a review chiefly by quotation, of the theories concerning nitrification as bearing on the probable origin of such deposits. H. S. G.

GEOLOGY.—*The Jurassic flora of Cape Lisburne, Alaska.* F. H. KNOWLTON. U. S. Geological Survey Professional Paper, 85-D. Pp. 55, with sections. 1914.

The Jurassic section of Cape Lisburne, to which the name Corwin formation has been given, reaches the thickness of over 15,000 feet. So far as at present known the fossil flora is uniformly distributed throughout, and embraces 17 species, only one of which is described as new. This flora is compared with known Jurassic floras of various parts of the world, and the conclusion is reached that it is not only undoubtedly Jurassic in age—which had previously been questioned—but belongs either in the upper part of the Middle Jurassic or Brown Jura, or the extreme lower part of the Upper Jurassic or White Jura—that is to say it is probably not older than the Bathonian, and certainly not younger than the Oxfordian. Several pages are devoted to a discussion of the geographic range of Jurassic floras in general, their means and avenues of dispersal, and the probable climatic conditions that prevailed in Alaska at the time this flora flourished there. F. H. K.

GEOLOGY.—*The origin of colemanite deposits.* HOYT S. GALE U. S. Geological Survey Professional Paper 85-A. Pp. 9, 1913.

Colemanite, the borate of lime from which practically all commercial borax and boric acid is derived in this country at the present time, has been discussed by various writers, but its origin has always been ascribed to the dessication of saline or alkaline waters, usually as deposits of

Tertiary lakes. A study of some of the characteristic colemanite deposits has suggested the probable vein origin of this mineral, without necessary association with dessication deposits. The vein character is indicated in the physical structure of the deposits, which also give evidence of the formation of colemanite by replacement of limestone. The boric acid is assumed to have been derived from volcanic sources, since volcanic activity has characterized the region in which these deposits occur, and intrusive or flow rocks are generally found in intimate association with the ore bodies. H. S. G.

GEOLOGY.—*Geology and ore deposits of Lemhi County, Idaho.* J. B. Umpleby. U. S. Geological Survey Bulletin 528. Pp. 182, with maps, sections and views. 1913.

The rock formations of Lemhi County, Idaho, include: (1) a gneissoid granite of Archean age, (2) a widespread series of Algonkian schists, slates and quartzites, (3) about 6000 feet of Paleozoic strata which include Cambrian quartzite, Ordovician, Silurian (?), and Devonian dolomitic limestones, and Mississippian limestone, (4) large batholithic masses of granite, and (5) Tertiary lavas and lake-beds.

The ore deposits may be grouped as gold placers and lodes, lead-silver veins and tabular replacements, copper-bearing gold veins, cobalt-nickel deposits, and tungsten-bearing veins. Two epochs of mineralization are recognized, the older late Cretaceous or early Eocene and the younger late Miocene or early Pliocene. All of the deposits, except a small group of gold-silver veins, belong to the earlier epoch.

The gold-bearing veins are inclosed in many types of rock in Lemhi County, but few of them are far distant from rocks of the granite rhyolite family. Lead-silver deposits are recognized only in the southeastern part of the county and at present are affording the principal production. They are inclosed in Paleozoic formations and are thought to be genetically related to a quartz diorite facies of the granite intrusion. The copper deposits have not proved of noteworthy commercial importance. Cobalt-nickel deposits occur in only one of the nineteen mining districts in the county. They occur as lens-like bodies and as bunches and disseminations along fractured zones. Some of them are known to contain about 2 per cent each of cobalt and nickel. Tungsten is mined in one district where it is associated with zinc, copper, lead, molybdenum, iron and silver minerals in lenticular quartz veins. J. B. U.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES.

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

A special meeting of the Anthropological Society of Washington was held February. 3, 1914, in the National Museum, the President, Mr. Stetson, in the chair. About eighty persons were present.

Miss Frances Densmore, of the Bureau of American Ethnology, read a paper on *Sioux War Songs*, using the stereopticon, the phonograph, and vocal selections in illustration of her theme. She first showed lantern slides of the prairie, where the long war drama of the Sioux was enacted, then portraits of some old Sioux warriors, and, last, a number of native drawings of war incidents. Many war customs were illustrated by the details, as well as by the subjects, of these drawings. One phonograph record of a woman's voice was given in connection with the portrait of a woman who sang a song in honor of a relative killed in war. The remaining songs were given vocally, the melodies being those sung by the Indians, but no effort being made to imitate the Indian manner of singing. Each drawing had one or more songs which were either sung at the time the incident occurred, or composed in honor of the event. These songs were phonographically recorded by the men who made the drawings, and were afterward transcribed in musical notation by the writer.

It is said that the Sioux, among all the Indian tribes, were the best as friends and the worst as enemies. They were indeed men to be feared in the old days. One of their societies was well named the "Strong Hearts." They were trained from childhood to have "strong hearts," and they held to a purpose when others failed. The warriors of a certain society carried in war a lance to which was fastened the skin of a crow. When that lance was planted in the ground they dared not retreat from it. So in loyalty to a friend, or in hatred of an enemy, they struck their lance into the ground and staid by it.

War among Indians had an aspect different from that which it has among civilized nations. It was not an occasional calamity, it more nearly resembled a steady occupation. To the individual it offered a career. A man could best become rich and honored by going to war. A man was rated according to his generosity, and having given away his goods there must be some way of securing a new supply of wealth. A war party afforded this opportunity. War was a means of revenge, and Indian revenge was a terrible thing. War was for the defence of the home, and the protection of the hunting ground which meant the food supply. Indian warfare was, after all, the physical expression of something which must always go on, only changing its form, as forces do, and passing from physical to mental battle grounds.

There was much of interest on the warpath besides the killing of enemies and the capture of horses. A war party traveled far and brought back strange tales of distant lands. New customs were frequently introduced into the tribe as a result of war expeditions or the taking of captives.

Only a successful warrior could belong to the leading societies of the tribe, with their special tents for meeting, their feasts and their parades, all of which were very attractive to the Indian. But the greatest reward was the right to sing of one's valor, at the assemblages of the tribe.

DANIEL FOLKMAR, *Secretary.*

THE CHEMICAL SOCIETY

The 235th meeting was held at the Cosmos Club on February 12, 1914. The following papers were read:

F. P. DEWEY, of the Bureau of the Mint: *Artificial sperrylite.* Sperrylite, $PtAs_2$, which is especially interesting as the only chemical compound containing Pt found in nature, has been duplicated in a matte made in the refinery of the San Francisco Mint. The product is beautifully crystallized and closely resembles the original sperrylite found at Sudbury.

P. H. WALKER, of the Bureau of Chemistry: *Note on a new extraction apparatus.* This apparatus, which is made of iron and copper tubing and is free from rubber connections, was shown and briefly described.

Discussion: Chamberlaine spoke of the method of extraction by repeated washings without a condenser.

F. K. CAMERON, of the Bureau of Soils: *Potash from kelp.* Four principal sources of potash have been in view: (1) desert salt deposits, (2) orthoclase, feldspar and leucite, (3) alunite, (4) the giant kelps of the Pacific. Four types of kelp yield considerable amounts of potassium chloride, which effloresces on the plant during drying. This salt can be separated from the sodium chloride without difficulty, but no method has been worked out for separating the potash while leaving the large amount of available nitrogen behind with the organic matter, thus giving the organic residue a value. It is estimated that the Pacific kelps could supply six times the amount of potash now imported into the United States. Lantern slides were shown illustrating the beds of kelp as they occur, from Southern California to Alaska, the appearance and manner of growth of the different species, and the methods of harvesting and loading now in commercial use in the South.

Discussion: In reply to inquiries by Andrews, Bunzel, Seidell, Sosman, and Bassett, the following points were brought out: Very little of the nitrogen is present as nitrate. The potash is not all removed by a single extraction. Only one company is operating on any considerable scale, although a number of companies have been floated; considerable kelp is being cut on the Mexican coast, where it is easily air dried. Capital has held back from investment in kelp-cutting largely because no monopoly rights or patents are connected with the industry. Data are lacking for a comparison of the relation of iodide to chloride in sea water with the same ratio in the plants. Houston discussed various points brought out by the lecturer, and suggested that the bulkiness of the kelp fertilizer is in some respects a desirable property; also that the present state of the fertilizer industry is not such as to encourage investment in new fertilizer ventures, one principal trouble being overproduction of mineral fertilizers both in the United States and Germany.

Robert B. Sosman, *Secretary*.

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 276th meeting was held at the Cosmos Club, December 10, 1913.

Presidential address. *The Tertiary orogeny of the North American Cordillera and its problem.* Frederick L. Ransome. In extended form this address will be published with other Silliman lectures for 1913 in a Dana memorial volume by Yale University.

The 21st Annual Meeting was then held at which the following officers were elected to serve for the ensuing year: President, Arthur Keith; Vice-presidents, T. Wayland Vaughan, Arthur C. Spencer; Treasurer, Sidney Paige; Secretaries, Frank L. Hess, Clarence N. Fenner; Members-at-large of the Council, Ernest F. Burchard, Charles W. Gilmore, D. F. Hewett, Esper S. Larsen, G. C. Martin. Vice-president, Washington Academy of Sciences, Frederick L. Ransome.

The 277th meeting was held at the Cosmos Club, January 14, 1914.

Under the head of "Informal Communications" E. G. Woodruff described a well at DeBeque, Colorado, with periodic discharges of oil, gas, and water.

Regular Program

Comparison of the geologic history of the Florida Reef tract with that of other reef areas (illustrated): T. Wayland Vaughan. The paper is published in *Journ. Washington Acad. Sci.* **4**: 26–34. 1914.

Some ellipsoidal lavas on Prince William Sound, Alaska (illustrated): S. R. Capps. Near Ellamar, Alaska, there is a series of several thousand feet of diabasic and basaltic lava flows interbedded at frequent intervals with water-laid sediments. Many of the flows show ellipsoidal, spheroidal, or pillow-shaped forms. It is believed that the alternation of marine sediments with lava flows, all being structurally comformable, gives strong evidence that the flows were poured out under water, and that in this area the ellipsoidal forms of the lavas are due to sub-aqueous cooling.

The original top of a flow, where overlain by sediments, is found to have an uneven surface, the sediments filling in the irregularities. The bottom of the sedimentary bed is thus uneven. The top of a sedimentary bed has an even surface, and the lavas outpoured upon it have themselves conformed to this surface, and the flow is therefore smooth on the bottom. This distinction was of great value in deciphering the structure in an area of considerable metamorphism and steeply tilted rocks.

Review of papers by L. Keith Ward (a) The relationship between the ore bodies and the igneous rocks of the Heemskirk-Comstock-Zeehan region, Tasmania. (b) The origin of certain contact rocks high in lime and magnesia. A. C. SPENCER. No abstract.

The 278th meeting was held at the Cosmos Club, January 28, 1914.

Under the head of "Informal Communications," J. M. HILL, described a copper deposit in an apparent sink hole in northeastern Arizona.

REGULAR PROGRAM

Bituminous shale in northwestern Colorado and northeastern Utah: E. G. WOODRUFF and D. T. DAY. In general this region is a moderately dissected plateau containing many small badland areas. Both Cretaceous and Tertiary rocks outcrop, but the bituminous shale was found only in the middle member of the Green River (Eocene) formation. The formation as a whole is a little more than 2,000 feet thick in the eastern part of the area but considerably less in the western part. Bituminous shale was found in long lenticular beds ranging from a fraction of an inch up to 80 feet in thickness. An exposure half a mile long shows only a moderate variation in thickness but a study of a township reveals great differences in thickness and continuity.

The shale is a brown tough rock with a light brown, waxy streak. The amount of carbonaceous material present varies considerably. The major bedding and a large part of the minor bedding is regular, but in most of the rich shale there is an irregularity of lamination which gives to it a peculiar curly structure.

Both field evidence and microscopic studies show that the movement of oil in the shale has not been extensive nor even locally intensive. Microscopic studies show also that the shale contains a considerable amount of oil which can be liberated by leaching. Greater quantities of oil, however, are obtained by ordinary distillation processes. The results of distillation tests are shown by the following table:

NUMBER OF TEST	PART OF SECTION SAMPLED	AMOUNT OF SHALE USED	AMOUNT OF OIL OBTAINED	GALLONS OF OIL PER SHORT TON OF SHALE
		lbs.	*gal.*	
Conn Creek	$1\frac{1}{2}$ ft.	100	3.06	61.2
Kimball Creek	6 ft.	150	2.375	31.6
Kimball Creek (second test)	6 ft.	156	2.03	26.2
Parachute Creek	5 ft. 10 in.	150	1.5	20.0
4A Ranch	5 ft. 10 in.	150	0.78	10.4
Temple Station	4 ft.	120	2.711	45.2
Ute Station	2 ft.	120	0.96	16.0
White River. Subsurface sample	3 ft. 6 in.	150	2.5	33.3
White River. Near surface	3 ft. 6 in.	135	2.4	35.5
Nine Mile Creek	6 in.	105	2.05	39.0
Hill Creek	9 in.	135	1.27	16.0

It is estimated that sufficient gas is generated during distillation to carry on the operation without the addition of other fuels. Different samples of the oil began to boil at from 70° to 80°. From 2 to 10 per cent of the oil was distilled under 150°. From 33 to 55 per cent of the oil volatized between 150° and 300°. The residues varied from 44 to 66 per cent. The amount of ammonia contained in the shale has not yet been determined. These data indicate that the bituminous shale is a valuable resource. The deposits are easily accessible by railroad, pipe lines or tram tracks.

The conditions of "antiplanation" in sub-Arctic regions (illustrated): H. M. Eakin. A widely distributed topographic feature in central and western Alaska, the development of which is apparently peculiar to those regions of the earth's surface that are exposed to the rigors of a sub-Arctic climate was described as essentially flat-topped accumulations of loose rock. They include flat-topped hills, ridges, passes and terrace-like forms. The materials involved have migrated under the thrust and heave of frost action in moisture saturated soil. They have been moved at extremely slow rates and for very short distances. Inequalities in the amount of soil mingled with the rock waste cause different parts of the accumulating mass to move at different rates. These irregularities are mutually cumulative and the slopes which they affect become more and more irregular and finally exhibit the flats and scarps here discussed. These phenomena indicate the action of a morphologic process distinct from the processes of aqueous erosion, which oppose its operation; distinct from equiplanation which, according to Cairnes, is a process affecting more widespread, regional areas, and which reduces relief by the migration of materials from hills to valleys; and distinct from the general phenomena of solifluction in being localized in its operation and in resulting in a special and distinct type of topographic feature. The process is termed antiplanation—a specific process that is active in forming high level flats and plains of limited extent wherever the essential conditions are met.

Problems of the glacial geologist: Frank Leverett. Certain problems, such as the cause of the glacial epoch, the alternation of glacial and interglacial stages, the origin and relations of loess deposits, etc., are world-wide in bearing. Others, such as the localization of the ice centers of North America and the Iowan drift question are regional. There are also collateral problems such as the effect of the ice load in producing deformation of the earth's crust, the effect of climatic changes of the ice age upon migration, extinction of species, and the development of new species. To the glacialist also fall certain determinations leading to a geologic time scale through combining data on cataract recession, ice-border recession, uplift of shore lines of glacial lakes, relative amounts of weathering, and erosion of the several drifts, etc.

The cause of the glacial epoch, which was thought by many, a generation ago, to be solved by Croll, is generally regarded today as an unsolved or but partially solved problem. Chamberlin and students under his direction have in the past twenty years thoroughly considered many terrestrial factors affecting climate and the varying relations of the ocean and the air under differing conditions of temperature as well as reactions involved in exposure of fresh areas to oxidation and weathering. The ingenious hypothesis of the cause of glaciation advanced by Chamberlin as a result of these studies is full of suggestive ideas which but few students have as yet had time adequately to consider.

As to the manner in which the ice sheet accumulated on the North American continent very little has as yet been determined. Conditions are much more complex here than in Europe and a solution seems likely to require about as elaborate an investigation as is required to determine the cause of the ice age. If, as seems likely, the Labrador center was fed by moist air currents from the Gulf of Mexico, and the Keewatin by those from the Pacific, it becomes a problem to explain the recently announced Patrician center north of Lake Superior. It is also difficult to account for the development and great extent of the Keewatin center under present conditions of altitude and slope. There are, however, indications that in early Pleistocene time the coast ranges of Alaska were much lower than now and they may have had less influence in checking the winds from the Pacific and in causing precipitation to be chiefly near the coast.

There is wide difference of opinion concerning the climatic conditions at the time of loess deposition and it remains to be determined whether the loess is interglacial or glacial. The opinion is almost unanimous that it is chiefly of eolian deposition, water being influential merely in distributing it down the great waterways and exposing it to the action of the wind. To what extent the loess is derived from the glacial materials and to what extent from the semi-arid western plains is undetermined.

The question of a stage of glaciation closely connected with the main loess deposition is still open. It is here that the Iowan glacial stage was originally placed. Opinions on the Iowan drift are now quite diverse, its existence being questioned by some, its Illinoian age being claimed by others, while a number of geologists still place it close to the main loess deposition and claim for it a much later time that the Illinoian.

The 279th meeting was held at the Cosmos Club, February 11, 1914.

Under the head of "Informal Communications," Dean Winchester described the anticlines of eastern Montana, Wyoming and North Dakota.

Regular Program

The Cannonball marine member of the Lance formation: E. R. Lloyd. The Lance formation in parts of the Dakotas consists of two parts; a lower part, approximately 400 feet thick, with predominant somber colored shale and yellow sandstone, of continental origin; and an upper part, about 300 feet thick of sandstone, shale, and limestone of marine origin. To this upper part the name Cannonball marine member is given. The lower sediments of continental origin contain a flora which according to Knowlton is indistinguishable from that of the Fort Union and is distinctly a Tertiary flora. It also contains remains of turtles and dinosaurs, particularly of the genus Triceratops which is diagnostic of the Lance formation and which has, at least until recently, been considered by vertebrate paleontologists to be a distinctively Cretaceous form. The Cannonball member contains an invertebrate and vertebrate fauna of over forty species very closely related to the marine cretaceous fauna of the Fox Hills sandstone.

The distinctively marine fossils of the Cannonball member were found near Haley, N. D., by C. J. Hares, and on Cannonball River, N. D., by E. R. Lloyd at about the same time in 1912. The member is thicker and better exposed on Cannonball River and this was accordingly selected as the type locality. The strata are practically flat lying, but a comparison of altitudes instrumentally determined on lignite beds in the Fort Union show a small but persistent dip to the northeast and north. The Cannonball member has been traced and mapped in a strip extending from near Mandan, North Dakota, to the eastern part of Harding County, South Dakota, a distance of about 130 miles. The marine fossils were found throughout the whole of this distance.

The mechanics of granite intrusion in the Black Hills, South Dakota. SIDNEY PAIGE. In the Black Hills schists and quartzites form the matrix for invading granite masses. The schists suffered marked deformation in the vicinity of the intrusive masses, being thrown into closely appressed recumbent folds and receiving a second schistose structure. Parallel with this new structure there has been *lit-par-lit* injection. The quartzite broke into blocks which became separated by the advancing magma. These features suggest that the conditions under which the intrusion occurred involved the lateral distension of the invaded rocks though this distension took place under a great load. There is no evidence that the magma was able to dissolve fragments of the schist upon a large scale, and it seems that such assimilation as may have occurred was merely incidental to physical or mechanical features, and not a primary process inducing or permitting the advance of the magma. Through injection and impregnation the composition and specific gravity of the schist approaches that of the granite. The prime cause of the advance of deep seated magmatic material is probably to be sought in movements incidental to adjustments toward isostatic equilibrium. As sea bottoms sink there is a landward transfer of material, and continents rise. Where there are weak spots strong warps develop, lateral distension results, and the upward invasion of the magma is permitted.

FRANK L. HESS, *Secretary.*

REFERENCES

Under this heading it is proposed to include, by author, title, and citation, references to all scientific papers published in or emanating from Washington. It is requested that authors coöperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

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Caudell, A. N. *Notes on the yellow crane-fly,* Tipula flavicans *Fabr.* Proceedings of the Entomological Society of Washington **15**: 45, 46. April 9, 1913.

Caudell, A. N. *A new pseudophylliid from Jamaica (Orthoptera, Locustidae).* Insecutor Inscitiae Menstruus **1**: 57, 58. May 31, 1913. (Gives a key to the Jamaican species of the genus Jamaicana and describes one new species, *J. flava.*—J. C. C.)

Chittenden, F. H. *The spotted beet webworm.* Bureau of Entomology Bulletin 127, Pt. 1, pp. 1–11, pls. 1–4. May 31, 1913. (A brief life-history of *Hymenia perspectalis* in the District of Columbia, with an account of some allied species and methods of control.—J. C. C.)

Chittenden, F. H. *The abutilon moth.* Bureau of Entomology Bulletin 126: 1–10, pls. 1–5. December 6, 1913. (A brief life-history of *Cosmophila erosa* in Virginia.—J. C. C.)

Chittenden, F. H. *The Florida fern caterpillar.* Bureau of Entomology Bulletin 125: 1–10. October 29, 1913. (A brief life-history of this species, *Eriopus floridensis,* injuring ferns in greenhouses in the northern United States, with methods of control.—J. C. C.)

CHITTENDEN, F. H. *The rose slug-caterpillar.* Bureau of Entomology Bulletin 124: 1–9. October 31, 1913. (A short life-history of *Euclea indetermina* in West Virginia and Maryland, with remedies.—J. C. C.)

COCKERELL, T. D. A. *Pseudomasaris bred in California.* Proceedings of the Entomological Society of Washington **15**: 107. October 2, 1913. (Describes one new subspecies.—J. C. C.)

CUSHMAN, R. A. *The Calliephialtes parasite of the codling moth.* Journal of Agricultural Research **1**: 211–235, figs. 1–15, pl. 20. December, 1913.

DYAR, H. G. *Notes on cotton moths.* Insecutor Inscitiae Menstruus **1**: 1–12. January 27, 1913. (A key to the American species of the genera Cosmophila, Gonitis, Aletia, Alabama, and Anomis, with descriptions of seven new species, mostly in the last named genus.—J. C. C.)

DYAR, H. G. *The species of* Sphida *Grote (Lepidoptera, Noctuidae).* Insecutor Inscitiae Menstruus **1**: 18, 19. February 20, 1913. (Gives a key to the North American species of Sphida and describes three new species.—J. C. C.)

DYAR, H. G. *The larvae of* Xanthopastis timais *Cramer (Lepidoptera, Noctuidae).* Insecutor Inscitiae Menstruus **1**: 20–22. February 20, 1913. (Describes one new species.—J. C. C.)

DYAR, H. G. *A note on the Macrothecinae (Lepidoptera, Pyralidae).* Insecutor Inscitiae Menstruus **1**: 22, 23. February 20, 1913. (Describes three new North American species.—J. C. C.).

DYAR, H. G. *The species of* Afrida *Möschler (Lepidoptera, Lithosiidae).* Insecutor Inscitiae Menstruus **1**: 26–33. March 29, 1913. (Gives a key to the American species of Afrida and describes twelve new species.—J. C. C.)

DYAR, H. G. *Five new North American Pyralidae.* Insecutor Inscitiae Menstruus **1**: 34, 35. March 29, 1913.

DYAR, H. G. *The American species of Dysodia (Lepidoptera, Thyrididae).* Insecutor Inscitiae Menstruus **1**: 37–45. April 30, 1913. (Gives a key to the American species and describes twelve new species.—J. C. C.)

DYAR, H. G. *The larva of* Trichostibas parvula *(Lepidoptera, Yponomeutidae).* Insecutor Inscitiae Menstruus **1**: 48, 49. April 30, 1913.

DYAR, H. G. *Another larva of* Xanthopastis timais *(Lepidoptera, Noctuidae).* Insecutor Inscitiae Menstruus **1**: 49, 50. April 30, 1913. (Gives a key to distinguish the four known larval forms.—J. C. C.)

DYAR, H. G. *The larva of* Delias henningia *Eschscholtz (Lepidoptera, Pieridae).* Insecutor Inscitiae Menstruus 1: 58. May 31, 1913.

DYAR, H. G. *A galleriine feeding in cacao pods (Lepidoptera, Pyralidae).* Insecutor Inscitiae Menstruus **1**: 59. May 31, 1913. (Describes the new genus Tineopsis, with a single species, *T. theobromae*, sp. nov.—J. C. C.)

DYAR, H. G. *Note on the systematic position of* Pseudaeontia rhizoleuca *Brabant (Lepidoptera, Noctuidae).* Insecutor Inscitiae Menstruus **1**: 59, 60. May 31, 1913. (Describes the new genus Brabantia, with a single species, *B. rhizoleuca*, from South America.—J. C. C.)

DYAR, H. G. *A note on* Talara ruficollis *Schaus (Lepidoptera, Lithosiidae).* Insecutor Inscitiae Menstruus **1**: 75. June 30, 1913. (Describes Paraprepia and Parillice, new genera, and one new species from Brazil.—J. C. C.)

DYAR, H. G. *The species of* Calyptocome *Warren (Lepidoptera, Geometridae).* Insecutor Inscitiae Menstruus **1**: 79–87. July 21, 1913. (Gives a key to the American species and describes thirteen new species.—J. C. C.)

Dyar, H. G. *The separation of some species of Lineodus (Lepidoptera, Pyralidae).* Insecutor Inscitiae Menstruus **1**: 94–96. August 23, 1913. (Gives a key to some of the American species and describes three new species.—J. C. C.)

Dyar, H. G. *Descriptions of six new Pyralidae from British Guiana.* Insecutor Inscitiae Menstruus **1**: 98–100. August 23, 1913.

Dyar, H. G. *A note on* Diathrausta nerinalis *Walker (Lepidoptera, Pyralidae).* Insecutor Inscitiae Menstruus **1**: 100–102. August 23, 1913. (Describes four new forms of this species.—J. C. C.)

Dyar, H. G. *Notice of volume II, no. 4, of Barnes and McDunnough's "Contributions to the Natural History of the Lepidoptera of North America."* Insecutor Inscitiae Menstruus **1**: 102–106. August 23, 1913. (Gives the synonomy of many of the species described as new in this article and describes one new species from Cuba.—J. C. C.)

Dyar, H. G. *Note on the American silvery species of Argyria (Lepidoptera, Pyralidae).* Insecutor Inscitiae Menstruus **1**: 111–114. September 15, 1913. (Gives a key to the American species which have silvery white ground color and describes seven new species.—J. C. C.)

Dyar, H. G. *An additional note on Calyptocome.* Insecutor Inscitiae Menstruus **1**: 120. September 15, 1913.

Dyar, H. G. *Notes on the species of* Galasa *Walker (Lepidoptera, Pyralidae).* Insecutor Inscitiae Menstruus **1**: 125–129. October 30, 1913. (Gives a key to the American species and describes five as new.—J. C. C.)

Dyar, H. G. *A new pyralid from Newfoundland (Lepidoptera, Pyralidae).* Insecutor Inscitiae Menstruus **1**: 139. November 29, 1913. (Describes *Pyrausta Beddeci*, sp. nov.—J. C. C.)

Dyar, H. G., and Knab, F. *Three new neoptropical mosquitoes.* Insecutor Inscitiae Menstruus **1**: 76–78. June 30, 1913.

Ely, C. R. *Notes on the cocoons of some of the species of the genus Acrobasis, and descriptions of three new species, from East River, Connecticut.* Insecutor Inscitiae Menstruus **1**: 51–57. May 31, 1913.

Ely, C. R. *The food plant of* Cleonus calandroides *Rand.* Proceedings of the Entomological Society of Washington **15**: 104, 105. October 2, 1913. (This species lives in the roots of *Cakile endetula.*—J. C. C.)

Folsom, J. W. *North American spring-tails of the subfamily Tomocerinae.* Proceedings of the U. S. National Museum **46**: 451–472, pls. 40–41. December 30, 1913. (Includes descriptions of one new species of Tritomurus and of one new species and one new variety of Tomocerus.—J. C. C.)

Forbes, W. T. M. Trichoclea ruisa, *new species; A structurally aberrant noctuid (Lepidoptera, Noctuidae).* Insecutor Inscitiae Menstruus **1**: 74, 75. June 30, 1913.

Foster, S. W. *The cherry fruit sawfly.* Bureau of Entomology Bulletin 116, Pt. 3, pp. 73–79, pls. 9, 10. January 31, 1913. (A brief seasonal history of this species, *Hoplocampa Cookei*, in California.—J. C. C.)

Gahan, A. B. *Identity of* Scotioneurus stenostigma *Prov.* Proceedings of the Entomological Society of Washington **15**: 38–40. April 9, 1913. (Species redescribed from type specimens and transferred to genus Aspilota.—J. C. C.)

Gahan, A. B. *Some notes on the palpi of Aphidiinae.* Proceedings of the Entomological Society of Washington **15**: 86, 87. June 10, 1913. (The maxillary palpi of *Diaerctus rapae* are almost as frequently three-segmented as four-segmented; examination of large series of specimens of other species of the subfamily showed no variation.—J. C. C.)

Gill, J. B. *The fruit-tree leaf-roller.* Bureau of Entomology Bulletin 116, Pt. 5, pp. 91–110, pls. 12–16. March 12, 1913. (Discusses the life-history and habits of *Archips argyrospila*, with notes on natural enemies and method of control.—J. C. C.)

Girault, A. A. *A new scelionid from Queensland, Australia, parasitic on acridiid eggs, with diagnosis of Australian species.* Proceedings of the Entomological Society of Washington **15**: 4–8. April 9, 1913. (Contains also a key to the Australian species of the genus Scelio.—J. C. C.)

Girault, A. A. *Critical notes on some species of Mymaridae from the Sandwich (Hawaiian) Islands, with comparative notes on Australian, North American, and European forms.* Proceedings of the Entomological Society of Washington **15**: 9–20. April 9, 1914. (Describes one new species and one new variety of the genus Polynema.—J. C. C.)

Heideman, O. *Description of two new species of North American Tingitidae.* Proceedings of the Entomological Society of Washington **15**: 1–4. April 9, 1913.

Hood, J. D. *Two new Thysanoptera from Porto Rico.* Insecutor Inscitiae Menstruus **1**: 65–70, pl. 1. June 30, 1913. (Includes description of the new genus Podothrips.—J. C. C.)

Hood, J. D. *On a eollection of Thysanoptera from Porto Rico.* Insecutor Inscitiae Menstruus **1**: 149–154, pl. 5. December 31, 1913. (Describes the new genus Dinurothrips, founded upon *D. Hookeri*, sp. nov.—J. C. C.)

Jones, P. R., and Davidson, W. M. *Life history of the codling moth in the Santa Clara valley of California.* Bureau of Entomology Bulletin 115, Pt. 3, pp. 113–181. January 18, 1913. (Methods of control also are treated.—J. C. C.)

Knab, F. *Some nectropical Syrphidae (Diptera).* Insecutor Inscitiae Menstruus **1**: 13–15. February 20, 1913. (Describes Quichuana, new genus, with two new species.—J. C. C.)

Knab, F. *Names and synonomy in Anopheles (Diptera, Culicidae).* Insecutor Inscitiae Menstruus **1**: 15–17. February 20, 1913.

Knab, F. *Some earlier observations on the habits of* Aphiochaeta juli (*Brues*). (*Diptera, Phoridae*). Insecutor Inscitiae Menstruus **1**: 24. February 20, 1913.

Knab, F. *A new bromelicolous Megarhinus (Diptera, Culicidae).* Insecutor Inscitiae Menstruus **1**: 35, 36. March 29, 1913.

Knab, F. *Changes in the mosquito-fauna of Panama.* Proceedings of the Entomological Society of Washington **15**: 40–42. April 9, 1913. (Changes of the physical features of Panama, due to the canal construction and the consequent formation of Gatun Lake, have brought about a great increase in the numbers of certain species of mosquitoes previously found to occur in very small numbers.—J. C. C.)

Knab, F. *A new Heterostylum from Mexico (Diptera, Bombyliidae).* Insecutor Inscitiae Menstruus **1**: 110, 111. September 15, 1913.

Knab, F. *The contentions regarding "Forest malaria."* Proceedings of the Entomological Society of Washington **15**: 110–114. October 2, 1913. (A reply to an article by Dr. Lutz reiterating a belief that the epidemics of malaria in question were caused by other than bromelicolous Anopheles.—J. C. C.)

Knab, F. *A new Cuban Chaoborus (Diptera, Culicidae).* Insecutor Inscitiae Menstruus **1**: 121, 122. October 30, 1913.

Knab, F. *A new American Phlebotomus (Diptera, Psychodidae).* Insecutor Inscitiae Menstruus **1**: 135–137, fig. 1. November 29, 1913. (Describes a new species, *P. atroclavatus*, from Trinidad.—J. C. C.)

Knab, F. *A note on some American Simuliidae.* Insecutor Inscitiae Menstruus **1**: 154–156. December 31, 1913. (The new name *Simulium Lutzi* is proposed for *S. exiguum* Lutz, not of Roubaud.—J. C. C.)

Lutz, A. *The insect host of forest malaria.* Proceedings of the Entomological Society of Washington **15**: 108, 109. October 2, 1913. (*Cellia argyrotarsis* is said to be much more responsible for the spreading of malaria in Brazil than *C. albimana*.—J. C. C.)

Malloch, J. R. *A new genus and two new species of Chloropidae (Diptera).* Insecutor Inscitiae Menstruus **1**: 46–48. April 30, 1913. (Includes description of Eugaurax, a new genus based upon *E. floridensis*, n. sp., from Florida.—J. C. C.)

Malloch, J. R. *Four new species of North American Chloropidae (Diptera).* Insecutor Inscitiae Menstruus **1**: 60–64. May 31, 1913.

Malloch, J. R. *A new species of Agromyzidae (Diptera).* Insecutor Inscitiae Menstruus **1**: 109, 110. September 15, 1913. (Describes *Milichia orientalis* from the Island of Guam.—J. C. C.)

Malloch, J. R. *A new species of Simulium from Texas.* Proceedings of the Entomological Society of Washington **15**: 133, 134. October 2, 1913.

Malloch, J. R. *Two new species of Borboridae from Texas.* Proceedings of the Entomological Society of Washington **15**: 135–137. October 2, 1913.

Marsh, H. O. *The horse-radish webworm.* Bureau of Entomology Bulletin 109, Pt. 7, pp. 71–76. January 30, 1913. (A short life-history of this species, *Plutella armoracia*, occurring in Colorado.—J. C. C.)

Marsh, H. O. *The striped beet caterpillar.* Bureau of Entomology Bulletin 127, Pt. 2, pp. 13–18, pl. 5. May 19, 1913. (A short account of the life-history of *Mamestra trifolii* in Colorado and Kansas, with a list of its natural enemies and recommendations for control.—J. C. C.)

Morgan, A. C. *An enemy of the cigarette beetle.* Proceedings of the Entomological Society of Washington **15**: 89. June 10, 1913. (Larvae and adults of the Clerid beetle, *Thaneroclerus girodi*, are predaceous, feeding on the cigarette beetle, in the larval, pupal, and adult stages.—J. C. C.)

Parker, W. B. *The hop aphis in the Pacific region.* Bureau of Entomology Bulletin 111: 1–43, pls. 1–10. May 6, 1913. (The life-history, habits, damage, natural enemies and control of this species, *Phorodon humuli*, are given at length.—J. C. C.)

Parker, W. B. *The red spider on hops in the Sacramento valley of California.* Bureau of Entomology Bulletin 117: 1–41, pls. 1–6. May 3, 1913. (Discusses the life-history and habits of *Tetranychus bimaculatus*, with methods of control.—J. C. C.)

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MINERALOGY.—*Crystallized chrysocolla from Mackay, Idaho.*
JOSEPH B. UMPLEBY, Geological Survey.

Crystallized chrysocolla has been found only in a few places, and descriptions of its optical properties do not agree.[1] It seems worth while, therefore, to describe briefly some exceptionally good material from the Empire copper mine, situated three and one-half miles southwest of Mackay, Idaho. The specimen analyzed was picked from the ore bins of the Copper Bullion tunnel during an examination of the deposits by the writer in 1912. Copper silicate ore has afforded most of the production from these deposits, but very little of the material is crystallized.

The chrysocolla is characteristically brown in color and contains much iron, but locally it is bluish green and free from iron. The latter variety only is described in this paper.

The crystallized chrysocolla at Mackay occurs as mammillary crusts, as small masses of irregular shape, and as acicular crystals imbedded in other copper minerals. The acicular crystals are microscopic in size and in the thin section appear both as radiating groups and narrow bands of closely packed individuals oriented normal to the sides of the bands. The massive variety offered the best material for analysis, but even with it considerable difficulty was experienced in separating a sufficient amount for chemical examination. Within distances of a few millimeters

[1] A description of chrysocolla from the Belgian Congo, by H. Buttgenbach (Ann. Soc. geol. publ. Congo Belge, p. 31–70, 1913) gives the following optical properties: fibres, uniaxial +, mean index of refraction 1.39 (average of 6 readings from 1.33 to 1.48); mostly second order colors. Lindgren (Prof. Paper 43, U. S. Geol. Survey, p. 113, 1904) states that chrysocolla from Clifton-Morenci, Arizona, is negative with double refraction about like augite.

the pure material grades into ferruginous chrysocolla and copper pitch ore, and traversing it are ill-defined layers of malachite; films of kaolin occur along minute fractures. The physical properties of this massive form are: hardness, about 3; density, 2.4 (Jolly balance determination not satisfactory, because of many minute fractures); luster, somewhat waxy; color, beryl green (Ridgway's color scale); streak, white; tenacity, brittle.

Examined microscopically both in refractive index solutions and in thin section the mineral is seen to have one distinct cleavage normal to the elongation and possibly one parallel to it, although what appears to be cleavage in the latter direction may be merely an overlapping of fibers. It is uniaxial, optically positive, has positive elongation, and is highly birefringent. The indices of refraction are W, 1.46 and E, 1.57 ±, a small variation in the values from different grains making it impossible to place a satisfactory value in the third decimal place. Thick grains show pleochroism in colorless (W) and pale bluish green (E) tones. The mineral belongs to the hexagonal or to the tetragonal system of crystallization.

PARTIAL ANALYSIS OF CHRYSOCOLLA, R. C. WELLS, ANALYST.

		RATIOS	APPROXIMATE MINERAL COMPOSITION	PER CENT
SiO_2	39.3	0.65	Chrysocolla	
CuO	32.0	0.40	CuO, SiO_2, $2H_2O$	87.3
H_2O	18.7	1.05		
Al_2O_3 (etc.)	2.4	0.02	Kaolinite $2SiO_2$,	
Fe_2O_3			Al_2O_3, $2H_2O$	4.5
FeO			Opal	
CaO	1.7	0.03	SiO_2, n H_2O	8.2
ZnO	3.6	0.05		
MgO	tr.			
	97.7			

A partial analysis of the massive material, carefully selected with a hand lens, was made in the chemical laboratory of the United States Geological Survey in order to make certain that the material was chrysocolla. Although the analysis is unsatisfactory in that it only totals 97.7 per cent, it is believed that the results prove that the crystalline substance is chrysocolla.

Prior to recasting the analysis into mineralogical composition portions of the pulp analyzed were examined in index solutions, in order to determine what compounds other than copper silicate should be recognized. Kaolinite is present along numerous cracks in the specimen, but it was impossible to estimate its relative amount. There is present, however, a considerable amount of amorphous material which breaks as does the chrysocolla and which has a refractive index lower than 1.45. It was identified as opal. One hundred grains were examined in each of ten portions of the pulp analyzed with the result that on the average 9 out of each 100 were opal, the maximum range being 5 to 14 with most of the counts approximating the average value. Many of the grains were in part amorphous and in part crystallized, so that the average value is based on numerous estimates in addition to the actual count. The percentage of opal in the material as thus determined corresponds well with that calculated from the analysis and serves as a check on the calculation. In the recasting of the analysis alumina was assumed to determine the amount of kaolinite; copper, zinc and calcium oxides to determine the amount of chrysocolla; and the balance was considered as opal. This gives an opal with 3.85 per cent of water, a reasonable amount.

ANTHROPOLOGY.—*Pan-pipes of Peru.* WILLIAM EDWIN SAFFORD, Bureau of Plant Industry.[1]

In 1887, while on a cruise in the South Pacific, the writer found in a prehistoric grave at Arica, on the coast of Chile near the Peruvian boundary, a pair of pan-pipes made of several graduated reeds, very similar in form to the syrinx, or fistula, of the ancient Greeks and Romans. This discovery inspired him with a desire to learn what he could regarding the occurrence of similar instruments in America and their possible connection with the classic instruments of the old world. Afterwards, while acting as commissioner to Peru and Bolivia, for the World's Columbian Exposition, the writer encountered at Puno, on the Peruvian shore of

[1] Read before the Anthropological Society of Washington at the meeting of March 3, 1914.

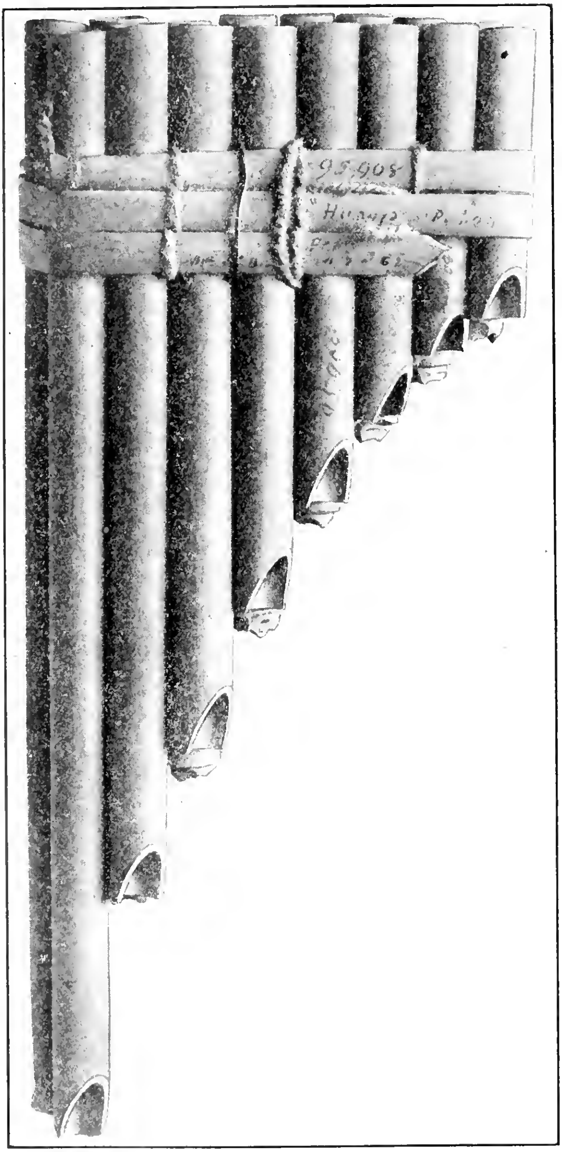


Fig. 1. Syrinx (*Huayra puhura*) from Peru. Photographed from a specimen in the U. S. National Museum (no. 95,908). About five-sixths natural size.

Lake Titicaca, an orchestra composed entirely of pan-pipes of various sizes, some of the instruments producing shrill notes like those of a piccolo, others flute-like notes, and the largest, tones like those of an organ or calliope.

It was observed that the instruments were always grouped in pairs. No single instrument was capable of producing all the notes of the scale, but only alternate notes, separated by intervals of a third, the intervening notes being played by a second player upon an instrument which was the mate or complement of the first. Nearly all the instruments consisted of 16 reeds arranged in 2 rows of 8 graduated reeds, those of the inner row closed at the bottom by a joint of the reed, while those of the outer row were open both at the top and bottom. The reeds were secured side by side, not by wax as in the Grecian syrinx, but by a splint of cane wrapped about them, the upper ends forming a horizontal line, the lower ends a series of steps, with the longest reeds on the right of the player when in use (fig. 1). The performers, who were full-blooded Quichua Indians, sounded the pipes by blowing across the opening of the inner or closed reeds, the corresponding outer open reeds apparently serving the purpose only of giving volume or quality to the note sounded. Some of the smaller instruments were composed only of 14, or 7 pairs, of reeds, but in other respects resembled the rest (fig. 2).

The lowermost instrument of each pair sounded the notes *mi, sol, si, re, fa, la, do, mi;* while its slightly smaller mate supplied the intervening notes *fa, la, do, mi, sol, si, re, fa.* The theme of one of the tunes played by the Titicaca Indians was the following:

This was repeated again and again. The time was quick and the Indians trotted along the street while playing, with short shuffling steps, keeping time to the music. When they arrived at a cross street and before the church they followed one another in ring, very much like the players represented on funeral vases from prehistoric graves. They wore close-fitting, pointed caps knit partly of vicuña and partly of sheep's wool, some of them prettily figured with geometrical designs or conventionalized figures of viscacachas or llamas, but all of them more or less greasy. Over the caps they wore broad-brimmed gray felt hats wreathed with flamingo feathers of a pretty rose color or with feathers of other birds artificially dyed in bright shades of magenta, yellow, or purple. Over coarse white shirts they wore ponchos and over loose white drawers tightly fitting trousers slit from the lower margin of each leg to the knee and displaying the white drawers beneath. Some of them wore sandals of rawhide, but the majority were barefooted. On reaching the residence of the prefect they entered the court and stood in a ring while they played the national air of Peru in a creditable manner. The writer was informed by the prefect, Don José de la Torre, that these Indians came every year during the national festivities from their home on an island in Lake Titicaca, to pay him a formal visit. When they finished playing, he applauded them and cried "*sumahh*," the Quichua word for good, or bravo! Then each player came before him and, bending one knee, bowed almost to the ground. The prefect patted each one on the head in succession, and then told them all to begone. Having regaled themselves with generous draughts of *pisco* they filed out of the patio and continued their procession through the streets of the town.

The instruments composing the orchestra were fairly well attuned. The middle pair, corresponding in pitch to the key of *c*, was composed of reeds varying in length from nearly 26 cm., producing the note *c*, to about 6.5 cm., producing a note exactly two octaves higher. The dimensions of the lower-toned pair were twice those of the middle pair, the pipes, ranging from approximately 52 cm. to 14 cm. in length (inside measurements), producing notes one octave lower. The smallest pair should have been one-half the size of the middle pair, but as a matter of fact, the component reeds were slightly short, and the resulting notes were consequently sharp. The effect of the whole orchestra, however, was not unpleasing to a musical layman.

On measuring the reeds composing the various sets of panpipes their lengths were found to correspond almost exactly with the theoretical lengths of pipes producing corresponding notes of the diatonic scale. If the length of the *c* pipe be indicated by *L*, the *c′* pipe, an octave higher, measures one-half this length, or $\frac{1}{2}$ *L*, while the lower *C* pipe measures twice its length, or 2 *L*. The upper *g*, or sol pipe, which produces the fifth, or dominant, measures $\frac{2}{3}$ *L*, while the lower *G* pipe is twice as long as the latter, or $\frac{4}{3}$ *L*. The length of the upper *f* pipe, which produces the fourth, or subdominant, is $\frac{3}{4}$ *L*, while the lower *F* pipe is twice as long, or $\frac{6}{4}$ *L*. In the same way, we have the length of the upper *e*, or mi pipe, producing the major third $\frac{4}{5}$ *L*; the lower *E* pipe $\frac{8}{5}$ *L*; the upper *a*, or la pipe, $\frac{3}{5}$ *L*; the lower *A*, $\frac{6}{5}$ *L*; the upper *b*, or si pipe, $\frac{8}{15}$ *L*; the lower *B* pipe, $\frac{16}{15}$ *L*; that is, $\frac{1}{15}$ longer than the *c* pipe.

The pipes were not all cut with equal accuracy: sometimes a reed was a little too long or too short, consequently producing a flat or a sharp tone.

The following table shows the actual measurements in millimeters of the reeds composing the smallest pair of syrinxes in the United States National Museum. (No. 210,439).

INSTRUMENT NO. 1 (8 REEDS)					INSTRUMENT NO. 2 (7 REEDS)				
	Notes	Proportional length	Theoretical length	Actual length		Notes	Proportional length	Theoretical length	Actual length
			mm.	*mm.*				*mm.*	*mm.*
1	*e* (mi)	$\frac{8}{5}$L	130	130	1	*f* (fa)	$\frac{3}{2}$L	122	122
2	*g* (sol)	$\frac{4}{3}$L	108	110	2	*a* (la)	$\frac{6}{5}$L	97	97
3	*b* (si)	$\frac{16}{15}$L	86	87	3	*c* (do)	L	81	81
4	*d* (re)	$\frac{8}{9}$L	72	70	4	*e′* (mi)	$\frac{4}{5}$L	65	65
5	*f′* (fa)	$\frac{3}{4}$L	61	62	5	*g′* (sol)	$\frac{2}{3}$L	54	55
6	*a′* (la)	$\frac{3}{5}$L	48	49	6	*b′* (si)	$\frac{8}{15}$L	43	44
7	*c′* (do)	$\frac{1}{2}$L	41	42	7	*d′* (re)	$\frac{4}{9}$L	36	35
8	*e″* (mi)	$\frac{4}{9}$L	33	33					

It could hardly be expected that in making instruments so crude as these pipes, fashioned from simple reeds, the Indians should have an established standard pitch. Slight variations were found in different sets of instruments in the same orchestra, although an attempt had undoubtedly been made to attune them perfectly. An odd Peruvin syrinx in the collection of the United

States National Museum (no. 95,908, shown in fig. 1) has pipes producing alternate notes of the scale as above described, but they are in lengths which produce a scale in the key of *f*. The reed producing the tonic, or *do* tone (*f*) is 120 mm. long (inside measurement). The *fa* and *la* (*B*♭ and *D*) pipes below, theoretically $\frac{3}{2}$ and $\frac{6}{5}$ the length of the *do* pipe, are actually 180 mm. and 144 mm. long; the *sol* (c) pipe above theoretically $\frac{2}{3}$ the length of the *do* pipe, is actually 80 mm., and consequently sounds true; but the upper *re* and *fa* (g' and b'♭) pipes at the extreme left of the instrument are too long, and consequently almost a half-tone flat. It is probable that this irregularity was not intentional on the part of the instrument maker, especially if he gauged the length of the pipes by his ear alone rather than by definite measurements. Writers on musical instruments often show a tendency to give too great importance to accidental irregularities of this kind and to regard them as intentional. As a matter of fact, to correct a pipe for flatness the Titicaca Indians pour either water or a little pisco (grape brandy) into it, thus shortening the vibrating column of air to the required length. Specimens of flutes made of single reeds with holes for the fingers and thumb are sometimes dug up from prehistoric graves in Peru with the original holes plugged and replaced by new holes slightly above or below the original ones, showing that the first holes had been made by guess work and the resulting tones were too sharp or too flat for the ear of the player, who, finding his instrument to be "out of tune," felt obliged to correct it. In the same way, when the players of pan-pipes come together to form an orchestra, it is often necessary for some of them to tune their instruments to accord with the others. This is easily done by raising the pitch of the flat-toned instruments, as described above.

That pan-pipes are not an intrusion from Spain is proved conclusively by their occurrence in prehistoric graves. That the ancient Peruvians played them in mated pairs producing alternating notes in the scale is equally certain from the fact that on vases interred with mummies, players of pan-pipes are represented in pairs, sometimes with the two instruments on which they are performing connected loosely by a long string.

So far as the writer knows, this is the first account of the methods used by the Peruvians in attuning and playing their pan-pipes. The instrument is often represented in collections by a single specimen, and the alternating notes produced by it have caused no little wonder to observers unaware that they represented not a scale but only half the notes of a scale, requiring a second complementary instrument to make it complete.

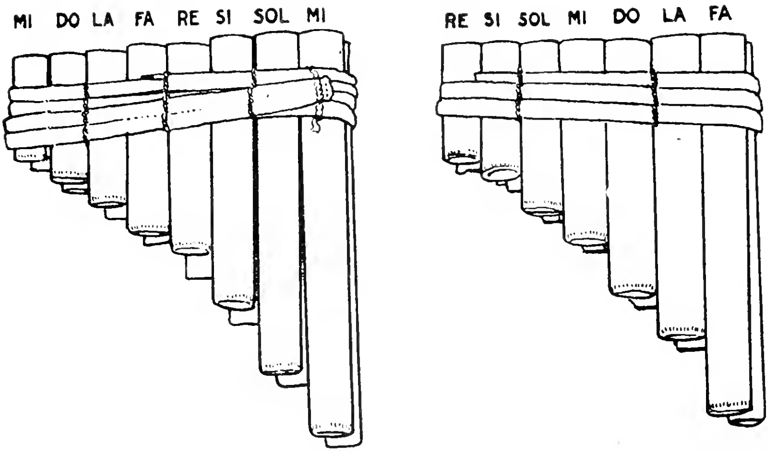
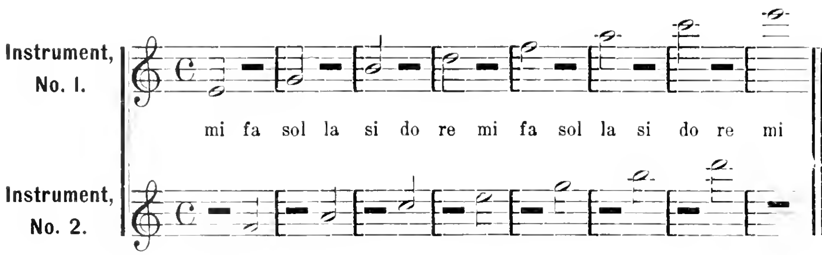


Fig. 2. A pair of syrinxes from Lake Titicaca. The two instruments are complementary. Both are necessary for producing the notes of the scale. Other instruments, also in pairs, are twice and four times the length of these. From specimens in the U. S. National Museum (no. 210,439) collected at Puno by W. E. Safford. About five-twelfths natural size.

Usually each instrument is played by a separate person; but the writer saw one expert performer who, to show his skill, played on two instruments at the same time, one superimposed upon the other, a feat evidently regarded by his companions with admiration. No melody can be played by a single instrument: a pair of instruments must always be used. What the original scale of the ancient Peruvians was is not definitely known, but this can be ascertained by measuring the lengths of the component reeds, even if they have been crushed and are incapable of yielding sounds. Undoubtedly they produced octaves, from the fact that there are always pipes one-half the length of larger pipes, and some of these must have sounded the key-note or tonic chord. The Peruvians also recognized, in all probability, the notes of the major or minor third and the fifth, corresponding to the dominant drone of the bagpipe. This would be suggested by a natural harmonic or node in a single pipe, formed after the manner of the harmonic tones of a bugle. Whatever may have been their scale it is certain that they did use instruments in pairs to produce notes necessary for producing a melody; and the variation in size of their instruments point to their playing in symphonious chords. The alternating notes may be compared to those of a mouth-organ or accordion; but in the latter instruments the consecutive notes of the scale are produced by alternately blowing and inhaling the air. It would require too much breath to blow continuously across the open tubes of a syrinx: the resulting music would have a "wheezy" or gasping effect. But when the scale is produced by two players, it is pleasantly legato, each player having an opportunity of catching his breath while his mate is piping a note. Thus:



The pan-pipe may be regarded literally as the prototype of the organ, the graduated pipes of which suggest a giant inverted syrinx blown from below. In Peru the orginal Quichua name of the pan-pipe is *huayra puhura*, or "air-pipes;" but it is now usually designated as *zampoña*, a Spanish word corresponding to the Italian *zampogna*. This name is used ordinarily in Spain and Italy to designate bag-pipes, but is likewise applied to pastoral wind instruments of various kinds, just as in English we use the name "pipes." On the shore of Lake Titicaca the pipers held the pipe in the left hand, beating time with a stick, held by the right hand on a drum suspended from the left arm. On some of the ancient Peruvian burial vases, instead of a drum, a hollow gourd is represented as the instrument for marking the rhythm.

The question as to whether the syrinx was invented independently by the aborigines of South America or whether it was brought to the western hemisphere from elsewhere is an interesting one. Certainly the instrument was wide-spread before the dawn of history. Syrinxes are found not only in Europe and on the southern shore of the Mediterranean but also in Java, on many islands of the Pacific Ocean, among certain tribes of North American Indians, as well as in northern South America, Brazil, Peru, and Bolivia. Whether their occurrence bears upon the problem of the origin of the American Indians is a question. The greatest caution should be exercised by the student of ethnology in tracing the origin of tribes by means of any one instrument or any single art. Often very similar arts are the result of similar conditions of climate and resulting raw materials. The art of weaving among the ancient Peruvians is very similar to that of the aborigines of Asia and Europe, yet it does not follow that this art was brought to Peru in prehistoric times. Llamas, alpacas, and vicuñas, are endemic in South America: why should not the art of weaving the wool obtained from these animals be equally of South American origin? It is a remarkable fact that the pan-pipes which are most closely similar in construction to those played by the Indians of Peru and Bolivia are found among the Solomon Islanders, especially those inhabiting the Florida Group —black-skinned, woolly-haired cannibals, in no way allied to the Indians of South America. Just as the orchestras of the Quichuas and Aymaras are composed of instruments of several definite sizes, so those of the Florida Islanders are similarly grouped; the shrill treble pipes being called *galevu-soniruka;* those of medium tone, half their size, *galevu-kahaumamu;* and the deeper, baritone instruments twice the size of the latter by the suggestive name *galevu-ngungu.* The instruments themselves, like those described above, consist of a double row of graduated pipes the reeds of one row being closed at the bottom by a natural joint, those of the other row being open.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal, and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEODESY.—*Interpretation of anomalies of gravity.* GROVE KARL GILBERT. U. S. Geological Survey Professional Paper 85-C. Pp. 37. 1913.

Hayford and Bowie, in discussing the deflections of the plumb line and the variations of gravity determined by the geodetic work of the U. S. Coast Survey, have introduced the following hypothesis: At a certain depth below the earth's surface, called the depth of compensation, stresses are uniform. Each vertical element above that level has the same mass, its density (assumed uniform) being low in proportion as its length is great. Under this hypothesis they find the most probable depth of the level of compensation to be 122 kilometers. The hypothesis approximately satisfies the requirements of gravity determinations for the United States but leaves certain residuals called anomalies of gravity. These have been ascribed to imperfection in the compensation. It is now pointed out that this explanation does not accord well with geologic data as to loading and unloading. Two alternative explanations are suggested, and computations indicate that each is quantitatively adequate: (1) The anomalies may be occasioned by inequalities in the vertical distribution of density above the level of compensation; (2) some of them may be occasioned by local inequalities of density within a rigid nucleus assumed to exist below the region in which mobility permits isostatic adjustment. These suggestions are in accord with a speculation as to the general structure of the earth,—that it includes a zone or layer of relative mobility, separating a superficial zone of less mobility from a highly immobile nucleus. The zone of relative mobility is the site of volcanic initiative, and is an important factor in those transgressions by which superficial tracts are tangentially shortened, as in the Appalachians, or tangentially extended, as in the Basin ranges.

G. K. G.

GEOLOGY.—*Coastal glaciers of Prince William Sound and Kenai Peninsula, Alaska.* U. S. Grant and D. F. Higgins. U. S. Geological Survey Bulletin 526. Pp. 75, with maps, views, and sections. 1913.

The history of the glaciation of the coastal region of Prince William Sound and Kenai Peninsula includes the formation of an extensive Pleistocene ice sheet, which extended to the sea and reached upward to the mountains. Since this period of maximum glaciation there has been a marked decrease in the extent of the ice-covered areas, until now only valley glaciers reach the sea. This withdrawal of the ice was probably punctuated by temporary advances, and the present is only an epoch in the long history since the maximum Pleistocene glaciation. Earth movements have also played a part, as yet little known, in this history; changes on Prince William Sound are still taking place, and since the maximum period of glaciation there has been a considerable sinking of the coast line in much of the area and between Resurrection and Nuka bays there are numerous drowned cirques. The glaciers here studied do not give uniform evidence as to a general retreat or a general advance within the last half century; some are evidently in a period of retreat and others in a period of advance, and the general balance between retreat and advance can not be accurately determined by data now at hand. A. H. Brooks.

GEOLOGY.—*Geology and ore deposits near Lake City, Colorado.* John Duer Irving and Howland Bancroft. U. S. Geological Survey Bulletin 478. Pp. 128, with maps, views, and sections. 1911.

Lake City is in southwestern Colorado and in the heart of the San Juan Mountains. These consist chiefly of volcanic rocks, with intrusive igneous masses, which now cover an irregular area of more than 3000 square miles. The eruptions occurred during Tertiary time, when many kinds of lavas were poured out, building up a huge volcanic plateau. There were also long intervals of quiet, during which erosion changed the topography of the volcanic pile.

In general the Lake City lodes may be regarded mineralogically as the outer or northeasterly edge of the heavily mineralized area of the San Juan. The lodes occur at a slightly older geologic horizon than in the adjacent districts and are definitely characterized by formation at moderate depths. They are fissure veins, formed partly through the replacement of shattered and sheeted zones in the country rock and mainly through the filling of open spaces. They average between 500 and 1000 feet in length, have a similar vertical range, and an average width of 10 inches to 5 feet. They show a wide range of strike and dip at steep angles. They comprise three closely related mineralogic types. The first contains pyrite, galena, sphalerite, and chalcopyrite with subordinate tetrahedrite, in a quartz gangue with some barite and rhodochrosite, and yields silver and lead with subordinate copper and little gold. The second contains galena, sphalerite, and tetrahedrite, with subordinate chalcopyrite and pyrite, in a gangue of quartz, barite, and rhodochrosite, and yields chiefly silver and lead. The third contains petzite, tetrahedrite, and minor quantities of other sulphides, in a gangue of fine-grained quartz carrying in places some hinsdalite, a new mineral; this type yields silver and gold in proportion by value of 1:1 and is characterized by high tenor in both metals. The first two groups include most of the Lake City lodes, as there is but one productive telluride vein. The lodes are of late Miocene or early Pliocene age. Their materials are believed to have been emitted from a magma of monzonite whose apophyses as intrusions are scattered through this general region in considerable numbers. ALFRED H. BROOKS.

GEOLOGY.—*Some ore deposits in northwestern Custer County, Idaho.* J. B. UMPLEBY. U. S. Geological Survey Bulletin 539. Pp. 104, with maps, figures and views. 1913.

The rock formations exposed in this area are schists, slates, and quartzites of Algonkian age. Unconformably on these rocks in parts of the area lies a great series, at least 9000 feet thick, of Paleozoic quartzites, slates, and dolomitic limestones. During the late or early Cretaceous Eocene epoch these rocks were invaded by granite, quartz diorite, and diorite, which are probably outliers of the great central Idaho batholith. Dikes of granite, granite porphyry, and diorite porphyry, closely related in age to the granite rocks, are locally abundant in the western part of the area. In the central portion and along the eastern margin occur vast accumulations of Miocene lava and tuff, which occupy old erosion valleys. Morainic material covers much of the highlands.

The ore deposits comprise gold placers, and lodes carrying gold-silver, gold-copper, silver-copper, and lead-silver ores. The first three types of lodes are typically fissure fillings, but the fourth might equally well be considered of replacement origin. The gold-silver deposits are characterized by a highly siliceous gangue; the others by a siderite gangue.

Two distinct periods of mineralization are recognized in the area, the deposits of each being distinct in character and their age relations clearly determinable. They are grouped as pre-Oligocene and post-Oligocene deposits. The latter are invariably inclosed in the Miocene eruptive rocks; the former in all the other rock formations. J. B. U.

GEOLOGY.—*The San Franciscan volcanic field, Arizona.* HENRY HOLLISTER ROBINSON. U. S. Geological Survey Professional Paper 76. Pp. 213, with maps, views, and sections. 1913.

The San Franciscan volcanic field, which takes its name from San Francisco Mountain, the largest volcano of the group, covers about 3000 square miles in the north central part of Arizona. The conspicuous features of the topography are the many volcanic cones rising to variable heights up to a maximum of 12,700 feet from a northward sloping plain 6000 to 7000 feet in altitude.

The oldest rocks of the region are the pure limestone of the Redwall formation, of Mississippian and Pennsylvanian age. The red sandstone of the Supai ("Lower Aubrey") formation, the crossbedded Coconino ("Upper Aubrey") sandstone, and the cherty Kaibab ("Upper Aubrey") limestone succeed one another in the order given and belong to the Pennsylvanian series. These four formations furnish a record of continuous marine sedimentation in shallow waters.

The Moencopie formation (Permian?), consisting of red sandstones and shales of fluviatile or shallow water origin, rests unconformably on the Kaibab limestone and in turn is separated by a slight unconformity from an overlying continental deposit of Triassic sandstone, shales, and marls. These Triassic rocks furnish the last record of sedimentation in this region, but a study of the surrounding country shows that deposition continued much longer and that Jurassic, Cretaceous, and possibly Eocene strata once covered the area.

Near the close of the Eocene epoch there was a period of folding and flexing, during the Miocene one of erosion and faulting, and in early Pliocene one of peneplanation. Extending from the late Pliocene to late Quaternary time there were three general periods of volcanic activity separated by intervals of quiescence, marked by faulting, uplift, and extensive erosion. The phenomena of the first volcanic period were of a simple nature and consisted of widespread eruptions of basalt from small cones. During the second period various lavas, ranging from andesites to rhyolites, were erupted and built up a few large cones. These cones, their history, their volume, together with the volume of the individual lavas, and the amount of erosion since the cessation of volcanic activity are described in detail. This period was further marked by laccolithic and semilaccolithic intrusions contemporaneous with the volcanic extrusions. The third period closely resembled the first in that it witnessed the eruption of a single lava—a basalt—but it was characterized by the formation of a larger number of cones and a less widespread distribution of the lava.

The occurrence, megascopic and microscopic character, crystallinity, together with the chemical and mineral composition of 23 types of rocks ranging from a biotite rhyolite to an augite basalt are described in detail and compared to certain "Reference types" established by averaging the analyses of certain subrangs of the quantitative system of classification. The average lavas of the composite cones are found to have practically the same composition as the average lava of the second period of eruption; it is thought that differentiation occurred in a deep-seated zone and that the original composition of the magma was probably basaltic; and it is concluded that the lavas may be considered as representing all possible members of the igneous series which could form under the magmatic conditions existing in the San Franciscan region. Finally these lavas form a genetically related series of pronounced continuity and are the differentiation products of an originally homogeneous magma. These lavas were derived from the original magma, or originated according to the laws of chemical solution.

J. F. Hunter.

HYDROLOGY.—*Underground water resources of Iowa.* W. H. Norton, W. S. Hendrixon, H. E. Simpson, O. E. Meinzer, and others. U. S. Geological Survey Water-Supply Paper No. 293. Pp. 994, with maps, section, and other illustrations. 1912. (Also published as a report of the Iowa Geological Survey.)

This paper is a comprehensive and detailed treatise on the underground waters of Iowa. Its chief contribution to geology consists of numerous carefully interpreted sections of deep wells and their correlation by the senior author. In the introductory chapter are outlined methods of collecting and studying sample drillings and of interpreting and correlating well sections. Paleozoic formations that outcrop in the northeastern part of the State are traced by means of well sections to the western part, where they are deeply buried under younger Paleozoic, Cretaceous, and Pleistocene deposits. A contour map of the upper surface of the St. Peter sandstone, one of the principal artesian aquifers, shows this formation to be about 1000 feet below sea level at Des Moines, and probably 2000 feet below at its lowest point, a short distance east of the southwestern corner of the State, toward which point the Paleozoic formations seem to dip from the east, north, and west. According to the interpretations that are made, the Pennsylvanian series is 1400 feet thick in the southwestern part of the State and extends more than 300 feet below sea level.

The underground waters in the northeastern part of the State, where older Paleozoic formations outcrop, have low mineralization, the total solids generally being less than 500 parts per million, whereas in the other parts of the State, where Pennsylvanian and Upper Cretaceous rocks occur, the underground waters are generally highly mineralized.
O. E. M.

HYDROLOGY.—*Geology and water resources of Sulphur Spring Valley, Arizona.* O. E. MEINZER and F. C. KELTON. With a section on agriculture by R. H. FORBES. U. S. Geological Survey Water-Supply Paper No. 320. Pp. 231, with maps, views, and other illustrations. 1913. (Also published as a bulletin of the Arizona Agricultural Experiment Station.)

Sulphur Spring Valley is bordered by ranges in which are found pre-Cambrian schist Paleozoic quartzites and limestones, Cretaceous sedimentary rocks, and large masses of igneous and pyroclastic rocks, chiefly acidic lavas of Tertiary age. The valley is underlain by Quaternary sediments correlated with the Gila conglomerate and shown by well sections to be more than 1000 feet thick. Interbedded with the Quaternary stream deposits is a clay bed at least 200 feet thick, correlated with similar stratified beds in other valleys of southeastern Arizona, indicating a lake stage or general submergence probably early in the Pleistocene epoch. Later in the Pleistocene the valley contained a lake of 120 square miles, as is shown by 33 miles of well-developed beach ridges. Beds of basalt interbedded with stream deposits indicate two epochs of volcanic eruption during the Pleistocene.

The valley sediments contain a main body of ground water and smaller bodies of perched water. The ground water is derived from the drainage of adjacent mountains and is returned to the atmosphere through capillary rise over extensive alkali flats.

As shown by maps with lines of equal mineralization, the mineral content of the ground water is related to the character of the rocks in the adjacent mountains. Sodium carbonate waters having less than 200 parts per million of total solids are found adjacent to mountains composed of igneous rocks. The soluble salts tend to become concentrated near the surface by capillary rise and evaporation, but salt accumulations have in some places been buried under clastic sediments.

The valley is divided into six zones of native vegetation, the pronounced segregation of the dominant plant forms being due to radical differences in the geographic controls, chiefly soil, temperature, and water supply. O. E. M.

HYDROLOGY.—*Water resources of Antelope Valley, California.* Harry R. Johnson. U. S. Geological Survey Water-Supply Paper No. 278. Pp. 89, with maps and other illustrations. 1911.

Antelope Valley, which lies in the southwestern part of the Mohave Desert, is enclosed by several mountain ranges in which are found metamorphic and granitic rocks, sandstones, shales, lavas, and tuff. The relief was produced chiefly by block faulting, but some of the sedimentary formations are much folded. The valley is underlain by gravels, sands, and clay derived through the erosion of the rocks in the mountains. In some places the valley deposits have been faulted and folded by recent earth movements, forming a well-defined ridge. They are waterbearing and give rise to flowing wells over an area of several townships. The artesian waters are derived from the floods discharged from mountain-sides bordering the valley and not from Owens Lake or other distant source, as is popularly believed. Alkaline clays and silt underlie the playas, where the ground water stands near the surface.
O. E. Meinzer.

HYDROLOGY.—*An intensive study of the water resources of a part of Owens Valley, California.* Charles H. Lee. U. S. Geological Survey Water-Supply Paper No. 294. Pp. 135, with maps, diagrams, and other illustrations. 1912.

The porous fill of Owens Valley occupies an impervious undrained rock basin, and the void spaces of the fill constitute an immense underground storage reservoir. The principal source of supply of this reservoir is percolation from precipitation in the valley and upon the tributary mountain areas. The principal discharge occurs through the flow of springs, the transpiration of plants, and the evaporation in low areas where the ground water is raised to the surface by capillarity. The accretions to and discharge from the underground reservoir were studied quantitatively in the Independence district of Owens Valley. The quantities discharged through evaporation and transpiration were determined for different depths to the water level by a series of tank experiments. For the district investigated it was found that loss by evaporation and transpiration occurs wherever the ground water stands within about 8 feet of the surface and that the amount varies inversely with the depth, being 50 or 60 inches a year where the ground water is at the surface and zero where it is as much as 8 feet below the surface. The average discharge of ground water in the district was determined to be approximately 155 second-feet, of which 93 to 114 second-feet is contributed by soil evaporation and transpiration from grass and alkali lands. The available data indicate that this discharge is about equal to the accretions of ground water, as determined by observations on the percolation from streams and other sources of supply. O. E. Meinzer.

HYDROLOGY.—*Ground water in Boxelder and Tooele Counties, Utah.* Everett Carpenter. U. S. Geological Survey Water-Supply Paper No. 333. Pp. 90, with maps and other illustrations. 1913.

The mountains under discussion, which were produced chiefly by block faulting, contain Paleozoic rocks ranging in age from Cambrian to Carboniferous, inclusive; also pre-Cambrian and Tertiary rocks. The intervening alluvial slopes and desert flats are underlain by unconsolidated sediments, chiefly Pleistocene. Lake Bonneville covered most of the area in the Pleistocene epoch.

The indurated rocks are not important as waterbearing formations but form huge reservoirs which contain unconsolidated sediments holding large quantities of water. Contributions to the underground supply are made by floods discharged over the alluvial slopes, and withdrawals occur on the valley flats and low deserts through the discharge of springs and through capillary rise. Where alkali flats occur ground water will be found near the surface. O. E. Meinzer.

PALEONTOLOGY—*Recurrent Tropidoleptus zones of the Upper Devonian in New York.* Henry S. Williams. U. S. Geological Survey Professional Paper 79. Pp. 103, with 6 plates. 1913.

The area covered by this investigation is included almost wholly in the Watkins Glen and Catatonk quadrangles, lying in south-central New York. In this investigation 1411 separate faunules were collected and examined from the Watkins Glen and Catatonk quadrangles and 103 more from the adjoining Cortland quadrangle. All the faunules which contained either *Tropidoleptus carinatus, Rhipidomella vanuxemi* or closely allied forms, or *Spirifer marcyi, Cypricardella bellistriata, Delthyris mesicostalis, Phacops rana,* and other species either recorded in the Hamilton faunas or closely allied to them were critically examined. Most of them are located in one or other of three definite zones in their respective sections. The author shows (1) that none of the species occur stratigraphically far above or below the immediate zones in which they are found, often in abundance, and (2) that several of them are habitually associated together. The faunules in each section containing any of these species are grouped together as recurrent Tropidoleptus zones, considering Tropidoleptus to be the most characteristic form.

The importance of the investigation lies chiefly in its disclosures in regard to the ancient geography of the region. Both the departure and the return of the fauna must have been due to diastrophic changes that at one time brought about conditions unfavorable to the continued existence of the fauna and at another time not only restored favorable conditions but also provided means for the remigration of the fauna into the region. Such changes may have resulted (1) from the alternate closing and reopening of an actual passageway which alternately prevented and permitted the access of the fauna and of waters favorable to them, or (2) from changes that affected the direction, character, or volume of existing ocean currents. DAVID WHITE.

ENTOMOLOGY.—*Observations on the life history of* Micromalthus debilis *Lec.* H. S. BARBER. Proceedings of the Entomological Society of Washington **15**: 31–38, pls. 2 and 3. April 9, 1913.

The few records and captures of this supposedly rare beetle from the original capture of adult and larva in 1874 are given, together with a preliminary account of the author's attempts to breed adults from larvae found in the vicinity of Washington. These attempts demonstrate an involved paedogenetic reproduction (the first case known among the beetles) through three types of larvae, but the development of the sexed adults is still unknown to the writer. Comparison is made with other examples of unusual reproduction. The systematic position of the species is considered doubtful. J. C. CRAWFORD.

ENTOMOLOGY.—*The dispersion of the gypsy moth.* A. F. BURGESS. Bureau of Entomology Bulletin 119: 1–62, pls. 1–16. 1913.

The present paper is an extended account of the spread of this species, *Porthetria dispar*, as observed principally in Massachusetts. The character of its spread is divided into two groups, local and long-distance spread; the former due to the transportation of caterpillars or egg clusters on carriages or wagons moving a short distance, or of egg clusters on driftwood; the latter due to shipment of egg clusters on lumber products, nursery stock, or boxes from the infested territory to outside points. Caterpillars may also be carried long distances on automobiles or trolley cars, and colonies have actually been established at a great distance from the mother colony by such means. The greatest factor in ready dispersion is that the first stage caterpillars are carried by winds. Extensive experiments were carried on to prove this, traps being moored in ponds or lakes, or put on tops of towers of various sorts in order to catch against their surfaces caterpillars driven by winds. The larvae possess hairs, called aerostatic hairs, with a small globular swelling near the base, which are supposed to aid in bouyancy. J. C. CRAWFORD.

ENTOMOLOGY.—*The Argentine ant.* WILMON NEWELL and T. C. BARBER. Bureau of Entomology Bulletin 122: 1–98, pls. 1–13. June 26, 1913.

A detailed account of the life-history and habits of *Iridomyrnex humilis.* This introduced species, found thus far in Louisiana, Mississippi, Alabama, and California, is extremely destructive to foods in houses and stores and also to crops, owing to its habit of protecting injurious insects which feed upon the sugar cane and corn. Its presence in orange groves is followed by rapid increase of destructive scale-insects on the trees, causing severe injury. In cotton fields where the boll weevil is present it is indirectly the cause of damage by annihilating native ants which destroy many of the immature stages of the boll weevil. It may also be found presently to be an important agent in the spread of disease, since individuals congregate in great numbers around garbage pails, etc., and are frequently hard to keep out of sick rooms. Methods of natural control and of repression, including the use of repellents and insecticides, are discussed. J. C. CRAWFORD.

ANTHROPOLOGY.—*Preliminary report on the linguistic classification of Algonquian tribes.* T. MICHELSON. 28th Ann. Rept. Bur. Amer. Ethnology, pp. 221–290b. 1912 [pub. 1913].

Algonquian tribes linguistically fall into four major divisions—Blackfoot, Cheyenne, Arapaho, and Eastern-Central. The Eastern-Central major division is divisible into two subtypes, Central and Eastern. The Central subtype has, furthermore, groupings within itself: Cree-Montagnais, Menominee, Sauk, Fox, Kickapoo, and Shawnee; Ojibwa, Ottawa, Potawatomi, Algonkin, and Peoria, together with Miami, etc.; Delaware and Munsee; and Natick. The Eastern subtype may be divided into two groups—Micmac, on the one hand, and the other extant dialects (Abnaki, Penobscot, Passamaquoddy, Malecite), which collectively may be designated Abnaki, on the other. The intimate connection of Eastern Algonquian with Sauk, Fox, Kickapoo, as well as with Shawnee, should be emphasized. The above classification is based on a study of the consonantic clusters of the various dialects, the pronouns of the present independent and subjunctive modes, together with certain phonetic and other considerations. The map showing the distribution and interrelation of the Algonquian dialects was prepared with the collaboration of Dr. John R. Swanton. T. M

ANTHROPOLOGY.—*Coos texts.* L. J. Frachtenberg. Columbia University Contributions to Anthropology **1**: 1–216. 1913.

These texts represent the Coos myths obtained in 1909 and those obtained by H. H. St. Clair, 2d, in 1903. The latter are normalized by Frachtenberg in his own phonetic scheme, save such words as are problematic. In these cases the correct form is given usually in footnotes. Interlinear translations accompany the first two myths, and these, as well as the vocabulary at the end, the list of suffixes, and the references to Frachtenberg's sketch of Coos grammar (Handbook of American Indian Languages, Bulletin 40, part 2, Bur. Amer. Ethnology, pp. 297–429) make it easy to follow the native text. L. J. F.

ELECTRICAL ENGINEERING.—*Electrolysis from electric railway currents and its prevention. An experimental test on a system of insulated return feeders in St. Louis.* E. B. Rosa, B. McCollum and K. H. Logan. Bureau of Standards Technologic Paper No. 32. (In press.)

The paper describes a comparative test on electrolysis conditions, first under a system of uninsulated return feeders, and then under an insulated feeder system, the same amount of copper being used in each test. Rail gradients were taken on a measured length of four feet of rail on all rails on both sides of each feeder tap. The average rail gradient with uninsulated feeders was 0.91 volts for the twenty-four hour period, and for the insulated feeders, 0.47 volts. Potential wires were placed 4 feet apart on 14 water and 7 gas pipes at points where the current on the pipes would probably be the largest. The average current flow on the pipes when the uninsulated feeder system was in operation was 5.7 times greater than under the insulated feeder system, there being no metallic connections between pipes and rails in either case. Potential differences between water pipes and rails observed at a large number of points, show a marked improvement under the insulated system. Twenty-two over-all potentials were measured between the tracks at the substation and the most distant feeding points. The average of those values was 10.4 volts with uninsulated and 2.6 volts with insulated feeders. The corresponding gradients in volts per thousand feet were 2.6 and 0.35 volts respectively. There is comparatively little difference in net cost of the two systems, while a summary of the test data shows that electrolysis conditions are very much better under the insulated return feeder system than under the uninsulated system. G. K. Burgess.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 519th meeting was held at the Cosmos Club, January 10, 1914, with President PAUL BARTSCH in the chair. Five new members were elected.

The discussion of the previous meeting on Parallel Development was continued. L. STEJNEGER spoke of Parallelism as exhibited in reptiles, while BARTON W. EVERMANN and THEODORE GILL discussed it as related to fishes. Messrs. Eastman, Bartsch, A. D. Hopkins, and William Palmer also took part in the discussion.

The 520th meeting was held January 24, 1914, with President BARTSCH in the chair. Five persons were elected to membership.

The program consisted of three communications:

Winter bird-life in the swamps of Alabama: E. G. HOLT.

Pollen protection in the flowers of Acacia and Annona: W. E. SAFFORD.

The problem of the gliding gull: WILLIAM PALMER.

The 521st meeting was held February 7, 1914, President BARTSCH in the chair. One new member was elected. Two communications were presented:

Notes on the fossil mammals of the Fort Union: J. W. GIDLEY.

Certain seeds used for ornamental purposes in the West Indies: J. N. ROSE.

The 522d meeting was held February 21, 1914, Vice-President J. N. ROSE in the chair. The program consisted of three communications:

Seasonal movements of fishes at Lake Maxinkuckee: BARTON W. EVERMANN.

An American Swastika: HENRY TALBOTT.

Surface temperature in the Humboldt current and its coastal eddies: R. E. COKER.

The 523d meeting was held March 7, 1914, with Vice-President A. D. Hopkins in the chair. Three persons were elected to membership. The program consisted of two communications:

Remains of a prehistoric feast: WILLIAM PALMER.

Further evidence of mutation in Oenothera (illustrated with lantern slides): H. H. BARTLETT.

The 524th meeting was held March 21, 1914, with President BARTSCH in the chair. Two new members were elected. Two communications were presented:

Arabic interpretations of the songs of birds: PAUL B. POPENOE.

Bird migration in the Mackenzie Valley (illustrated with lantern slides): WELLS W. COOKE.

D. E. LANTZ, *Recording Secretary.*

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 734th meeting was held on January 17, 1914, at the Cosmos Club, President FISCHER in the chair; 29 persons present. The minutes of the 730th, 731st, and 733d meetings were read and approved.

Mr. H. E. MERWIN presented a paper on *A formula for calculating solubility, vapor pressure, and optical dispersion.* An equation of the type $\frac{x_3 - x_2}{y_3 - y_2} = \frac{x_3 - x_1}{y_3 - y_1} + C(x_2 - x_1)$ can be written in the form of an equilateral hyperbola which does not pass through the origin. If x and y represent temperature and pressure, or temperature and solubility, or other sets of quantities that are used in graphs on rectangular coördinates, interpolations may be made. Or x and y may represent two temperatures at which pressures or solubilities, etc., of two substances are equal, thus expressing the relation of two similar curves, and making accurate interpolations possible for curves which are not readily representable by equations. The form of the curve of the equation is readily altered by putting $C(y_2 - y_1)$ in place of $C(x_2 - x_1)$, or by writing for the right hand member $\frac{x_3 - x_1}{y_3 - y_1} \cdot C^{\left(\frac{x_2 - x_1}{x_3 - x_1}\right)}$. Two standard solubility curves were described, and it was shown that many solubility curves are rectangular hyperbolas.

Mr. G. W. VINAL presented a paper, illustrated by lantern slides, *On certain electrochemical problems:* (*a*) *Reversibility of voltameter reactions,* (*b*) *Purity of silver deposits,* (*c*) *Ratio of silver to iodine,* (*d*) *Value of the Farady.* Since the complexion theory has been disproved by recent work at the Bureau of Standards, the question of reversibility was again investigated. Quantitatively the results show substantial agreement in loss at anode and gain at cathode. When a striated anode was used no such equivalence was found. Previous work on the inclusions of foreign material in the deposited silver was reviewed and the contradictory nature of the results pointed out. No conclusion can be drawn as to nature or amount of inclusions, but it is believed that they are very small in deposits made from the purest electrolyte. In striated deposits some evidence of included water was found. Comparative experiments in which the iodine voltameter (used by Dr. S. J. Bates) and the silver voltameter (porous cup and Smith forms) were compared afforded a new electrolytic method of determining the ratio of silver to iodine. The value 0.85017 was found, which is 22 parts in 100,000 higher than the ratio of the present international atomic weights. The value for the electrochemical equivalent of iodine was determined to be 1.31052 mg. per coulomb. The value of the Farady (I = 126.92) is found to be 96,515. Value calculated from silver (Ag = 107.88) is 96,494, whence, for general use, round number 96,500 is recommended. The paper was discussed by Messrs. Hersey and Sosman.

The 735th meeting was held on January 31, 1914, at the Cosmos Club, Vice-President EICHELBERGER in the chair; 31 persons present. The minutes of the 734th meeting were read and approved.

Mr. W. P. WHITE presented a paper on *Thermostats of relatively high precision*. By the aid of a few simplifying assumptions, it is possible to give a very simple mathematical treatment of the ordinary mercury contact thermostat. The results showed that, in general, an increase in the precision of such a thermostat demands both an increase in the temperature sensitiveness and a decrease in the temperature lag. Since it is rather difficult to increase the sensitiveness and at the same time diminish the lag, it will be desirable to reduce as much as possible the heating rate, since this diminution diminishes the temperature lag. In many cases, a rather elaborate procedure in this direction may be the simplest way of increasing the precision. Some special devices which tend to obviate the difficulties encountered in the ordinary type of thermostat were mentioned. The paper was discussed by Messrs Miller and Gray.

Mr. F. E. WRIGHT presented a paper on *The measurement of crystallographic and optical properties at high temperatures*, illustrated by an exhibition of instruments. The basis of crystallography is the law, discovered in 1669 by Steno, of constancy of angle between crystal faces. The methods developed arose from consideration of possible changes in crystal angles with temperature changes. The furnace used for heating crystals and appurtenances were described. The cleavage angle of calcite changes one degree between 0° and 575°, the change being practically linear. Quartz shows much less change, about 11′ in the same temperature range; above 575° rate of change is rather less. Optical properties were also examined at different temperatures. Furnace attachment to regular microscope was described and exhibited. The paper was discussed by Messrs. White, Bowie, Priest, Burgess, Briggs, Agnew, Miller, Coblentz, and Fenner.

The 736th meeting was held on February 14, 1914, at the Cosmos Club, Vice-President EICHELBERGER in the chair; 25 persons present. The minutes of the 735th meeting were read and approved.

Mr. H. H. KIMBALL presented an illustrated paper on *The relation between the solar radiation intensities and the air temperatures for the northern hemisphere*. The speaker discussed the marked diminution in the intensity of direct solar radiation following the eruption of Katmai Volcano in June, 1912. There was an increase in the quantity of heat received diffusely from the sky, but the net result was a decrease in the amount of heat energy received at the surface of the earth. The diminution in insolation has had a cooling effect on the temperature of the northern hemisphere as a whole, but in regions where storms are frequent and atmospheric circulation vigorous, this circulation has determined the character of the local temperature and, in some cases, has brought it above the normal rather than below. The paper was discussed by Messrs. Abbot and Bowie.

Mr. F. E. Fowle then presented an illustrated paper on *Atmospheric transparency for radiation*. The transparency of the atmosphere on clear days is dependent on scattering due to three obstructions: the molecules of the air itself (dry air), the hindrances associated with water vapor (wet haze), and ordinary dust (dry haze). It is due to the change in these last two factors with the altitude that the quality of the transparency of the air, even with homogeneous rays, changes and that Bouguer's formula for atmospheric transmission may not be used in passing from one altitude to another. Above an altitude of 1000 meters on clear days the dry haze may become a negligible factor and the formula developed by the speaker can be used to compute the transparency to within 1 per cent. Above Mount Whitney (4420 meters) the wet haze on clear days may also become negligible. The paper was discussed by Mr. Abbot.

Mr. W. W. Coblentz then presented a paper on *The exudition of ice from plants*. Lantern slides were shown illustrating some beautiful forms. Messrs. Abbot, Wright, and Waite discussed the paper, particularly as regards the cause of the phenomenon noted.

J. A. Fleming, *Secretary*.

REFERENCES

Under this heading it is proposed to include, by author, title, and citation, references to all scientific papers published in or emanating from Washington. It is requested that authors coöperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

PALEONTOLOGY

GIDLEY, J. W. *Notice of the occurrence of a Pleistocene camel north of the Artcic Circle.* Smithsonian Miscellaneous Collections **60**^{26}: 1, 2. March 21, 1913. (Discusses the finding of one of the phalanges of a camel among fossil remains of *Elephas primigenius*, Equus, and Bison in Yukon Territory.—W. R. M.)

GIDLEY, J. W. *An extinct American eland.* Smithsonian Miscellaneous Collections **60**^{27}: 1–3, pl. 1. 1913. (Describes *Taurotragus americanus*, sp. nov., from Pleistocene cave deposits near Cumberland, Maryland.—W. R. M.)

GILMORE, C. W. *A new dinosaur from the lance formation of Wyoming.* Smithsonian Miscellaneous Collections **61**^{5}: 1–5, text figs. 1–5. May 24, 1913. (A preliminary paper describing *Thescelosaurus neglectus*, a new genus and species from Wyoming; referred provisionally to the family Camptosauridae. —W. R. M.)

HAY, O. P. *Descriptions of two new species of ruminants from the Pleistocene of Iowa.* Proceedings of the Biological Society of Washington **26**: 5–8. January 18, 1913. (Describes *Cervalces Roosevelti*, sp. nov.; also the new genus Aftonius, with a single member, *A. Calvini*, sp. nov.—W. R. M.)

HAY, O. P. *Description of the skull of an extinct horse found in central Alaska.* Smithsonian Miscellaneous Collections **61**^{2}: 1–18, pls. 1, 2. June 4, 1913. (Includes description of *Equus niobrarensis alaskae*, subsp. nov.—W. R. M.)

JORDAN, D. S. *Ellima, a genus of fossil herrings.* Proceedings of the Biological Society of Washington **26**: 79. March 22, 1913. (The name Ellipes of Jordan, 1912, being preoccupied by Ellipes of Scudder, 1902, for a genus of crickets, the new name Ellima is proposed for the former genus of extinct clupeoid fishes.—W. R. M.)

BOTANY

BARTLETT, H. H. *Inheritance of sex forms in* Plantago lanceolata. Rhodora **15**: 173–178. October 17, 1913.

COCKERELL, T. D. A. *Some plants from New Mexico.* Proceedings of the Biological Society of Washington **26**: 203, 204. October 23, 1913. (Includes description of *Oenothera Hookeri Hewetti*, subsp. nov.—W. R. M.)

COLLINS, G. N. *A drought-resisting adaptation in seedlings of Hopi maize.* Journal of Agricultural Research **1**: 293–301, figs. 1 and 2, pls. 29–32. January, 1914.

Cook, O. F. *A new ornamental palmetto in southern Texas.* Bureau of Plant Industry Circular 113: 11–14. February 15, 1913. (Describes *Inodes exul* Cook.—W. R. M.)

Cook, O. F., and Doyle, C. B. *Three new genera of stilt palms (Iriarteaceae) from Colombia, with a synoptical review of the family.* Contributions from the U. S. National Herbarium **16**: 225–238, text fig. 41, pls. 54–65. February 21, 1913. (Includes descriptions of the new genera Acrostigma, Catostigma, and Catoblastus, each founded upon a single new species.—W. R. M.)

Cook, O. F. *Wild wheat in Palestine.* Bureau of Plant Industry Bulletin 274: 5–56, pls. 1–15, figs. 1–11. April 3, 1913.

Cook, O. F. *Relationships of the false date-palm of the Florida Keys, with a synoptical key to the families of American palms.* Contributions from the U. S. National Herbarium **16**: 243–254, pls. 74–77. May 14, 1913. (The new families Pseudophoenicaceae, Geonomaceae, Malortieaceae, Chamaedoraceae, Iriarteaceae, Synechanthaceae, and Acristaceae are here established.—W. R. M.)

Griffiths, D. *Einige neue Opuntioideen.* Monats. Kakteenkunde **23**: 130–140. September 15, 1913. (Includes descriptions of seven new species of Opuntia and one of Nopalea.—W. R. M.)

Hasse, H. E. *The lichen flora of southern California.* Contributions from the U. S. National Herbarium **17**: 1–132. June 9, 1913.

Holm, T. Phryma leptostachya *L., a morphological study.* Botanical Gazette **56**: 306–318, pls. 8–10. October 15, 1913.

Kearney, T. H., Briggs, L. J., Shantz, H. L., McLane, J. W., Piemeisel, R. L. *Indicator significance of vegetation in Tooele Valley, Utah.* Journal of Agricultural Research **1**: 365–417, figs. 1–13, pls. 42–48. February 16, 1914.

Krause, K. *A new shrub of the genus Esenbeckia from Colombia.* Smithsonian Miscellaneous Collections **61**[16]: 1. September 29, 1913. (Describes *E. Pittieri*, sp. nov., allied to *E. leiocarpa* and *E. cornuta*.—W. R. M.)

McAtee, W. L. *A list of plants collected on St. Vincent Island, Florida.* Proceedings of the Biological Society of Washington **26**: 39–52. March 22, 1913.

McAtee, W. L. *Some local names of plants.* Torreya **13**: 225–236. October 14, 1913.

Mason, S. C. *The pubescent-fruited species of Prunus of the southwestern states.* Journal of Agricultural Research **1**: 147–177, figs. 1–8, pls. 9–16. November, 1913.

Maxon, W. R. *Studies of tropical American ferns—no. 5.* Contributions from the U. S. National Herbarium **17**: 391–425, pls. 11–23, text figs. 8–10. January 21, 1914. (Includes a revision of the American species of Oleandra, 6 out of the 11 recognized being described as new; extended notes upon *Polypodium duale* and related species; descriptions of 6 new species of Polypodium, 5 of these related to *P. trichomanoides;* descriptions of new species in several other genera; and a revision of the North American species of Hemitelia, section Euhemitelia.—W. R. M.)

Montgomery, E. G. *Experiments in wheat breeding: experimental error in the nursery and variation in nitrogen and yield.* Bureau of Plant Industry Bulletin 269: 5–61, pls. 1–4, figs. 1–22. April 24, 1913.

PIPER, C. V. *Supplementary notes on American species of Festuca.* Contributions from the U. S. National Herbarium **16:** 197–199. February 11, 1913. (Includes description of *Festuca sororia*, sp. nov.—W. R. M.)

PIPER, C. V. Delphinium simplex *and its immediate allies.* Contributions from the U. S. National Herbarium **16:** 201–203. February 11, 1913. (Includes description of *D. cyanorcios*, sp. nov., from Idaho and Oregon.—W. R. M.)

PIPER, C. V. *The identity of* Heuchera cylindrica. Contributions from the U. S. National Herbarium **16:** 205, 206. February 11, 1913. (Includes description of *Heuchera chlorantha*, sp. nov.—W. R. M.)

PIPER, C. V. *New or noteworthy species of Pacific coast plants.* Contributions from the U. S. National Herbarium **16:** 207–210. February 11, 1913. (Seven new species are described in the genera Alsine, Pentstemon, Oreobroma, Aster, and Arabis.—W. R. M.)

RADLKOFER, L. *New Sapindaceae from Panama and Costa Rica.* Smithsonian Miscellaneous Collections **61**[24]: 1–8. February 9, 1914. (Describes 4 new species in Serjania, Paullinia, and Talisia; also the new genus Dipterodendron, with two species, one of which, *D. costaricense*, is new.—W. R. M.)

ROSE, J. N., AND STANDLEY, P. C. *The American species of Meibomia of the section Nephromeria.* Contributions from the U. S. National Herbarium **16:** 211–216, pl. 51. February 11, 1913. (*Meibomia Painteri*, *M. metallica*, and *M. angustata*, are described as new.—W. R. M.)

SAFFORD, W. E. *Raimondia, a new genus of Annonaceae from Colombia.* Contributions from the U. S. National Herbarium **16:** 217–219, pls. 52, 53. February 11, 1913. (Describes *Raimondia monoica*, a new genus and species.—W. R. M.)

SIEVERS, A. F. *Individual variation in the alkaloidal content of belladonna plants.* Journal of Agricultural Research **1:** 129–146, fig. 1. November, 1913.

STANDLEY, P. C. *A new Dodecatheon from New Mexico.* Proceedings of the Biological Society of Washington **26:** 195, 196. October 23, 1913. (Describes *Dodecatheon Ellisiae*, sp. nov.—W. R. M.)

SWINGLE, W. T. Citrus ichangensis, *a promising, hardy new species from southwestern China and Assam.* Journal of Agricultural Research **1:** 1–14, figs. 1–7, pl. 1. October, 1913.

SWINGLE, W. T., AND KELLERMAN, MAUDE. *Citropsis, a new tropical African genus allied to Citrus.* Journal of Agricultural Research **1:** 419–436, figs. 1–7, pl. 49. February, 1914.

TIDESTROM, I. *A new Salicornia.* Proceedings of the Biological Society of Washington **26:** 13, 14. January 18, 1913. (Describes *S. utahensis*, sp. nov., from Utah.—W. R. M.)

WOOTON, E. O., AND STANDLEY, P. C. Descriptions of new plants preliminary to a report upon the flora of New Mexico. Contributions from the U. S. National Herbarium **16:** 109–196, pls. 48–50. February 12, 1913.

PHYTOPATHOLOGY

BROOKS, C. *Quince blotch and apple fruit spot.* Phytopathology **3:** 249, 250. August, 1913.

BROWN, NELLIE A., AND JAMIESON, CLARA O. *A bacterium causing a disease of sugar-beet and nasturtium leaves.* Journal of Agricultural Research **1:** 189–210, figs. 1–5, pls. 17–19. December, 1913.

Harter, L. L. *Foot-rot, a new disease of the sweet potato.* Phytopathology **3:** 243–245, figs. 1, 2. August, 1913. (Describes *Plenodomus destruens,* sp. nov., on stems of *Ipomoea Batatas.*—W. R. M.)

Harter, L. L. *The foot-rot of the sweet potato.* Journal of Agricultural Research **1:** 251–273, fig. 1, pls. 23–28. December, 1913.

Hartley, C. *Twig canker on black birch.* Phytopathology **3:** 248, 249. August, 1913.

Hartley, C. *Bark rusts of* Juniperus virginiana. Phytopathology **3:** 249. August, 1913.

Hedgcock, G. G., and Long, W. H. *Notes on cultures of three species of Peridermium.* Phytopathology **3:** 250, 251. August, 1913.

Hedgcock, G. G., and Long, W. H. *An undescribed species of Peridermium from Colorado.* Phytopathology **3:** 251, 252. August, 1913. (Describes *Peridermium Betheli,* sp. nov.—W. R. M.)

Ingram, Della E. *A twig blight of* Quercus prinus *and related species.* Journal of Agricultural Research **1:** 339–346, figs. 1–7, pl. 38. January, 1914.

Long, W. H. *Three undescribed heart-rots of hardwood trees, especially of oak.* Journal of Agricultural Research **1:** 109–127, pls. 7 and 8. November, 1913.

Long, W. H. Polyporus dryadeus, *a root parasite on the oak.* Journal of Agricultural Research **1:** 239–248, pls. 21 and 22. December, 1913.

Long, W. H. *An undescribed species of Gymnosporangium from Japan.* Journal of Agricultural Research **1:** 353–356. January, 1914.

Metcalf, H. *The chestnut bark disease.* Yearbook of the Department of Agriculture **1912:** 361–372, pls. 34–37. 1913.

Rand, F. V. *Some diseases of pecans.* Journal of Agricultural Research **1:** 303–337, figs. 1–8, pls. 33–37. January, 1914.

Taubenhaus, J. J. *The black rots of the sweet potato.* Phytopathology **3:** 159–166, pls. 14–16. August 1, 1913. (Includes description of *Sclerotium bataticola,* sp. nov.—W. R. W.)

ENTOMOLOGY

Hood, J. D. *Nine new Thysanoptera from the United States.* Proceedings of the Biological Society of Washington **26:** 161–166. June 30, 1913.

Hopkins, A. D. *Discontinuous geographical distribution.* Proceedings of the Entomological Society of Washington **15:** 118–121. October 2, 1913. (The occurrence of closely related species in widely separated localities is credited to parallel evolution under long-continued similar environments from a common primitive ancestral base.—J. C. C.)

Knab, F. *A new bot-fly from reindeer.* Proceedings of the Biological Society of Washington **26:** 155, 156. June 30, 1913. (Describes *Oedenagena terraenovae,* from Newfoundland.—J. C. C.)

Paine, J. H. *A new genus of Mallophaga from African Guinea fowl in the United States National Museum.* Smithsonian Miscellaneous Collections **61**[23]: 1–4, text fig. 1. January 31, 1914. (Describes *Somaphontus lusius,* new genus and species, upon specimens taken from *Numida ptilorhyncha.*—W. R. M.)

Parker, W. B. *A sealed paper carton to protect cereals from insect attack.* Bulletin of the U. S. Department of Agriculture, No. 15. Pp. 1–8. October 16, 1913. (Discusses briefly the advisability of using a sealed paper carton, showing its efficiency and the non-efficiency of the unsealed packages.—J.C.C.)

Pierce, W. D. *The occurrence of a cotton boll weevil in Arizona.* Journal of Agricultural Research **1**: 89–96, figs. 1–9, pl. 6. November, 1913.

Pierce, W. D. *New potato weevils from Andean South America.* Journal of Agricultural Research **1**: 347–351, figs. 1–3, 39–41. January, 1914.

Quaintance, A. L. *Remarks on some of the injurious insects of other countries.* Proceedings of the Entomological Society of Washington **15**: 54–83. June 10, 1913. (For the economic entomologists the author has brought together notes on the important injurious insects of all orders, giving the type of injury of the various species.—J. C. C.)

Quaintance, A. L., and Baker, A. C. *Classification of the Aleyrodidae—Pt. I.* Bureau of Entomology, Technical Series, No. 27, Pt. 1, pp. 1–93, pls. 1–34. March 6, 1913. (In this paper, which treats of the species of the whole world, one new subfamily, the two new genera Leonardius and Neomaskellia, the two new subgenera Lecanoideus and Metaleurodicus, and eight new species are described.—J. C. C.)

Rohwer, S. A. *A new braconid from South America.* Proceedings of the Entomological Society of Washington **15**: 144. October 2, 1913.

Rohwer, S. A. *VI. Chalcidids injurious to forest-tree seeds.* Bureau of Entomology, Technical Series, No. 20, Pt. 6, pp. 157–163. February 10, 1913. (Contains notes on the habits of the species of the genus Megastigmus and *Syntomaspis druparum*.—J. C. C.)

Russell, H. M. *Observations on the egg parasites of* Datana integerrima *Walk.* Proceedings of the Entomological Society of Washington **15**: 91–97. June 10, 1913. (Four species are recorded, three of these being chalcids.—J. C. C.)

Sasscer, E. R. *An index to catalogues of recently described Coccidae included in Technical Series Nos. 12 and 16.* Bureau of Entomology, Technical Series, No. 16, Pt. 7, pp. 99–116. January 23, 1913.

Sasscer, E. R., and Pierce, W. D. *Preliminary report of the finding of a new weevil enemy of the potato tuber.* Proceedings of the Entomological Society of Washington **15**: 143, 144, pls. 4, 5. October 2, 1913. (Records the finding of *Rhigopsidius tucumanus* in potato from Peru, Bolivia and Chile, and states that the injury is not noticeable externally, so that there is danger of the importation of this injurious insect.—J. C. C.)

Schaus, W. *Two new noctuids from French Guiana (Lepidoptera, Noctuidae).* Insecutor Inscitiae Menstruus **1**: 25, 26. March 29, 1913. (Describes *Celiptera therides* and *Safia olearos*.—J. C. C.)

Scott, E. W., and Siegler, E. H. *Lime-sulphur as a stomach poison for insects.* Bureau of Entomology Bulletin 116, Pt. 4, pp. 81–90, pl. 11. January 17, 1913. (The experiments were conducted at Benton Harbor, Mich.—J. C. C.)

Snyder, T. E. *Record of the rearing of* Cupes concolor *Westw.* Proceedings of the Entomological Society of Washington **15**: 30, 31, pl. 1. April 9, 1913.

Snyder, T. E. *The ovipositor of* Parandra brunnea *Fab.* Proceedings of the Entomological Society of Washington **15**: 131, 133. October 2, 1913. (A discussion of the anatomy of the ovipositor.—J. C. C.)

Townsend, C. H. T. *A new genus of Streblidae.* Proceedings of the Entomological Society of Washington **15**: 98, 99. June 10, 1913. (Describes the new genus Synthesiostrebla, with one new species, from Peru.—J. C. C.)

Townsend, C. H. T. *Preliminary characterization of the vector of verruga,* Phlebotomus verrucarium, *sp. nov.* Insecutor Inscitiae Menstruus **1**: 107–109, pl.

3. September 15, 1913. (In describing this new species the author states that "although the transmission of verruga by means of the species . . . . has not yet been accomplished, it is now practically certain from the entomological standpoint, considered in connection with the very peculiar conditions of the verruga zones, that it is the vector, if not the true intermediary host, of the causative organism of the disease."—J. C. C.)

Townsend, C. H. T. *Criticism and muscoid taxonomy.* Insecutor Inscitiae Menstruus **1**: 115-117. September 15, 1913. (A reply to certain criticisms of articles by the author, with mention of material and data regarded as essential to a proper classification of the muscoid flies.—J. C. C.)

Townsend, C. H. T. *New muscoid flies, mainly Hystriciidae and Pyrrhosiinae from the Andean Montanya.* Insecutor Inscitiae Menstruus **1**: 144-148. November 29, 1913. (To be continued; this part contains a general introduction, with description of the region and notes on tribal characters.—J. C. C.)

Viereck, H. L. *Descriptions of ten new genera and twenty-three new species of Ichneumon-flies.* Proceedings of the U. S. National Museum **44**: 555-568. April 18, 1913. (Describes the new genera Coelinidea and Ericoelinius in the family Alysiidae; Atanycolimorpha, Coeloidimorpha, and Hysterobolus in the Braconidae; Chroistlimorpha, Diapetimorpha, Ethaemorpha, Mesostenimorpha, and Orthocryptus in the Ichneumonidae.—J. C. C.)

Walton, W. R. *Efficiency of a tachnid parasite on the last instar of Laphygma.* Proceedings of the Entomological Society of Washington **15**: 128-131. October 2, 1913. (A study of the effectiveness of parasitism by Tachinidae, the maximum number of adult Tachinids to issue from one individual host, and the effect, if any, of the deposition of supernumerary eggs on the development of the resulting adult flies.—J. C. C.)

Walton, W. R. *The variation of structural characters used in the classification of some muscoidean flies.* Proceedings of the Entomological Society of Washington **15**: 21-28. April 9, 1913. (Gives examples of the variation of chaetophorous characters in various species.—J. C. C.)

Webster, F. M. *The Southern corn rootworm, or budworm.* Bulletin of the U. S. Department of Agriculture, No. 5, pp. 1-11. September 27, 1913. (An account of food-plants of the larvae, the amount of damage to corn, seasonal history of the insect, natural enemies, and suggestions for remedial and preventative measures.—J. C. C.)

Webster, F. M., and Parks, T. H. The serpentine leaf-miner. Journal of Agricultural Research **1**: 59-87, fig. 1-17, pl. 5. October, 1913.

Weld, L. H. *A new oak gall from Mexico (Hymenoptera, Cynipidae).* Insecutor Inscitiae Menstruus **1**: 132-134, pl. 4. October 30, 1913. (Describes the gall, its market, and a new species of inquiline.—J. C. C.)

Woglum, R. S. *Report of a trip to India and the Orient in search of the natural enemies of the Citrus white fly.* Bureau of Entomology Bulletin 120: 1-58, pls. 1-12. February 28, 1913. (An internal parasite of the white fly, *Aleyrodes citri*, was discovered in India; but, since specimens shipped to the United States arrived during the winter months and thus could not be established, the possibility of their being able to survive in this climate and their subsequent efficiency are problematical.—J. C. C.)

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GEOLOGY.—*Origin and mode of formation of magmatic gases.*[1] STANISLAS MEUNIER, Professor of Geology at the National Museum of Natural History, Paris. Communicated by ARTHUR L. DAY.

The presence of gases, intimately associated with the products ejected by volcanoes, namely, lavas, ashes, and fumarole deposits, represents one of the most important problems in general geology, for it leads to a recognition of the preponderant part played by a long series of gasiform substances, deep down in the earth's crust. This consideration has evidently been overlooked by all those authors who have cherished the hope of accomplishing the experimental synthesis of crystalline rocks by processes of simple fusion. Their results, typically illustrated by the work of Fouqué and Michel Lévy, bear only a partial resemblance to the natural products, the origin of which they do not fully explain.

On the other hand, volcanic action has been so steadily at work from the remotest geologic periods, and it still bears so large a share in the evolution of the earth's surface, that any view regarding it which is not in perfect harmony with the understanding of all the other telluric functions can not be considered trustworthy. It would in fact be easy to show that, in order to reach the conclusion which to us seems the right one, nothing more is needed than to enumerate the successive conditions through which the deeper parts of the earth's crust have passed.

[1] Translation of French manuscript.

One of the principal effects of the recently formed crust has been to imprison the entire nuclear region of the earth, and thus to isolate it. The progressive thickening of the crust has produced a growing difference of temperature between its external or epidermic region and its internal parts, which have only recently passed into the solid state. Aqueous infiltrations from the surface penetrated into the thickening external zone, while at the same time the successive seas piled up layer upon layer of sediments, which, at first saturated with water, came in time to contain nothing more than "rock water."

From this first remark it follows that the earth's crust is divided into two concentric zones, passing gradually one into the other, the deeper zone being as yet very hot, even incandescent at certain points, while in the superposed zone the solid mineral elements are associated with considerable amounts of substances volatilizable at relatively low temperatures, such as water and the innumerable series of compounds which may so readily be extracted from fossiliferous and other strata, by subjecting them to simple distillation.

In the second place, the progressive cooling of the earth, the very cause of planetary evolution, has constantly tended to disturb the original condition of equilibrium established in the solid crust forming the surface of the liquid nucleus. The process bears a striking resemblance to that on which liquid thermometers are based. These thermometers indicate the temperature because the volume of the liquid and the volume of the solid container do not vary at the same rate. The earth may be regarded as a liquid thermometer, say a mercurial thermometer, consisting merely of the bulb, which is exactly filled at the moment of observation. The spontaneous cooling causes a contraction both in the crust, corresponding to the bulb, and in the nuclear mass, corresponding to the mercury. Owing to the difference in physical condition, the nucleus contracts more rapidly than the crust, whereupon the latter, being no longer supported by the nucleus at every point, is subjected to a set of stresses, the resultant of which tends to be tangential and to produce horizontal thrusts, which are by common accord regarded as the origin and mechanism of the "irregularities" of the earth's surface. Thus arise the alternate synclinal and anticlinal *folds,* with all their variants; thus are formed the *faults,* which in all mountain chains, wherever their cross section is exposed, are found in such vast numbers as to constitute an essential element in orogeny; thus are started the *fissure eruptions* the study of which has already been so fruitful of results.

Having recalled these two points, we have now to inquire what will be the necessary consequences of their coexistence. The zone of maximum contraction is evidently situated at a depth which, though not yet accurately measured, is nevertheless indicated by the location of earthquakes. From that zone as a focus starts the impulse which gives rise to the subterranean phenomena. Along the plane of contact, of any given extent, between the internal incandescent zone and the superposed zone impregnated with volatilizable material, what will happen when a part of the latter zone is covered by the rocks intruded from below? It will form a wedge, as it were, clamped between two very hot bodies: beneath it, the rocks remaining in their previous relative positions, and above it, the rocks that have been intruded along the plane of injection. Its temperature will necessarily rise. To understand the resulting effects, we may well turn for information to the celebrated experiments by Sénarmont.

Suppose that mineral matter is subjected to heat in an elastic atmosphere consisting of those vapors very appropriately called *mineralizers,* chiefly superheated water. A relatively moderate temperature—of a few hundred degrees—will then suffice, without any necessary change in composition, to produce the long series of crystallized substances characteristic of volcanic rocks. On this point the laboratory results, conclusive in themselves, may be further supplemented with the informaton furnished by certain natural localities, where human action has caused syntheses of the same kind to assume geologic proportions. Fire started as a result of mining operations in certain deposits of combustible material, that is, in coal mines, causes the metamorphosis of clays into crystalline agregates of minerals identical with those of the lavas, such as ferro-magnesian silicates (pyroxene) and aluminium silicates (anorthite and other feldspars). It is to be noted that the formation of these products, while sufficient to elucidate the origin of volcanic minerals, and often carried out at the expense of sedimentary strata which have undergone the orogenic over-blanketing by an intruded sheet, as described above, is nevertheless incomplete from our point of view, because of the free communication of the subterranean laboratory with the atmosphere. That communication is in fact incompatible with the retention of those gaseous substances that represent the generative force, and hence incompatible with the conditions that enable the eruption to take place. That situation, however, will vanish of itself, if in place of the burning coal mine we consider the case of a natural over-blanketing with its accompanying conditions.

Among the results of the heating of sedimentary layers impregnated with the products that would escape from them if subjected to distillation, two require special mention: (1) The mobility imparted to the molecules, enabling them to enter the crystalline state through a veritable refusion which we may call aqueous; (2) the incorporation, by occlusion, of these vapors themselves within the liquid produced. The resulting substance is a compound which, despite the enormous difference in composition and surroundings, suggests a comparison with aqueous liquids at ordinary temperature in which soluble gases have been imprisoned by pressure. The typical case is that of Seltzer water (soda-water), that is to say, the solution, under the necessary pressure, of carbonic acid gas in water, which constitutes a sort of *aqueous magma*.

The characteristic property of this magma is its *tension;* it persists without change of constitution so long as the surrounding pressure does not diminish; but if by any process the reservoir containing this magma is put in communication with a region of less pressure, the equilibrium which tends to establish itself between the two regions causes the disengagement of all or part of the dissolved gas. Thus by merely pressing on the lever of a soda water siphon, a veritable *eruption* may be produced. The dissolved gas, tending to reach a state of equilibrium with the adjoining atmosphere, separates from its solvent, but carries that solvent along with it and causes it to be spurted out to a greater or less distance. That ejection might even take on all the leading characters of a volcanic eruption, if the ordinary stopcock, which curves downward, were replaced by a straight tube pointing upward. In that case a veritable spray of water would be seen spurting forth, just as a veritable spray of lava spurts forth from a crater. This spray of lava, called ashes because of its color, occurs when the projected liquid is solidified so rapidly that the rock has not time to crystallize but assumes the vitreous state and reproduces the phenomena of Prince Rupert drops when suddenly broken.

If we suppose our soda-water spray to be produced in a space with sufficiently low temperature, it will fall in the shape of extremely fine ice-dust, which would correspond to the volcanic ashes. If, however, the siphon be left open, it can not keep up the ejection of this spray indefinitely. Soon the gas escaping from occlusion, issuing with less violence, will carry the liquid with it more sluggishly, till finally it merely drivels over the mouth of the bottle and runs over the table along the slope presented by the latter. In that condition it represents the lava flow issuing from the volcano. In both cases it will be found that the emission of gases does not stop at once. If you hold your nose close to the liquid bubbling out of the bottle, you will feel the prickling characteristic of carbonic acid. Similarly, the coulée of Vesuvius or Etna will continue for some time to emit jets of vapor, which, by reason of their complexity, in contrast with the simplicy of the carbonic acid, have deposited all the characteristic coatings of fumaroles.

Carrying the comparison still further, we may subject a soda-water siphon to cooling till the liquid therein is reduced to a lump of ice. It will then be noticed that cavities are formed, especially in the upper part of the lump of ice, which represent the casts, as it were, of the bubbles of gas relinquished by the solvent and retained by its solidification. An important fact will then be observed, namely, that the siphon may be opened with impunity; no "eruption" takes place. This is strictly analogous to the history of the volcano. Our lump of ice resembles in many respects, the laccolites, those products of aborted eruptions, aborted because the siphon was not opened in time; that is to say, no fissure was formed between the subterranean reservoir of tensioned matter and the atmosphere, before solidification.

Thus, in order that a volcanic eruption prepared in the deeper regions may reach the surface it is necessary that the lava capable of gushing out shall find a passage from the subterranean laboratory to the surface. This passage may be formed either by corrosion from below upward, or (more frequently) by the cracking of the crust, for example, as the result of a seismic shock.

It is hardly necessary to point out to what degree the preceding observations explain the variants presented by the different volcanoes as regards the composition of their magmatic gases. Some rocks will furnish to the subterranean distillation nothing but water, accompanied by a greater or less quantity of various secondary products; others, such as coal beds or carbonaceous schists, will yield hydrocarbons or related compounds; others, containing deposits of sea salt or various chlorides, will furnish hydrochloric acid or its compounds; others, containing layers of gypsum or similar deposits of sulphates and sulphides, will yield sulphuric acid or sulphurous acid or sulphohydric acid. Elsewhere, fossiliferous layers, filled, say, with animal remains, such as the sapropelites of the oldest terranes, will yield ammonia and nitrogenous compounds. It is easy to imagine the infinity of cases that may occur either separately or in association.

In a word, the preceding theory seems adequate to explain the different circumstances of the geographic distribution at each epoch, the geologic position, and the chemical behavior of volcanoes. It recommends itself by its intimate connection with all the other characteristics of planetary physiology, of which it appears to be an inevitable consequence.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal, and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Geology and mineral resources of the Peoria quadrangle, Illinois.* J. A. UDDEN. U. S. Geological Survey Bulletin 506. Pp. 103, with maps, views, and sections. 1912.[1]

The surface of most of the Peoria quadrangle is formed by the upland divided by the alluvial-filled valley of the Illinois River. The major part of this upland consists of flat interstream areas which mark a plain in most cases dipping gently to the south. Numerous water courses have dissected the upland, especially in that part lying northwest of the Illinois River. Some of these valley cuttings have reached bed rock, which is of Pennsylvanian age. In this series two conformable formations are recognized, a lower consisting of shales, sandstones, and coal beds, and an upper made up chiefly of limestone. These are the only hard rock formations exposed in the quadrangle, but well borings have penetrated older strata to a depth of 1300 feet. By these borings the presence of Ordovician, Silurian, Devonian, and Mississippian formations have been revealed. The oldest formation penetrated is the St. Peter sandstone (Ordovician).

During the greater part of the Tertiary period the Peoria quadrangle was probably a land area. Some gravel which overlies bedrock under the glacial drift at one locality may represent a residuum of surficial deposits of early Pleistocene or late Tertiary time, preceding the glacial epoch.

Erosion in preglacial time had produced a land surface which differed considerably from the present topography. Since that time the land has been rebuilt by glaciation, the general effect of which has been to reduce the relief. The old land surface has undergone some changes by postglacial agencies, but these are small.

[1] See also, this Journal, **2**: 440. 1912.

The Pleistocene deposits consist of remnants of a probably early drift of unknown age, Illinoian drift, Wisconsin drift, loess, and postglacial alluvium. At several localities dark bowlder clay was noted, which resembles in some respects an old till occurring under the Illinoian and the Kansan drift sheets in Iowa. This bowlder clay contains a smaller percentage of dolomitic limestone pebbles among the smaller sizes than is normally present in the Illinoian drift, and it is associated with silt that commonly occurs in association with the older drift in Iowa. The till itself contains large pockets of yellow sand, such as are common in the old tills west of the Mississippi. The till in these places is of unknown age, but it differs considerably from the local Illinoian till in its general appearance and probably represents an earlier invasion of the ice.

The till resulting from the Illinoian ice invasion was no doubt originally laid down over the entire area of this quadrangle. In the eastern part it is overlain by drift of Wisconsin age wherever the latter was not removed by interglacial erosion or worked into the later till. The thickness of the Illinoian till varies from about 20 to nearly 80 feet. On its surface is a soil formed in interglacial time and known as the Sangamon soil. Outside the limits of the Wisconsin drift the weathered and eroded surface of the Illinoian till is covered by loess. In places also similar loess is exposed intercalated between the weathered Illinoian till and the overlying Wisconsin till showing that a part at least of the super-Illinoian loess is of pre-Wisconsin age.

The Wisconsin drift is limited to the eastern and northeastern half of the quadrangle. Its margin is traceable through the central part of the region, though the terminal moraine is not strongly marked.

In places remnants of two former flood plains border the present bottom lands of the streams. Both of these date from late stages of the Wisconsin ice invasion. The older terrace has an average elevation of 520 feet above sea level. The surface of this terrace has been considerably modified by erosion. The later Wisconsin terrace has an average elevation of 476 feet above sea level and forms a narrow strip bordering the older terrace.

Loess, a dusty yellow material, generally not calcareous in this area, covers all of the upland, overlying both the Illinoian and Wisconsin drift sheets. Its upper part is dark from decayed vegetation, forming the upland soil. Directly under the soil the loess in many places is impregnated with ferruginous material, which gives it a reddish-brown color in various shades. In other places, especially where the ground has been poorly drained, the iron stain immediately under the black soil has been leached away and the deposit has an ashen-gray, almost white appearance.

The thickness of the loess is fairly constant for each drift sheet on which it rests. On the upland of the Illinoian till it ranges from 20 to 30 feet and averages 24 feet. In two localities this older and thicker loess was seen to contain fossil land snails. In each of these places the loess is slightly calcareous. On the Wisconsin drift the loess averages 7 feet thick, but it varies considerably. On the older Wisconsin terrace much of the surface is covered 3 or 4 feet deep by material which in every way resembles the loess, except that in places it contains a small percentage of fine sand.

The greater part of the loess outside the limit of the Wisconsin drift must be older than the Wisconsin till, since a considerable thickness also underlies the later till. It is a suggestive fact that the buried loess is nowhere known to reach a thickness which when added to the average depth of the loess on the Wisconsin till would exceed the average depth of the deposit on the Illinoian till. W. C. Alden.

GEOLOGY.—*The mud lumps at the mouths of the Mississippi.* Eugene Wesley Shaw. U. S. Geological Survey Professional Paper 85-B. Pp. 27, views and sections. 1913.

The territory within a mile or two of each of the mouths of the Mississippi is characterized by large swellings or upheavals of tough bluish-gray clay, called "mud lumps." Many of these rise just offshore and form islands an acre or more in extent and 5 or 10 feet high, but some do not reach the water surface. They rise and subside at irregular rates, some of them suddenly.

Certain features of the Delta suggest that it is affected by a process which heretofore seems not to have been suspected, namely, a bodily flowage toward the sea. The surface receives a new layer of sediment at each flood, but its altitude above sea does not seem to show a corresponding increase. The sinking is due in part, no doubt, or perhaps entirely, to the compacting of the sediment. Whatever its exact nature, the facts that the subsidence is greatest where the Delta is growing most rapidly, and that because of the very watery condition of the material it is presumably becoming more compact, make it seem probable that the process is only in part, if at all, one of isostatic adjustment.

The hypothesis better favored by the data now in hand than any other, is that the mud lumps are produced by a gentle seaward flow of layers of semifluid clay under the land and the shallow water near the ends of the passes, where this flow is opposed by the comparatively resistant parts of the foreset beds. The tendency to flow is assumed to be due to pressure developed by constant additions of sediment. The mud lumps appear to be the product of flow, because in no other places have such thick bodies of clay been found; and the facts that they occur almost exclusively near the ends of the passes—most commonly west of them, where probably the principal part of the sediment is being deposited—and that they are most active during and after times of high water seem to be in accord with the hypothesis here presented.

A. H. Brooks.

GEOLOGY.—*Geology and ore deposits of the San Francisco and adjacent districts, Utah.* B. S. Butler. U. S. Geological Survey Professional Paper 80. Pp. 212, with map, sections, and illustrations. 1913.

The San Francisco and adjacent districts are located in Beaver County, southwestern Utah, about 180 miles a little west of south of Salt Lake City. The sedimentary rocks of the area range in age from Ordovician to Triassic and in character from quartzites to limestone. A total thickness of about 18,000 feet of sedimentary rocks is present.

In Tertiary time the area was buried beneath thick flows of lava, and following the extrusion of the lavas large bodies of igneous material were intruded into the sedimentary and extrusive rocks, forming the quartz monzonite stocks of the region.

Accompanying and following the intrusion of the quartz monzonite there was extensive alteration of the rocks and the deposition of ores. The copper ores occur mainly as replacement deposits in the quartz monzonite and as contact deposits. Lead-silver ores occur as replacement veins in the sedimentary and extrusive rocks. These also contain some copper and zinc.

All the ore deposits of the district are believed to have had a common origin, namely, they were the result of the differentiation of the quartz monzonite magma. Such an origin is indicated by the presence of original sulphides in aplitic rocks and by the presence of coarse pegmatitic quartz associated with the copper ores. The transition from contact deposits to replacement deposits in the sediments is especially well illustrated in the district.

Since the original ores were formed the deposits have been acted upon by waters leaching downward from the surface, and in many instances the different metals in the original ores have been concentrated in zones. Thus, in the Horn Silver mine the surface zone is rich in lead and silver; beneath this is a zone rich in copper and zinc; and at still greater depth is the original ore in which these metals are all present. This rearrangement of the metal content has been an important factor in determining the commercial value of the ore deposits. B. S. B.

GEOLOGY.—*The Mount Lyell copper district of Tasmania.* Chester G. Gilbert and Joseph E. Pogue. Proceedings of the U. S. National Museum **45:** 609–625, pls. 48–51. July 22, 1913.

This paper is based upon microscopic and metallographic study of a comprehensive collection of rocks and ores in the National Museum. The ore deposits include (1) a pyritic mass of remarkable size lying within deeply dipping sericite schists adjacent to a faulted conglomerate contact and consisting of fine-grained, homogeneous pyrite bearing disseminated chalcopyrite and localized areas of enargite and tetrahedrite; and (2) lenticular masses of bornite carrying subordinate chalcocite and some tetrahedrite, pyrite, and chalcopyrite, in sericitic and chloritic schists. Microscopic study points unmistakably to the formation of the ores through replacement of the minerals of the schists. The study leads also to the conclusion that the ore deposition took place during a distinct mineralizing epoch marked by solutions progressively changing in composition and depositing a series of sulphide minerals in *sequential* and *transitional* stages. The order of deposition runs from pyrite through chalcopyrite, bornite, and chalcocite, to the tetrahedrite-enargite group (accompanied by chalcopyrite of a second generation). This succession is in exact harmony with the order of increasing copper content and with that of decreasing iron content. It is believed that the ore-bearing solutions were a deep-seated development from a differentiating mass of igneous rocks, and that these solutions rose along structurally developed channels, changing gradually in composition from the beginning to the end of the depositional epoch.

The paper gives a general account of the history and geology of the district; a detailed description of the ore minerals, accompanied by two photographs and eleven microphotographs of polished ore sections, two showing a crystallographic intergrowth of bornite and chalcocite; a brief discussion of the important analogous deposits of the world; and closes with a bibliography. J. E. P.

GEOLOGY.—*The geology of Long Island, New York.* MYRON L. FULLER. U. S. Geological Survey Professional Paper 82. Pp. 231, with maps, views, and sections. 1914.

Geologically Long Island belongs to the inner part of the Atlantic Coastal Plain. The line of demarkation between the basal metamorphic rocks and the younger sediments of the coastal plain crosses the extreme western end of the island. There are a few occurrences of Cretaceous clays in the western half of the island, and these make up the basal formation of the sedimentary series. No equivalents of the Tertiary deposits of the mainland have been definitely recognized, although some loose sands possibly of Tertiary age occur at one locality. The greater part of both the surface and the underlying materials throughout the island are Pleistocene morainal and outwash deposits associated with the continental glaciers. Two morainal ridges forming the backbone of the island are the direct continuation of the series of moraines of Wisconsin age that are traceable almost continuously from the Rocky Mountains to New Jersey and thence through Long Island and the islands on the east as far as Nantucket and Cape Cod. Beneath these ridges and above the Cretaceous are various Pleistocene deposits of considerable thickness, to be correlated with older drift sheets of the central United States and with the Pleistocene formations of the New England Coast.

Eight stages have been récognized in the Pleistocene history of Long Island, and some of these are divisible into substages. The oldest, the Manetto stage, which was glacial, is recorded by gravel deposits, and probably of pre-Kansan age. This was followed by Post-Mannetto stage, an interglacial period of erosion and to be provisionally correlated with the Aftonian. A second glacial epoch is represented by the Jameco stage, represented by gravel deposits (Kansan?), and this succeeded by the Gardiner clays, deposited during an interglacial epoch. A transitional epoch to another glacial epoch is recorded in the Jacob sands. The next event is the Manhasset glacial stage, probably to be correlated with the Illinoian. This event is represented by the deposition of a lower gravel member (Herod), succeeded by a second period of ice erosion, then by the deposition of an upper gravel member (Hempstead). Erosion during an interglacial period followed the Manhasset stage, accompanied by the deposition of the Vineyard formation, consisting of marine deposits and peat. In early Wisconsin time glacial conditions again prevailed, and this epoch is represented by the older Ronkonkoma or outer moraine and the younger Harbor Hill or inner moraine, both associated with till and outwash deposits.

After the disappearance of the Wisconsin ice the land seems to have stood somewhat higher than at present, as indicated by the buried and submerged peats along the coast, the difference in level being perhaps 25 feet. This would indicate the elevation of 45 feet in late Wisconsin or post-Wisconsin time. In recent years there has been depression estimated at the rate of 6 inches to 2 feet in one hundred years. A sinking of not more than 25 feet apparently has occurred since the beginning of this movement. ALFRED H. BROOKS.

GEOLOGY.—*Resins in Paleozoic plants and in coals of high rank.* DAVID WHITE. U. S. Geological Survey Professional Paper 85-E. Pp. 97, with plates. 1914.

Lumps of resin of different kinds are present nearly everywhere in coals of low rank, such as lignites and sub-bituminous coals, the resins being very abundant and conspicuous in some beds. The amount of microscopic resin probably far exceeds that visible to the naked eye.

The presence of resins in Paleozoic coals, which has been seriously questioned, the available information being limited, is set at rest by the observation of small lumps found in coals of a medium bituminous rank in Iowa, Illinois, and Indiana. The examination of the woods and petioles, found under conditions favorable for examination in Paleozoic coals, indicates that plants secreting resinous substances were not only present but common in the Carboniferous flora. Therefore, absence of resins is not distinctive of Paleozoic coals.

Observations in the Cretaceous and Tertiary coal fields indicate that, in the processes of metamorphism which have converted lignites and other low rank coals to coals of higher rank, the lump resins are deformed, discolored, and carbonized, with probable high losses of volatile matter, as the coals are brought to a moderately high bituminous rank corresponding to a percentage of about 65 per cent of fixed carbon in pure coal, the megascopic resins being very rarely recognizable to the unaided eye when the coal has reached the good cooking rank. It is probable that the resins undergo minor chemical change soon after deposition with the organic debris from which the coals are formed.

D. W.

HYDROLOGY.—*Geology and water resources of a portion of south-central Washington.* GERALD A. WARING. U. S. Geological Survey Water-Supply Paper No. 316. Pp. 46, 1 pl. 1913.

Two geologic formations are exposed in the region here discussed: Yakima basalt, of Miocene age, and the Ellensburg Lake deposits, also Miocene, which are deposited directly on the basalt. Over a considerable area these formations are obscured by wind-borne material. Glacial erratics occur sparingly.

The main surface features conform to the structure, broad ridges and wide plains and valleys being the dominant topographic forms. The ridges resemble basin ranges but are unsymmetrical anticlines rather than faulted blocks. Faulting has, however, produced the steeper slopes.

Stream gorges that cut directly across ridges appear to have been formed by the slow uplift of the ridges across the established stream courses. O. E. MEINZER.

HYDROLOGY.—*The effects of ice on stream flow.* WILLIAM GLENN HOYT. U. S. Geological Survey Water Supply Paper No. 337. Pp. 77, with plates and views. 1913.

The quantity and distribution of winter stream flow are the result of the combination of factors that may be classified as climatic, geologic, topographic and vegetational. The climatic factors are precipitation, temperature, barometric pressure and winds; the geologic factors include surface and underground rock structure; the topographic factors include relief and slope which determine the character and amount of natural storage, the location, size and trend of the drainage basin, and the character of the streams and their tributaries; the vegetational factors comprise not only forestation, but the effects of all plant growth and cultivation. A fifth factor is the result of artificial control of the streams for water supply or power.

The determination of stream flow during open water periods is based upon a relation between stage and discharge which is determined by measurements. During periods of low temperature, surface ice, frazil and slush ice, and anchor ice, alone or in combination, will be formed. The presence of ice in any of the above forms on the river tends to raise the stage without a corresponding increase in flow. The presence of ice is due primarily to low temperature, so that in order to determine the stream flow during the winter it is necessary to make a study of temperature, ice formation and gage height in connection with discharge measurements. The temperature is also the largest factor in determining the amount of winter stream flow, so that it becomes necessary to study temperature not only as a means of arriving at the true flow but also in making comparisons between the low flow of other winter periods. W. G. H.

HYDROLOGY.—*The Ohio Valley flood of March to April, 1913. (Including comparisons with some earlier floods.)* A. H. HORTON and H. J. JACKSON. U. S. Geological Survey Water-Supply Paper No. 334. Pp. 96, with maps, hydrographs, tables, and views. 1913.

The Ohio River has not failed to overflow its banks and flood large areas of bottom land at some point along its course in every year since 1873 and, very probably, in every year previous to 1873. Since 1873 there have been three floods of special prominence—that of February, 1884, that of March to April, 1907, and, last and greatest, that of March to April, 1913.

Of the forty-six floods on record at Cincinnati, Ohio, above the danger line, only three occurred outside of the four months, January, February, March and April; namely, one in December, 1847, one in May, 1865, and the third in August, 1875.

The flood of March to April, 1913, was caused by heavy precipitation over the entire Ohio Basin. Over a large portion of northern Ohio the total precipitation for the five-day period March 23–27, was over ten inches. Floods were produced and practically all the tributaries, and stages far above all previous floods were reached on the northern Tributaries in Indiana and Ohio, causing inconceivable damage and destruction in these two states and throughout the entire length of the Ohio River. Previous record stages were exceeded on the Ohio from St. Marys, West Virginia, to Maysville, Kentucky, at Madison and Mt. Vernon, Indiana, and at Shawneetown and Cairo, Illinois.

The flood of March to April, 1907, was caused by heavy rains in the northern part of the basin and over the headwaters above Pittsburgh. The melting of a heavy fall of snow on the tributaries above Pittsburgh, in conjunction with rain, increased the runoff materially. The stage at Pittsburgh exceeded all records.

The flood of February, 1884, was caused by a warm rain throughout the basin, which fell on a heavy accumulation of snow resulting from a winter of large snowfall and unusually low temperatures. Record stages were reached at all points on the Ohio which have been exceeded only by the 1913 flood, and at Pittsburgh by the 1907 flood.

To have kept the 1913 flood below the danger line at Wheeling, West Virginia, storage would have to have been provided for 44,800 million cubic feet of water; at Cincinnati 190,000 million cubic feet; at Evansville 322,000 million cubic feet. Preliminary investigation during 1908 in the Kanawha River basin showed 17 reservoirs with a total capacity of 280,000 million cubic feet, in that basin alone.

At the present time the two methods that are most advocated for the control of floods are reservoirs and levees. Before any method can be selected as the best, full information must be available in regard to the quantity of water carried by the Ohio and larger tributaries and its distribution as to drainage area and time. A. H. H.

BOTANY.—*Indicator significance of vegetation in Tooele Valley, Utah.* T. H. KEARNEY, L. J. BRIGGS, H. L. SHANTZ, J. W. MCLANE, and R. L. PIEMEISEL. Journal of Agricultural Research **1**: 365–417, figs. 1–13, pls. 42–48. February 16, 1914.

The types of vegetation in Tooele Valley were found to be so closely correlated with the soil moisture and salinity conditions as to be useful indicators of the crop producing capabilities of the corresponding types of land. This suggests the practicability of classifying land in this region upon the basis of the native vegetation.

The presence of the Sage Brush (*Artemisia tridentata*) Association indicates that the soil is readily permeable and well drained and that its salt content is very low. The soils occupied by the Kochia (*Kochia vestita*) and Shadscale (*Atriplex confertifolia*) Associations are usually less permeable than the Sage Brush soil and are relatively free from salts to a depth of one or two feet, while the subsoil is usually very saline. Where these three associations occur the moisture supply is not sufficient to maintain the vegetation in an actively growing condition throughout the summer. The Shadscale and Kochia lands, owing to their low absorption, offer in this respect less favorable conditions than the Sage Brush land. The Greasewood—Shadscale (*Sarcobatus vermiculatus* and *Atriplex confertifolia*) Association is found upon soils which are strongly saline nearly or quite to the surface and are usually moist throughout the summer at all depths below the first foot. The Salt Flat vegetation, which comprises such extremely halophytic species as *Allenrolfea occidentalis, Salicornia utahensis,* and *S. rubra,* occupies land which is strongly saline and usually very moist throughout the summer from the surface downward.

It remains to be determined whether these correlations hold good in other portions of the Great Basin region. The evidence at hand indicates that, with relatively little modification, they obtain throughout much of the intermountain territory. T. H. K.

BACTERIOLOGY.—*The preparation of dried cultures.* L. A. ROGERS. Journal of Infectious Diseases **14**: 100–123. January, 1914.

This paper discusses the preparation of dried cultures of bacteria of various kinds by a method adapted from that first proposed by Shackell. The method consists essentially in holding the previously frozen culture over sulphuric acid in a container in which a vacuum of a few hundredths of a millimeter is maintained. Cultures of Streptococci, *B. bulgaricus*, and similar organisms, when dried by this method are much more active than when dried by the usual methods in an air blast. The length of time that the dried culture remains active is in a general way inversely proportional to the amount of moisture present and the temperature at which it is held. Cultures deteriorate much more rapidly in air or oxygen than in an inert gas, such as hydrogen or nitrogen. The best results were obtained with cultures held in a vacuum. Dried cultures held in evacuated tubes at a temperature below freezing deteriorated very slowly. L. A. R.

BACTERIOLOGY.—*Bacteriology of cheese of the Emmenthal type.* E. E. ELDREDGE and L. A. ROGERS. Centralblatt f. Bakteriologie **40**[2]: 5–21. February 16, 1914.

The bacterial flora of domestic Emmental cheese consists for the most part of bacilli which may be classed with the so-called *Bacillus bulgaricus.* Cocci were present in small numbers at one stage of the ripening. There was a progressive change in the flora as the cheese ripened, in that one morphological type which predominated in the beginning was gradually replaced by another. In one cheese the proprionic bacteria, which according to Jensen supply gas for the eye formation by fermenting calcium lactate, were found by special methods in comparatively small numbers.

It has been shown in a previous investigation that the gas inflating the eyes is carbon dioxide, and in this work it was found that certain cultures were able to produce carbon dioxide from milk from which the sugar had been removed by fermentation. Without inoculation of some kind it is impossible to make normal Emmental cheese outside the restricted area in which it has been made for years. This may be accomplished by using a mixed culture obtained by adding a small amount of good cheese to sterile whey. It has also been accomplished in a few preliminary experiments with pure cultures isolated from good cheese. L. A. R.

ZOOLOGY.—*A list of the Rotatoria of Washington and vicinity, with descriptions of a new genus and ten new species.* Harry K. Harring. Proceedings of the U. S. National Museum **46:** 387–405, pls. 34–38. 1913.

As the local rotatorian fauna has not been recorded previously, a list of 246 species is given. A new genus, Rousseletia, and ten new species are described: *Rousseletia corniculata, Encentrum aper, E. myriophylli, E. ricciae, Lecane stichaea, Monostyla acus, M. crenata, M. sylvatica, Trichotria brevidactyla* and *Asplanchnopus hyalinus.* A redescription of *Sphyrias lofuana* (Rousselet) and some notes on *Notommata pachyura* (Gosse), *Diglena clastopis* Gosse, *Diurella procellus* (Gosse) and *Testudinella parva* (Ternetz) are added. H. K. H.

ZOOLOGY.—*Synopsis of the Rotatoria.* Harry K. Harring. Bulletin 81, U. S. National Museum. Pp. 1–226. June 28, 1913.

In this paper an attempt has been made to bring rotatorian nomenclature into agreement with the International Code of Zoological Nomenclature. As generally happens in similar cases, a number of generic names become displaced by others. Thus *Cephalosiphon,* in the usually accepted sense, has been replaced by *Beauchampia,* n. gen.; *Anapus* Bergendal by *Chromogaster* Lauterborn; *Diglena* Ehrenberg partly by *Cephalodella* Bory de St. Vincent, partly by *Dicranophorus* Nitzsch; *Floscularia* Ehrenberg-Oken by *Collotheca,* n. gen. (*Floscularia* Cuvier displacing *Melicerta* Schrank.). *Encentrum* Ehrenberg is substituted for a group of species previously distributed among several genera; *Enteroplea* Ehrenberg for *Triphylus* Hudson; *Epiphanes* Ehrenberg for *Hydatina* Ehrenberg and *Notops* Hudson; *Filinia* Bory de St. Vincent for *Triarthra* Ehrenberg; *Keratella* Bory de St. Vincent for *Anuraea* Ehrenberg; *Lecane* Nitzsch for *Cathypda* Gosse and *Distyla* Eckstein; *Lepadella* Bory de St. Vincent for *Metopidia* Ehrenberg; *Macrochaetus* Perty for *Polychaetus* Perty; *Macrotrachela* Milne for *Callidina* Ehrenberg; *Pedalia* Barrois for *Pedalion* Hudson; *Philodinavus,* n. n., for *Microdina* Murray; *Ptygura* Ehrenberg for *Oecistes* Ehrenberg; *Rhinoglena* Ehrenberg for *Rhinops* Hudson; *Rotaria* Scopoli for *Rotifer* Cuvier-Schrank; *Sinantherina* Bory de St. Vincent for *Megalotrocha* Ehrenberg-Bory de St. Vincent; *Squatinella* Bory de St. Vincent for *Stephanops* Ehrenberg; *Testudinella* Bory de St. Vincent for *Pterodina* Ehrenberg; *Trichocerca* Lamarck for *Rattulus* Lamarck; *Trichotria* Bory de St. Vincent for *Dinocharis* Ehrenberg; Zelinkiella, n. n., for *Discopus* Zelinka.

A bibliographic list of nearly 1500 books and memoirs dealing with the Rotatoria is added. In nearly all cases this has been verified from the originals and a reference given to the Washington library in which the publication may be found. H. K. H.

ZOOLOGY.—*Crustacean parasites of West Indian fishes and land crabs, with descriptions of new genera and species.* CHARLES BRANCH WILSON. Proceedings of the U. S. National Museum **44**: 189–277, pls. 18–53. April 3, 1913.

The present paper consists of a general account of the parasites on fish, crustaceans, and ascidians obtained during a three months stay at the biological laboratory of Johns Hopkins University at Montego Bay, Jamaica. The parasites comprise isopods, copepods and ostracods, but only the last two groups are described in this paper. There are 52 species of copepods, of which 31 are new to science. These belong to the genera Ergasilus, Bomolochus, Artacolax, Pseudoeucanthus, Taeniacanthus, Caligus, Dentigryps (new genus), Anuretes, Paralebion, Lernanthropus, Sagum (new genus), Nemesis, Hatschekia, Lernaeolophus, Thysanote, Clavella, Brachiella and Cancrincola (new genus).

The occurrence of an ostracod, *Cypridina parasitica* (new species), on the gills of several kinds of fish is the first record of parasitism among the ostracods.

The illustrations are from drawings of the living specimens.

MARY J. RATHBUN.

ENTOMOLOGY.—*The remarkable life-history of a new family (Micromalthidae) of beetles.* H. S. BARBER. Proceedings of the Biological Society of Washington **26**: 185–190, pl. 4. August 8, 1913.

Continuing work described in a preceding paper, the author records a most remarkable life cycle for *Micromalthus debilis*—a cycle unparalleled in our knowledge of insects and still incomplete in that the stages connecting the adult to the paedogenetic form remain unknown. The observations have demonstrated (1) pluriviviparous and (2) unioviparous paedogenetic reproduction and (3) the still unobserved normal, sexual reproduction, all three types appearing in the progeny of single mother of the first of these three types. Males develop from the single egg of the second type of paedogenetic mother through three strange forms of larvae (the second of these, or feeding stage, devouring the contents of the abdomen of the mother through the vulva); females develop from some of the progeny of the viviparous paedogenetic mother through the same series of larval forms which usually again produce paedogenetic individuals. In live material of the third stage larvae which are to become viviparous paedogenetic individuals the ovaries can easily be seen, but in the same stage individuals which are to be either the oviparous paedogenetic form or the pupa the ovaries were not apparent. Males and females of the same brood appear to issue at different times, greatly reducing the chances of inbreeding. A diagram, graphically illustrating the life cycles (sixteen forms—four of which are hypothetical, being yet unknown to the author), is given and a new family is proposed for the species. J. C. Crawford.

ENTOMOLOGY.—*The mosquitoes of North and Central America and the West Indies.* L. O. Howard, H. G. Dyar, and F. Knab. Carnegie Institution of Washington, Publication no. 159, Vol. 1, pp. 1–520, pls. 1–14. January 21, 1913. Vol. 2, pls. 1–150. February 24, 1913.

Volume 1 is devoted to a general consideration of mosquitoes and contains chapters dealing in detail with the structure of the adult mosquito, including its internal anatomy; the structure of the eggs, larvae, and pupae; habits of adult mosquitoes and of the larvae; the natural enemies of mosquitoes; methods of collecting, mounting, and rearing. There is given also an extended account of the relation of mosquitoes to man, dealing in detail with the diseases transmitted by mosquitoes and the consequent economic loss, together with an account of protective and remedial work against mosquitoes, the methods of carrying on such work, and its efficiency, as illustrated by examples from various parts of the world. A bibliography of thirty-eight pages is included.

Volume 2 includes only plates, together with explanatory legends of the various species to be considered in the systematic volumes to follow.

J. C. Crawford.

ANTHROPOLOGY.—*Chippewa music*, II. Frances Densmore. Bulletin 53, Bureau of American Ethnology. Pp. i–xxi, 1–341. 1913.

This book is a continuation of a work entitled "Chippewa Music" published as Bulletin 45 of the Bureau of American Ethnology. The collection of 340 Chippewa songs comprised in these books includes songs of native ceremonies, as well as of war, dances, and social life. The tabulated analyses indicate a connection between the laws of sound and the forms assumed by the melodies. The descriptive analyses show that certain songs which have in common an underlying idea possess similar melodic and rhythmic peculiarities. F. W. Hodge.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE CHEMICAL SOCIETY

The 236th meeting was held at the Cosmos Club on Thursday, March 12, 1914. Mr. Milton G. Wolf of the Bureau of Chemistry was elected to associate membership. The following papers were presented by members of the Bureau of Plant Industry:

R. H. True, of the Office of Plant Physiological and Fermentation Investigations: *Alcohol and agriculture in Germany.* The manufacture of agricultural alcohol has been more successful in Germany than elsewhere, largely due to the practise of utilizing the sandy lands of the eastern provinces. Potatoes are grown in rotation with grains, clover, and other pasture crops, together with a considerable development of the dairy industry. The best potatoes are usually sold for human consumption, the culls and surplus being used to feed stock and in part for the manufacture of alcohol. The distillery is valuable chiefly because it enables the farmer to grow more potatoes which in turn makes it possible to improve more land and results in the great increase of all crops through the system of rotation and fertilization followed. It is probable that few distilleries pay actual expenses from the sale of the alcohol made, the profits coming rather from the enterprise as a whole than from any one feature. Thus, alcohol distillation is thought to pay. The legal relations have been determined by two objects, (1) to secure revenue, (2) to discourage the distillation of alcohol for beverage purposes and to increase its use for industrial purposes. The outlook for industrial alcohol in the United States as a separate agricultural proposition is not encouraging. If it be combined with a proper agricultural system and handled by a technically trained man, the outlook is much better. (Author's abstract.)

Discussion. In reply to inquiries by Gore and I. K. Phelps, it was stated that about 28 per cent of the potato crop of Germany is used for food, about 5.8 for alcohol manufacture, and about 40 per cent for stock feed. Sugar producing plants do not at present seem a promising source of alcohol as compared with starch plants. W. B. Clark stated that the cost of agricultural alcohol in Cuba is now very low.

W. W. Garner, C. W. Bacon, and C. L. Foubert, of the Office of Tobacco and Plant Nutrition Investigations: *Changes that take place in the curing of cigar-leaf tobacco.* Read by Mr. Bacon. The curing of tobacco has been shown to be a life process, consisting essentially of the phenomena known to the plant physiologist as respiration and translocation. Curing on the stalk and by picking the leaves have been investigated, and the changes characteristic of each have been determined. In the primed leaves there is a loss of 12 per cent to 15 per cent of dry matter, a complete removal of starch and sugar, a loss of from 50 per cent to 60 per cent of protein nitrogen and a decrease in malic acid, nicotine and total nitrogen, while there have been increases in the amount of amid and amino nitrogen and citric acid. In case of the stalk-curing method the loss in dry matter is from 25 per cent to 30 per cent; the losses noted by the priming method are also present here, but in addition the effect of translocation comes into play, and we find a very large loss of amid and amino nitrogen and a small loss of mineral matter, while there has been an increase only in the citric acid. Special experiments have shown a marked increase in diastase in the cured leaves. Finally, by curing leaves at different temperatures it has been determined that the rate of increase with the temperature is of the same order as the rate of increase for ordinary chemical reactions. (Author's abstract.)

W. Blair Clark, of the Office of Sugar Plant Investigations: *A laboratory routine auxiliary to sugar beet breeding.* This paper presented in detail: (1) Laboratory equipment and arrangements suitable for seed-beet testing; (2) data upon which to base calculations of the work and time required for testing any given number of samples; and (3) data from which it is possible to make a reasonable estimate of the labor cost of such tests. It is believed that the data given will hold, up to 4000 tests per day. Above that point it should be possible to introduce modifications productive of still greater economies.

Discussion. Jodidi discussed the paper, and asked several questions, to which it was replied that the greatest difficulty is to cut a really representative sample from each beet, since the percentage of sugar varies greatly in different parts of the beet. Also that specific gravity has been used only in preliminary selection, and that cold water extraction eliminates most of the non-sugar rotating substances.

H. Hasselbring, of the Office of Plant Physiological and Fermentation Investigations: *Carbohydrate transformations in sweet potatoes during storage.* Cane sugar is not readily used up in respiration, but the invert sugar is consumed, and also some of the starch. The starch transforms to sugar at a higher temperature in the sweet potato than in more northern plants.

Discussion. Yoder discussed the question of difference in varieties in the North and South. Questions by Jodidi, Gore, and Berg brought out the facts that each analysis is based on 10 kgms; the respiration rate has not been determined; water was determined by immersing in alcohol and drying off at 78°.

A special meeting was held at the Cosmos Club on Monday, March 16, jointly with the Washington Academy of Sciences. President Sullivan of the Chemical Society presided. Dr. Wolfgang Ostwald lectured on *The chemistry of colloids.* The lecture was illustrated with experiments and lantern slides.

Robert B. Sosman, *Secretary.*

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 737th meeting was held on February 28, 1914, at the Cosmos Club, President FISCHER in the chair; 44 persons present. The minutes of the 736th meeting were read and approved.

The evening was devoted to a symposium on allotropy. Mr. H. S. RAWDON spoke on *Allotropy in metals*. Iron was selected as a type of substances of this class and its behavior upon heating and cooling described. The evidence for believing in any transformation other than $\alpha \rightarrow \beta$ and $\beta \rightarrow \gamma$ is too meager to be worthy of much consideration. The results of the experimental work at the Bureau of Standards go to show that the A_2 or β-change takes place both on heating and cooling and may be detected if the method used is refined enough. The work answers the contention that the so-called β-change is only the end of the γ-change (A_3) which has been depressed because of the impurities which must necessarily be present. A_2 does represent a phase change and not merely a change in molecular equilibrium. The work has not been carried far enough to offer a plausible and sufficient explanation as to the real nature of the β-phase. The paper was discussed by Messrs. Silsbee and Humphreys.

Mr. C. N. FENNER presented a paper on *Allotropy as illustrated by the forms of silica*. Silica is remarkable for the number of allotropic modifications which it shows and the way in wh'ch the various forms pass into each other throws some light on the molecular processes concerned in transformations. The relations of the different phases to each other were represented on a diagram in which the coördinates are temperature and vapor pressure and attention directed to the peculiar behavior of cristobalite at the $\alpha \rightarrow \beta$ inversion point. Smith's theory that frequently two or several kinds of molecules are present in the same crystal structure offers an explanation. His theory that every substance having an inversion point must consist of several kinds of molecules is not so plausible. A crystal is a complex structure in which the molecules are held together in a definite pattern. Under conditions of stability there is an equilibrium of forces, but at an inversion point some system of forces becomes unstable, so that molecules may either arrange themselves differently in the crystal or change may involve the structure of the molecules themselves. This may possibly explain the two radically unlike types of inversion shown by different forms of silica. Paper was discussed by Mr. White.

Mr. R. B. SOSMAN spoke on *Allotropy from the physico-chemical standpoint*. Allotropy or polymorphism is only a special case of the general phenomenon of isomerism, which includes all cases of substances having the same chemical composition by weight but differing in properties. A consideration of the various kinds of isomerism known shows that sharp lines can not be drawn between the different types. The phenomenon seems in all cases dependent upon differences in molecular weight or molecular structure. Recent theories of the thermodynamic side of the subject were discussed. Mr. C. A. Briggs made some remarks upon the paper.

J. A. FLEMING, *Secretary*.

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 280th meeting was held at the Cosmos Club, February 25, 1914.

REGULAR PROGRAM

Some geologic features of the Eastport region, Maine (illustrated): E. S. Bastin. No abstract. The paper was a part of the matter contained in the United States Geological Survey's Eastport Folio, No. 192, now in press.

A hypothesis for the origin of the carnotite deposits of Utah and Colorado (illustrated): Frank L. Hess. The great bulk of the carnotite deposits of Utah and Colorado lie between the Rocky Mountains, the San Rafael Swell, the Denver and Rio Grande Railroad and the Arizona line, and are in crossbedded sandstones, which mostly seem to be of McElmo (Jurassic) age, though part of the deposits may be in similar sandstones of La Plata (lower Jurassic) age.

The deposits contain besides carnotite, other oxidized vanadium minerals, iron oxides, some copper carbonates and in places a chromium mineral, and are invariably associated with fossil wood and reed-like plants. The degree of decay before fossilization seems to have had much to do with the quantity of the minerals deposited and in places logs are almost wholly replaced by carnotite and accompanying soft minerals. On Red Creek in Brown's Park, Uinta County, Utah, carnotite has formed in cracks adjacent to a copper bearing vein in Cambrian (?) or pre-Cambrian (?) quartzite. At two other places veins carrying smaller quantities of uranium and vanadium minerals have been found. It is thought possible that the crossbedded sandstones may have been deposited in a very shallow inland sea with many islands and spits on which lodged vegetable débris which had been washed from surrounding shores. Also that sulphidic veins carrying uranium, vanadium, iron and chromium minerals were eroded; that sulphuric acid set free by the oxidation of pyrite formed soluble sulphates of the other metals; that these were carried into the sea and on coming into contact with the vegetation were, in part at least, reduced to sulphides, though the uranium was possibly reduced to an oxide, or to some combination with the vanadium. Upon the raising, draining and oxidation of the rocks the minerals now found were formed.

Owing to his illness, Willis T. Lee did not deliver his paper, *Bearing of stratigraphy on the physiographic conditions of the Rocky Mountain region during upper Cretaceous time* (illustrated).

The 281st meeting was held at the Cosmos Club, March 11, 1914.

Under the head of Informal Communications F. C. Greene gave a short discussion of the age of the loess of the Mississippi Valley, and Frank L. Hess showed photographs of concretions in crossbedded La Plata (?) sandstone on the northeast flank of the Henry Mountains, Utah. The concretions follow both horizontal lines and the crossbedding planes. Their positions are believed to have been fixed by the ground water level and the movement of water along the crossbedding planes.

REGULAR PROGRAM

Some fossil waters: CHASE PALMER. No abstract. This paper is to be published in *Economic Geology*.

The stratigraphic break below the Jurassic sandstone in southwestern Colorado: WHITMAN CROSS and ESPER S. LARSEN. (Communicated by WHITMAN CROSS.) The representation of the Hayden geological map of Colorado by which the Dakota sandstone (Cretaceous) is shown to overlap Jurassic strata in Gunnison Canyon and extend for 35 miles up the canyon to the vicintiy of the town of Gunnison in contact with pre-Cambrian rocks has been found to be erroneous. Likewise, the representation of the Hayden map that Colorado shales (Cretaceous) rest on the pre-Cambrian on either side of Tomichi Creek above Gunnison, is incorrect. The error as regards the Dakota sandstone is not one of observation but is due to the fact that A. C. Peale, who mapped the zone of the Gunnison Canyon, included in the Dakota 400–500 feet of beds which are now known to belong to the Jurassic and are assigned to the Gunnison group, embracing the McElmo formation and the La Plata sandstone.

The representation of an area of Colorado shales resting directly on crystalline rocks is due to F. M. Endlich and was a result of incomplete observations, for while some shales occur east of Cochetopa Creek, they are underlain by the Dakota sandstone and the Gunnison sandstones and shales in the full section normal for the region.

Between the Gunnison Canyon and the Uncompahgre Valley below Ouray, the Jurassic strata must overlap in succession the Triassic and all Paleozoic formations of the region, but there are no exposures to illustrate this transgression in the branches of Cimarron Creek, north of Uncompahgre Peak, as indicated on the Hayden map. The volcanic rocks descend to the stream beds at the places where the uncomformity is represented.

From Uncompahgre Valley around the western slopes of the San Juan Mountains and eastward on the south side to the ridge between Pine and Piedra Rivers, the Jurassic La Plata sandstone rests on a variable thickness of Triassic strata, of the Dolores formation. While the relation of the two formations is in many localities that of apparent physical conformity, actual erosional unconformity is shown in other places, and there is clearly a constant hiatus below the La Plata, representing an unknown amount of Triassic beds. These relations have been fully described in the Ouray, Telluride, Rico, La Plata, and Engineer Mountain folios of the Geological Survey.

In the valley of Piedra River we have found evidence that the La Plata sandstone overlaps the entire section from the Triassic to the pre-Cambrian. The actual angular unconformity is beautifully exposed in the Piedra Canyon in the stretch between two of its western tributaries, Weminuche Creek and First Fork, a distance of 7 miles. The Hayden map represents the canyon as cut entirely in Upper Dakota.

The full section of Paleozoic and Mesozoic formations known in the San Juan region extends from the Animas Valley to the ridge east of Pine River, but somewhere within a distance of 6 or 7 miles southwest of Graham Peak (the point of elevation 12,336 on Hayden map) the La Plata sandstone overlaps all formations from the Triassic to the pre-Cambrian. This must be in the zone where the Hayden map represents the "Upper Carboniferous" in contact with the pre-Cambrian. But inasmuch as a great fault-fold occurs about on the line where that map represents "Upper Dakota" in contact with pre-Cambrian, west of Weminuche Creek, it is possible that the unconformity below the La Plata may not be exposed.

The Hayden geologists believed that a land area of pre-Cambrian rocks existed in the San Juan region during Cretaceous time. The observations here recorded, with others of recent years, show, rather, that this land mass was produced during the pre-La Plata interval of uplift and erosion and that sediments now supposed to be Jurassic were probably deposited over the San Juan area and far to the north. It seems to us not unlikely that the Morrison beds on the east were connected originally with the Gunnison on the west.

Review of "Principles of Stratigraphy" by A. W. Grabau: G. S. Rogers. No abstract.

Clarence N. Fenner,
Frank L. Hess,
Secretaries.

REFERENCES

Under this heading it is proposed to include, by author, title, and citation, references to all scientific papers published in or emanating from Washington. It is requested that authors coöperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

MAMMALOGY

ALLEN, G. M. *A new bat from Tonkin.* Proceedings of the Biological Society of Washington **26**: 213, 214. December 20, 1913. (Description of *Harpiocephalus rufulus*, sp. nov.—W. R. M.)

BAILEY, V. *Ten new mammals from New Mexico.* Proceedings of the Biological Society of Washington **26**: 129–134. May 21, 1913. (Describes 10 new species and subspecies in 8 genera.—W. R. M.)

BAILEY, V. *Two new subspecies of North American beavers.* Proceedings of the Biological Society of Washington **26**: 191–193. October 23, 1913. (Descriptions of *Castor canadensis mexicanus* and *C. canadensis michiganensis*.—W. R. M.)

COCKERELL, T. D. A., MILLER, L. I., and PRINTZ, M. *The relative lengths of the large and small intestines in rodents.* Proceedings of the Biological Society of Washington **26**: 205–207. December 20, 1913.

GOLDMAN, E. A. *Descriptions of new mammals from Panama and Mexico.* Smithsonian Miscellaneous Collections **60**[22]: 1–20. February 28, 1913. (Fourteen new species and subspecies are described, 11 of these being from Panama.—W. R. M.)

GOLDMAN, E. A. *A new generic name for the Asiatic tapir.* Proceedings of the Biological Society of Washington **26**: 65, 66. March 22, 1913. (The Asiatic tapir is regarded as of equal rank with the American tapirs, Tapirus and Tapirella, and is segregated as a new genus, Acrocodia, with a single species, *A. indica*.—W. R. M.)

HELLER, E. *Four new subspecies of large mammals from equatorial Africa.* Smithsonian Miscellaneous Collections **61**[22]: 1–7. January 26, 1914. (Describes one new subspecies each of Hippopotamus, Phacochoerus, Equus, and Crocuta.—W. R. M.)

HELLER, E. *New races of antelopes from British East Africa.* Smithsonian Miscellaneous Collections **61**[7]: 1–13. July 31, 1913. (Describes 9 new subspecies in several genera.—W. R. M.)

HELLER, E. *New antelopes and carnivores from British East Africa.* Smithsonian Miscellaneous Collections **61**[13]: 1–15. September 16, 1913. (Describes 1 new species and 13 new subspecies in 11 genera.—W. R. M.)

Heller, E. *New races of ungulates and primates from equatorial Africa.* Smithsonian Miscellaneous Collections **61**^{17}: 1–12. October 21, 1913. (Describes 12 new subspecies.—W. R. M.)

Heller, E. *New races of carnivores and baboons from equatorial Africa and Abyssinia.* Smithsonian Miscellaneous Collections **61**^{19}: 1–12. November 8, 1913. (Describes 9 new subspecies of Aonyx, Felis, Acinonyx, and Papio. —W. R. M.)

Heller, E. *The white rhinoceros.* Smithsonian Miscellaneous Collections **61**^{1}: 1–77, pls. 1–31. 1913.

Henderson, J., and Cockerell, T. D. A. *Notes on the pikas of Colorado.* Proceedings of the Biological Society of Washington **26**: 125–128. May 21, 1913.

Hollister, N. *Two new polecats related to* Mustela larvata. Proceedings of the Biological Society of Washington **26**: 1–4. January 18, 1913. (Describes two new species, *Mustela lineiventer* and *M. tiarata*, from Siberia and China, respectively.—W. R. M.)

Hollister, N. *Description of a new gazelle from northwestern Mongolia.* Smithsonian Miscellaneous Collections **60**^{19}: 1, 2. February 8, 1913. (Describes *Procapra altaica*, allied to *P. gutturosa*.—W. R. M.)

Hollister, N. *Two new mammals from the Siberian Altai.* Smithsonian Miscellaneous Collections **60**^{24}: 1–3. March 13, 1913. (Describes *Apodemus nigritalus* and *Sorex roboratus*, spp. nov.—W. R. M.)

Hollister, N. *The type species of* Cuniculus *Brisson.* Proceedings of the Biological Society of Washington **26**: 79. March 22, 1913.

Hollister, N. *Two new Philippine fruit bats.* Proceedings of the Biological Society of Washington **26**: 111, 112. May 3, 1913. (Describes two new species: *Pteropus balutus*, from Balut Island, and *P. Mearnsi*, from Basilan Island. —W. R. M.)

Hollister, N. *Two new bats of the genus Taphozous.* Proceedings of the Biological Society of Washington **26**: 157, 158. June 30, 1913. (Descriptions of *T. solifer* and *T. cavaticus*, new species from China and West Sumatra, respectively.—W. R. M.)

Hollister, N. *Three new subspecies of grasshopper mice.* Proceedings of the Biological Society of Washington **26**: 215, 216. December 20, 1913. (Three new subspecies of Onychomys are described, one from California, Arizona, and Oklahoma, each.—W. R. M.)

Howell, A. H. *Description of a new weasel from Alabama.* Proceedings of the Biological Society of Washington **26**: 139, 140. May 21, 1913. (Describes *Mustela peninsulae olivacea*, subsp. nov.—W. R. M.)

Jackson, H. H. T. *Two new weasels from the United States.* Proceedings of the Biological Society of Washington **26**: 123, 124. May 21, 1913. (Two new species are described: *Mustela primulina*, from Missouri, and *M. campestris*, from Nebraska.—W. R. M.)

Lyon, M. W. *Treeshrews: An account of the mammalian family Tupaiidae.* Proceedings of the U. S. National Museum **45**: 1–188, pls. 1–11, text figs. 1–15. November 29, 1913.

Merriam, C. H. *Six new ground squirrels of the* Citellus mollis *group from Idaho, Oregon and Nevada.* Proceedings of the Biological Society of Washington **26**: 135–138. May 21, 1913.

Miller, G. S., jr. *Five new mammals from tropical America.* Proceedings of the Biological Society of Washington **26**: 31–34. February 8, 1913. (Describes 5 new species: *Marmosa purui* from Brazil, *Glossophaga rostrata* from Grenada, *Brachyphylla minor* from Barbados, *Ardops annectens* from Guadeloupe, and *Promops pamana* from Brazil.—W. R. M.)

Miller, G. S., jr. *A new pteropine bat from Luzon.* Proceedings of the Biological Society of Washington **26**: 73, 74. March 22, 1913. (Description of *Eonycteris robusta*, sp. nov.—W. R. M.)

Miller, G. S., jr. *Some overlooked names of Sicilian mammals.* Proceedings of the Biological Society of Washington **26**: 80, 81. March 22, 1913. (Includes publication of the new name *Apodemus flavicollis rusiges*.—W. R. M.)

Miller, G. S., jr. *A new vole from eastern Mongolia.* Smithsonian Miscellaneous Collections **60**[28]: 1, 2, pl. 1. March 31, 1913. (Description of *Microtus Warringtoni*.—W. R. M.)

Miller, G. S., jr. *A new shrew from Baltistan.* Proceedings of the Biological Society of Washington **26**: 113, 114. May 3, 1913. (Describes *Crocidura pergrisea*, sp. nov.—W. R. M.)

Miller, G. S., jr. *A new cacomistle from Nevada.* Proceedings of the Biological Society of Washington **26**: 159. June 30, 1913. (Description of *Bassariscus astutus nevadensis*, subsp. nov.—W. R. M.)

Miller, G. S., jr. *Two new murine rodents from Baltistan.* Proceedings of the Biological Society of Washington **26**: 197, 198. October 23, 1913. (Describes *Alticola glacialis* and *Epimys rattus shigarus*.—W. R. M.)

Miller, G. S., jr. *Fifty-one new Malayan mammals.* Smithsonian Miscellaneous Collections **61**[21]: 1–30. 1913. (Descriptions of 51 new species and subspecies in the genera Paradoxurus, Arctogalidia, Epimys, Sciurus, Lariscus, Ratufa, Petaurista, and Presbytis.—W. R. M.)

Nelson, E. W. *A new bat from the eastern United States.* Proceedings of the Biological Society of Washington **26**: 183, 184. August 8, 1913. (Describes *Myotis winnemana*, sp. nov., the type being from Plummers Island, Maryland.—W. R. M.)

Osgood, W. H. *The name of the Rocky Mountain sheep.* Proceedings of the Biological Society of Washington **26**: 57–62. March 22, 1913.

Osgood, W. H. *A new name for* Ochotona minima. Proceedings of the Biological Society of Washington **26**: 80. March 22, 1913. (Proposes the new name *Ochotona fenisex* for the pika of southern British Columbia.—W. R. M.)

Osgood, W. H. *Two new mouse opossums from Yucatan.* Proceedings of the Biological Society of Washington **26**: 175, 176. August 8, 1913. (Two new species are described: *Marmosa Gaumeri* and *M. mayensis*.—W. R. M.)

True, F. W. *Diagnosis of a new beaked whale of the genus Mesoplodon from the coast of North Carolina.* Smithsonian Miscellaneous Collections **60**[25]: 1, 2. March 14, 1913. (Describes *Mesoplodon mirum*, sp. nov.—W. R. M.)

True, F. W. *Description of* Mesoplodon mirum, *a beaked whale recently discovered on the coast of North Carolina.* Proceedings of the U. S. National Museum **45**: 561–658, pls. 52–57, text fig. 1. November 29, 1913.

Warren, E. R. *Additional notes on the distribution of Colorado mammals.* Proceedings of the Biological Society of Washington **26**: 9–12. January 18, 1913.

Warren, E. R. *Dichromatism in* Neotoma mexicana fallax *from Costilla County, Colorado.* Proceedings of the Biological Society **26**: 35–38, pls. 1, 2. February 8, 1913.

ENTOMOLOGY

Banks, N. *A new mite from Thurberia.* Proceedings of the Entomological Society of Washington **16**: 44. March 23, 1914. (Describes *Eriophyes thurberiae*, new species.—J. C. C.)

Busck, A. *Two Microlepidoptera on* Thurberia thespesioides. Proceedings of the Entomological Society of Washington **16**: 30, 31. March 23, 1914. (Describes *Bucculatrix thurberiella*, new species, from Arizona.—J. C. C.)

Coad, B. R., and Pierce, W. D. *Studies of the Arizona Thurberia weevil on cotton in Texas.* Proceedings of the Entomological Society of Washington **16**: 23–27. March 23, 1914. (Experimental cross breedings were made at Victoria, Texas, between both sexes of the Arizona variety *Anthonomus grandis thurberiae* Pierce and the opposite sexes of the true *Anthonomus grandis*, bred from cotton in Texas. Offspring were bred in each case, with very slight differences in the length of the developmental period. There was a greater variation in the rate of egg deposition per day. Typical *thurberiae* fed on cotton squares oviposited only 0.2 eggs per day in May, but 4.5 eggs per day in September; female *thurberiae* fertilized by male *grandis* laid 2.8 per day in May, and 3.5 per day in September; female *grandis* fertilized by male *thurberiae* laid 2.2 per day in May, and 1.9 per day in September. The offspring of the male *grandis* and female *thurberiae* rearings were interbred and deposited 8.1 eggs per day; while the offspring of the male *thurberiae* and male *grandis* rearings were interbred and deposited 3.5 eggs per day.—W. D. P)

Cockerell, T. D. A. *Coleoptera at the British Museum, Bloomsbury.* Proceedings of the Entomological Society of Washington **16**: 8–10. March 23, 1914. (Notes on the list of beetles found on the premises of the British Museum, together with a few extracts from this list.—J. C. C.)

Cockerell, T. D. A. *Bees visiting Thurberia.* Proceedings of the Entomological Society of Washington **16**: 31, 32. March 23, 1914. (Describes from Arizona *Melissodes thurberiae* and *Perdita punctifera* and records two other species.—J. C. C.)

Crawford, D. L. *A contribution toward a monograph of the homopterous insects of the family Delphacidae of North and South America.* Proceedings of the U. S. National Museum **46**: 557–640, pls. 44–49. March 4, 1914. (Includes descriptions of the new genera Lepticus, Eucanyra, Liburniella, and Bakerella, 35 new species, and 9 new varieties.—J. C. C.)

Crawford, J. C. *Two new parasitic Hymenoptera from Arizona.* Proceedings of the Entomological Society of Washington **16**: 29. March 23, 1914.

Crawford, J. C. *Three new Hymenoptera.* Insecutor Inscitiae Menstruus **2**: 36–38. March 30, 1914. (Describes three Chalcidoidea from the United States.—J. C. C.)

Hood, J. D. *On the proper generic names for certain Thysanoptera of economic importance.* Proceedings of the Entomological Society of Washington **16**: 34–44. March 23, 1914. (Shows that the name Euthrips is a synonym of Thrips

and assigns to the correct genera the various American species which were formerly included under the name Euthrips; proposes the name *Frankliniella tritici var. moultoni* for *Euthrips tritici californicus* Molton, 1911, not *E. ulicis californicus* Molton, 1907; includes a bibliography of the important references to the species involved in the paper.—J. C. C.)

HOOD, J. D. *Two Porto Rican Thysanoptera from sugar cane.* Insecutor Inscitiae Menstruus **2**: 38–41. March 30, 1914. (Describes *Haplothrips* (?) *tibialis*, new species.—J. C. C.)

HUTCHISON, R. H. *The migratory habit of housefly larvae as indicating a favorable remedial measure. An account of progress.* Bulletin of the U. S. Department of Agriculture, No. 14. Pp. 1–11. February 28, 1914. (In this professional paper are given the results of experiments which show that the migratory habit of the larva is a response to various internal and external stimuli, moisture being, perhaps, the most important of the latter. Since the larvae migrate to the drier portions of the manure heaps to pupate, this habit offers an important point of attacks in attempt to control this pest.—J. C. C.)

KNAB, F. *On the genus Cryptochaetum.* Insecutor Inscitiae Menstruus **2**: 33–36. March 30, 1914. (Gives a table of certain species and describes *C. curtipenne*, from Ceylon.—J. C. C.)

PIERCE, W. D., and MORRILL, A. W. *Notes on the entomology of the Arizona wild cotton.* Proceedings of the Entomological Society of Washington **16**: 14–23. March 23, 1914. (Describes some of the localities in which the Arizona wild cotton, *Thurberia thespesioides*, was found and records the principal insects attacking it, together with a list of the miscellaneous insects breeding on it and a list of the miscellaneous visitors. The principal enemy is a variety of the cotton boll weevil, *Anthonomus grandis var. thurberiae* Pierce; other important enemies are the leaf worm, *Alabama argillacea*, a boll worm, and a blister mite of the genus Eriophyes.—J. C. C.)

SCHAUS, W. *New species of noctuid moths from tropical America.* Proceedings of the U. S. National Museum **46**: 485–549. January 29, 1914. (Describes the new genera Chytonidia, Colodes, Encruphion, Anorena, Ateneria, Neoptodes, Sinosia, Eromidia, and Polygnamptia, and 136 new species in the family Noctuidae, all except three species having been taken by the author and Mr. J. Barnes in British, Dutch and French Guiana.—J. C. C.)

SCHWARZ, E. A., HEIDEMANN, O., and BANKS, NATHAN. *Life and writings of Philip Reese Uhler.* Proceedings of the Entomological Society of Washington **16**: 1–7. March 23, 1914. (Contains a bibliography of the articles published by Mr. Uhler, with portrait as a frontispiece.—J. C. C.)

TOWNSEND, C. H. T. *New muscoid flies, mainly Hystriciidae and Pyrrhosiinae from the Andean Montanya. (Continuation).* Insecutor Inscitiae Menstruus **2**: 42–48. March 30, 1914. (Describes 6 new species, 2 new subspecies, and the new genera Trichethoropsis, Gabanimyia, Eubletharipeza and Neojurinia. —J. C. C.)

WALTON, W. R. *A new tachnid parasite of* Diabrotica vittata. Proceedings of the Entomological Society of Washington **16**: 11–14, pl. 1. March 23, 1914. (Describes *Neocclatoria ferox*, a new genus and species from Maryland, and gives observations on the method of oviposition.—J. C. C.)

WEBSTER, F. M. *The Western corn rootworm.* Bulletin of the U. S. Department of Agriculture, No. 8, pp. 1–8. September 27, 1913. (A short account of its seasonal history and damage, with suggestion of crop-rotation as a preventative measure.—J. C. C.)

WOOD, H. P. *Experiments in the use of sheep in the eradication of the Rocky Mountain spotted fever tick.* Bulletin of the U. S. Department of Agriculture, No. 45, pp. 1–11. November 22, 1913.

ICHTHYOLOGY

COCKERELL, T. D. A. *The scales of the simenchelyid, ophidiid, brotulid and bregmacerotid fishes.* Proceedings of the Biological Society of Washington **26**: 75–78. March 22, 1913.

COCKERELL, T. D. A. *The scales of the blennioid fishes.* Proceedings of the Biological Society of Washington **26**: 89–92. May 3, 1913.

GILBERT, C. H. *Descriptions of two new fishes of the genus Triglops from the Atlantic coast of North America.* Proceedings of the U. S. National Museum **44**: 465–468. April 30, 1913.

GUDGER, E. W. *Natural history notes on some Beaufort, North Carolina fishes, 1912.* Proceedings of the Biological Society of Washington **26**: 97–110. May 3, 1913.

JORDAN, D. S. *Description of* Anguilla manabei, *a new eel from Japan.* Proceedings of the U. S. National Museum **44**: 359, 360. April 3, 1913.

JORDAN, D. S., and SNYDER, J. O. *Description of the Yachats "smelt,"* a new species of atherinoid fish from Oregon. Proceedings of the U. S. National Museum **45**: 575, 576, pl. 46. June 21, 1913. (Describes and figures *Atherinops oregonia*, sp. nov.—W. R. M.)

NICHOLS, J. T. *On two new characins in the American Museum.* Proceedings of the Biological Society of Washington **26**: 151, 152. June 30, 1913. (Describes 2 new species, *Coelurichthys lateralis* and *C. tenuis*, their source not known.—W. R. M.)

RADCLIFFE, L. *Description of seven new genera and thirty-one new species of fishes of the families Brotulidae and Carapidae from the Philippine Islands and the Dutch East Indies.* Proceedings of the U. S. National Museum **44**: 135–176, pls. 7–17. April 3, 1913.

SMITH, H. M. *The hemiscyllid sharks of the Philippine Archipelago, with description of a new genus from the China Sea.* Proceedings of the U. S. National Museum **45**: 567–569, pl. 45, text figs. 1–2. June 21, 1913. (Includes description of *Cirrhoscyllium expolitum*, new genus and species, from the China Sea.—W. R. M.)

SMITH, H. M. *Description of a new carcharioid shark from the Sulu Archipelago.* Proceedings of the U. S. National Museum **45**: 599–601, pl. 47, text figs. 1–3. June 21, 1913. (Describes *Eridacnis Radcliffei*, a new genus and species secured near the island of Jolo.—W. R. M.)

SNYDER, J. O. *Notes on* Ranzania makua *Jenkins and other species of fishes of rare occurrence on the California coast.* Proceedings of the U. S. National Museum **44**: 455–460. April 12, 1913.

ʼ# JOURNAL

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GEOPHYSICS.—*Isostasy in India.*[1] William Bowie, Coast and Geodetic Survey.

The investigations carried on by the United States Coast and Geodetic Survey in recent years have proved conclusively that for the total area of this country isostasy is practically perfect. The two reports on the gravity reductions show that areas in the United States of much smaller extent than the whole are largely compensated. This is clearly shown by the gravity anomaly map in the last gravity report.[2] But the area of the United States is a small percentage of the land surface of the earth and the scientist may well reserve judgment as to whether complete isostasy obtains generally until the theory has been tested in other lands. It is the earnest hope of advocates of this theory, and even of its opponents, that such tests may be undertaken in the near future. The determination of the dimensions of the mean figure of the earth (the ellipsoid) and the actual shape of the earth's surface (the geoid) are problems which the truth or falsity of the theory of isostasy will help the geodesist to solve. The degree of rigidity and the strength of the earth's crust may be more closely estimated or computed after knowing more about isostasy, and this is a very important matter to the geologist, the

[1] Paper read in abstract before the Philosophical Society of Washington on April 11, 1914.

[2] Illustration No. 2, Effect of Topography and Isostatic Compensation on the Intensity of Gravity. Special Publication No. 12, U. S. Coast and Geodetic Survey.

TABLE 1
Summary of Results, 1912-13

Station	Latitude ° ′ ″	Longitude ° ′ ″	Height above M. S. L.	Observed value of g	Correction for: Height	Correction for: Mass (Bouguer)	Correction for: Mass (Hayford)	$g_0 = g$ corrected for height only	$g_0'' = g$ corrected for height and mass (Bouguer)	γ_0	$g_0 - \gamma_0$ (Free Air)	$g_0'' - \gamma_0$ (Bouguer)	$g - \gamma$ (Hayford)
			feet	*dynes*	*dynes*	*dynes*	*dynes*	*dynes*	*dynes*	*dynes*	*dynes*	*dynes*	*dynes*
1. Bhopal	23 15 58	77 25 00	1630	978.711	+0.152	−0.057	−0.007	978.863	978.806	978.810	+0.053	−0.004	+0.046
2. Balianpur.....	24 07 11	77 39 17	1763	978.777	+0.164	−0.062	−0.011	978.941	978.879	978.867	+0.074	+0.012	+0.063
3. Kina	24 10 41	78 11 46	1355	978.795	+0.120	−0.047	±0.000	978.921	978.874	978.871	+0.050	+0.003	+0.050
4. Goona	24 38 48	77 19 13	1569	978.807	+0.146	−0.055	−0.007	978.953	978.898	978.903	+0.050	−0.005	+0.043
5. Lalitpur.....	24 41 29	78 21 26	1199	978.814	+0.112	−0.042	+0.003	978.926	978.884	978.906	+0.020	−0.022	+0.023
6. Sipri..........	25 25 52	77 39 25	1533	978.876	+0.143	−0.054	−0.009	979.019	978.965	978.958	+0.061	+0.007	+0.052
7. Jhansi..........	25 27 02	78 33 43	858	978.910	+0.080	−0.030	+0.007	978.990	978.960	978.959	+0.031	+0.001	+0.038
8. Gwalior..........	26 13 57	78 12 49	658	978.958	+0.061	−0.023	+0.012	979.019	978.996	979.015	+0.004	−0.019	+0.016
9. Dholpur	26 42 01	77 54 47	577	978.999	+0.054	−0.020	+0.015	979.053	979.033	979.048	+0.005	−0.015	+0.020
10. Agra	27 10 20	78 01 07	535	979.056	+0.050	−0.019	+0.018	979.106	979.087	979.083	+0.023	+0.004	+0.041
11. Mattra	27 28 25	77 41 48	562	979.072	+0.052	−0.020	+0.019	979.124	979.104	979.105	+0.019	−0.001	+0.038
12. Hathras	27 36 52	78 03 22	587	979.075	+0.055	−0.021	+0.020	979.130	979.109	979.116	+0.014	−0.007	+0.034
13. Aligarh	27 53 32	78 00 31	612	979.075	+0.057	−0.021	+0.021	979.132	979.111	979.137	−0.005	−0.026	+0.016
14. Khurja..........	28 14 19	77 51 53	649	979.083	+0.061	−0.023	+0.024	979.143	979.120	979.163	−0.020	−0.043	+0.004

geophysicist, the seismologist, and the astronomer. There are other branches of scientific research to which this question of isostasy is also of interest and importance.

Gravity reductions made by the older methods, the Free Air, which ignores topography, and the Bouguer, which postulates a rigid earth with the topography as an added load, do not give any definite idea as to the strength of the earth's crust. It is believed that the new (Hayford) method does give valuable information on this question.

In India and Italy gravity stations are being reduced by the Hayford method and it is the work already done in the former country that is the basis of this paper. In the Report of the Board of Scientific Advice for India for 1912–13, there are given the results of the reduction of fourteen gravity stations which throw some light on the question of the degree of perfection of isostasy in India. These stations are in approximately the same longitude and extend from latitude 23° 16′ to latitude 28° 19′. The report gives the data for the fourteen stations listed in table 1.

The theoretical value of gravity, γ_0, shown in table 1, is obtained from the Helmert formula of 1884, which is

$$\gamma_0 = 978.00\ (1 + 0.00531 \sin^2 \phi)$$

The means of the anomalies of the several methods of reduction without regard to sign are: Free Air, 0.031; Bouguer, 0.012; Hayford, 0.035; The means with regard to sign are: Free Air, +0.029; Bouguer, −0.008; Hayford, +0.035.

These values of the anomalies with regard to sign for the several methods of reduction, and by the old Helmert formula, indicate the presence of systematic errors in the reductions, though the Bouguer method seems to be the one most nearly free from such errors.

The constants in the new Helmert formula (1901) are derived from many more gravity stations and much more accurate data. This formula is

$$\gamma_0 = 978.030\ (1 + 0.005302 \sin^2 \phi - 0.000007 \sin^2 2\ \phi)$$

When the 1901 formula is used to obtain the theoretical value of gravity at sea level and at the latitude of the station the sea level values and the anomalies are those shown in table 2.

TABLE 2

STATION	γ_o	$g_o - \gamma_o$ (Free Air)	$g_o'' - \gamma_o$ (Bouguer)	$g - \gamma$ (Hayford)
1. Bhopal	978.835	+0.028	−0.029	+0.021
2. Balianpur	978.892	+0.049	−0.013	+0.038
3. Kina	978.896	+0.025	−0.022	+0.025
4. Goona	978.928	+0.025	−0.030	+0.018
5. Lalitpur	978.931	−0.005	−0.047	−0.002
6. Sipri	978.983	+0.036	−0.018	+0.027
7. Jhansi	978.984	+0.006	−0.024	+0.013
8. Gwalior	979.039	−0.020	−0.043	−0.008
9. Dholpur	979.073	−0.020	−0.040	−0.005
10. Agra	979.107	−0.001	−0.020	+0.017
11. Muttra	979.128	−0.004	−0.024	+0.015
12. Hathras	979.139	−0.009	−0.030	+0.011
13. Aligarh	979.160	−0.028	−0.049	−0.007
14. Khurja	979.186	−0.043	−0.066	−0.019

The means of the anomalies are as follows: Without regard to sign: Free Air, 0.021; Bouguer, 0.032; Hayford, 0.016. With regard to sign: Free Air, +0.003; Bouguer, −0.032; Hayford, +0.010.

This formula makes the mean Hayford anomalies without regard to sign smaller than the mean anomalies by the other methods, but the mean with regard to sign is smaller for the Free Air anomalies. The sign of the Free Air anomalies seems to change with the change in elevation of the stations. All except one of the anomalies at stations above 800 feet are positive, while all stations with elevations less than 800 feet have negative anomalies. The Bouguer anomalies are all negative, and the values are double the values of the Hayford anomalies on an average.

With the 1901 Helmert formula applied the anomalies indicate that the rigid crust postulated in the Bouguer method is far from the truth.

The United States Coast and Geodetic Survey formula[3] for theoretical gravity (Helmert's formula of 1901 with a new first

[3] See p. 25, Effect of Topography and Isostatic Compensation upon the Intensity of Gravity. Special Publication No. 12, U. S. Coast and Geodetic Survey.

TABLE 3

STATION	γ_0	$g_0 - \gamma_0$ (Free Air)	$g_0'' - \gamma_0$ (Bouguer)	$g - \gamma$ (Hayford)
1. Bhopal	978.843	+0.020	−0.037	+0.013
2. Balianpur	978.900	+0.041	−0.021	+0.030
3. Kina	978.904	+0.017	−0.030	+0.017
4. Goona	978.936	+0.017	−0.038	+0.010
5. Lalitpur	978.939	−0.013	−0.055	−0.010
6. Sipri	978.991	+0.028	−0.026	+0.019
7. Jhansi	978.992	−0.002	−0.032	+0.005
8. Gwalior	979.017	−0.028	−0.051	−0.016
9. Dholpur	979.081	−0.028	−0.048	−0.013
10. Agra	979.115	−0.009	−0.028	+0.009
11. Muttra	979.136	−0.012	−0.032	+0.007
12. Hathras	979.147	−0.017	−0.038	+0.003
13. Aligarh	979.168	−0.036	−0.057	−0.015
14. Khurja	979.194	−0.051	−0.074	−0.027

term) as derived from gravity observations in the United States is:

$$\gamma_0 = 978.038\,(1 + 0.005302 \sin^2 \phi - 0.000007 \sin^2 2\,\phi)$$

If this formula is used for the India stations we have the results listed in table 3.

Then the mean anomaly becomes: Without regard to sign: Free Air, 0.023; Bouguer, 0.040; Hayford, 0.014. With regard to sign: Free Air, −0.005; Bouguer, −0.040; Hayford, +0.002.

Here we have a mean Hayford anomaly with regard to sign of almost zero which is an indication that the Coast and Geodetic Survey formula more nearly meets the conditions in India, within the small area under consideration, than either of the two Helmert formulas.

The values at the different stations vary in size and sign and therefore we seem to have local rather than regional departures from the perfect isostatic state. The data, though small in amount, indicate that isostasy may be nearly as perfect for large areas in India as in the United States. We await with great interest further reports on the important and valuable investigations now being made in that country.

GEOLOGY.—*Correlation of the Hawthorn formation.*[1] THOMAS WAYLAND VAUGHAN and CHARLES WYTHE COOKE, Geological Survey.

Dr. W. H. Dall in 1892 applied the name Hawthorn beds to certain upper Oligocene deposits of clay and phosphatic sandstones which outcrop in northern Florida and are characterized by silicified oyster shells and silicified corals. Among the localities mentioned are several near Hawthorn, Devils Mill Hopper near Gainesville, the hilltops near Archer and Arredonda, Nigger Sink and a well near Newnansville, Fort White, a sink 4 miles north of Lake City, and White Springs on Suwannee River. In 1894 Doctor Dall published the statement that the Hawthorn beds are to be correlated with the Chattahoochee series, as are also the Orthaulax bed and Tampa limestone at Tampa and the chert of Hillsboro River. This correlation was adopted by Clapp and Matson.

Studies subsequent to those of Doctor Dall, published in 1894, have all tended to confirm the essential correctness of his opinion regarding the age relations of the Chattahoochee "series" and the beds around Tampa mentioned by him; but additional information obtained during the progress of field work in Florida having led to doubts as to the correctness of the stratigraphic reference of the Hawthorn beds, a special re-examination of all important localities was made during the field season of 1913. In this connection, in fairness to Doctor Dall, it should be stated that his account of the Hawthorn "beds" was mostly based on the field notes of others and that he did not personally examine the critical exposures. An exposure at White Springs, Suwannee River, Hamilton County, proved to be the key to the problem.

Following is the description of the section at this locality published by Doctor Dall from notes supplied by Dr. J. C. O'Neal:

At White Springs on the Suwannee the following section was obtained:

[1] Published by permission of the Director of the U. S. Geological Survey.

	feet
1. Gray soil, sand, and humus	2
2. White sand	4
3. Clay with silicified corals and oyster (Hawthorne beds)	6–8
4. Indurated clayey rock (Hawthorne beds?)	2
5. Clayey sand-rock, rather fine-grained and soft	4
6. The same, somewhat coarser and harder	8–10
7. Sand rock of coarser, sharp grains, coated and cemented together with white, limy matter	4–6
8. Foraminiferal Eocene top-rock (Vicksburg) indefinitely below....	

The silicified corals of bed No. 3 are sometimes 20 to 60 pounds in weight, and along the river when dislodged from the clay often wear immense potholes in the softer lime rocks. Miocene sharks' teeth and fragments of bone also occur in the clay. Under bed No. 8, when it is tilted up, as occurs in various places along the river, is found the older Orbitoides limestone of the Vicksburg group.

The following is a description of a section observed by us near White Springs:

Section, Rock Island and spring about 250 feet above it, left bank of Suwannee River, about three-quarters of a mile in a straight line above the White Springs wagon bridge.

	THICKNESS feet	inches
10. Terrace material about 60 feet above water level in the river. This represents the extensive, highest terrace recognized along Suwanne River,—the sands grayish or white	12	
9. Yellowish sands, about	12	
8. Grayish sand on surface, float of oyster shells, etc., about	13	
7. Bed with gray concretions, immediately above which are many silicified *Ostrea mauricensis*, *Siderastrea* sp., and fossil bones, probably manatee	1	
6. Greenish sands and clays	1	
5. Calcareous quartz sands coated by calcium carbonate; numerous phosphatic particles. Fossils: Orbitolites, Ostrea, etc	4	
4. Calcareous sands containing rotten shell fragments	1	2
3. Light colored, greenish-gray sandy marl containing many fossil shells but fewer specimens of Pecten than the underlying bed	4	9
2. Base of spring section, light colored, greenish-gray sandy marl; sand grains clear quartz, mostly rounded. Many blackish phosphatic particles. Fossils numerous: *Goniopora* sp., *Pecten madisonius* var. *sayanus*, *Ostrea mauricensis*. (The dip of this bed is about $2\frac{1}{2}$ feet in 50 feet; direction S. 50° E., that is up stream. Between it and the chert and limestone exposed at Rock Island it is estimated that about 5 feet are concealed.)	2	6

1. The material exposed at Rock Island outcrops about 150 feet down stream from the spring exposure. The rock was originally a yellowish granular limestone which has been largely silicified. The silicification is frequently or usually as concentric shells. In some instances silicified masses are surrounded by unchanged material. The echinoid genus Cassidulus is common. A number of species of fossil mollusks were collected. Worn specimens of *Ostrea mauricensis* and *Siderastrea* sp. were also seen on the surface, but these had evidently washed out of overlying beds and had been brought secondarily into the position where seen. (The geologic age of this bed will be discussed in a future publication. It is probably not of Vicksburg age, as stated by Professor O'Neal.) Down stream from Rock Island the dip is again down stream and the marls overlying the limestone and chert are again exposed. The exposure at Rock Island is due to a small anticline lying across the river course.

The silicified corals, Siderastrea, and silicified specimens of *Ostrea mauricensis* were seen at many places where they overlie the fossiliferous marl bed which carries a fauna very similar to that of the Chipola marl member and the Oak Grove sand member of the Alum Bluff formation.[2]

In this locality the Hawthorn formation either overlies or is a part of the Alum Bluff formation. The lithology, greenish gray sand and clay—the clay frequently resembling fuller's earth—is that usual for the typical Alum Bluff. *Ostrea mauricensis* is a common species in that formation; and as there is no stratigraphic break in the deposition, the Hawthorn formation as here exposed should in our opinion be considered as only a part of the Alum Bluff formation.

Similar material, in places containing a larger proportion of phosphatic sandstone, usually with silicified oysters and specimens of Siderastrea, was found at all the localities cited by Doctor Dall. At Alachua limesink the phosphatic sandstone is interbedded with greenish clays. The material was traced as far southward as Ocala where it immediately overlies the Ocala limestone of the Vicksburg group.

It seems definitely established that the Hawthorn formation does not represent any part of the Chattahoochee formation but

[2] The term Alum Bluff formation as used in this paper, in that it is made to include the Chipola marl as a member, differs from the sense in which Doctor Dall originally applied it.

is the essential equivalent of the Alum Bluff formation, if the basal fossiliferous marl exposed at White Springs be included with the Hawthorn. In western Florida the formation rests upon the Chattahoochee formation, while in central Florida, from Gainesville and Alachua southward, it immediately overlies the Ocala limestone.

Although the term "Hawthorn beds" was proposed in 1892 and Alum Bluff in 1894, it seems better to suppress Hawthorn and adopt Alum Bluff, as the latter term has been extensively applied in western Florida and the formation traced across southern Georgia and thence northeastward to Savannah River.

MINERALOGY.—*The optical properties of azurite and alamosite.* H. E. MERWIN, Geophysical Laboratory.

Azurite. The chief optical properties of azurite, except the refractive indices, were described by Des Cloizeaux.[1] I have measured microscopically the refractive indices and 2V of crystals from Broken Hills, Australia, and from Butte, Montana. The observed values for the two specimens do not differ more than as indicated. For Na-light $\alpha = 1.730 \pm 0.002$, $\beta = 1.758 \pm 0.003$, $\gamma = 1.838 \pm 0.003$.

Very thin sections transmit sufficient Na-light to permit a fairly satisfactory measurement of 2V by the method based upon the curvature of a zero isogyre. Three measurements varied between 62° and 70°. The optic axis of each of these sections could be located within 0.75°. Such location was not measurably different for the greenish-blue light transmitted by the section in white light. From one thick section showing an optic axis and the acute bisectrix an accurate measurement of 2V gave the value 68°. Very thin sections show slight horizontal dispersion. With decreasing wave-length the refractive index increases rapidly. The following values were observed: at $671\mu\mu$ $\alpha = 1.719$, at $589\mu\mu$ $\alpha = 1.730$, at $486\mu\mu$ $\alpha = 1.756$.

Since 2V for yellow and blue are nearly equal, the observed angle, $2E = 151°$, obtained by Des Cloizeaux may be reduced to

[1] Manuel de Minéralogie **2**: 194. 1874.

2V by using $\beta = 1.758$. The resulting value is $2V = 67°$. Thus the crystals from three localities are optically similar or quite identical.

Alamosite, $PbSiO_3$. In the original description of alamosite[2] the only optical property definitely described was that the optic plane is parallel to the plane of symmetry and the cleavage. The results of a further microscopical study of a few fragments of the original mineral are here presented.

α and γ for Na-light were measured, with a probable error of ± 0.001, in standard mixtures of piperine, and antimony and arsenic iodides, and also in solutions of arsenic trisulphide in methylene iodide. β was computed $\alpha = 1.947$, $\beta = 1.961$, $\gamma = 1.968$. A measurement of $\gamma - \alpha$ on a cleavage fragment in Na-light gave the value 0.023. Dispersion of the optic axes is very strong, but the inclined dispersion of the bisectrices is too weak to be measured with the microscope. A few grains embedded in a medium with refractive index near β were found suitable for measuring the angle between the acute bisectrix and an optic axis. By observing the direction of greater refraction in these grains the negative optical character of the mineral, which had not been satisfactorily determined on account of the strong dispersion, was established. 2V for Li-light $= 58°$; for Na-light $= 65°$; for blue light ($\lambda = 425\mu\mu$) $= 78°$—all within $\pm 5°$.

Two small pieces were fused on a strip of platinum, and the refractive index of the glass found by the method used for the crystals. Most of the fragments of the crushed glass from both pieces were alike, $n = 1.906$. For a very few fragments $n = 1.910$ to 1.920. Possibly a few specks of cerrusite were adhering to the crystal grains.

[2] Palache and Merwin, Amer. Journ. Sci. IV. **27**: 399. 1909.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal, and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEODESY.—*Fourth general adjustment of the precise level net in the United States and the resulting standard elevations.* WILLIAM BOWIE and H. G. AVERS. Special Publication No. 18, U. S. Coast and Geodetic Survey. Pp. 328, 4 pls., 1 map. 1914.

This publication contains the results of all precise leveling, done in the United States before the year 1912, which formed closed loops. Several spur lines were not included. The elevations are referred to mean sea level as the datum. The mean level of the sea at all points on the open coasts is supposed to define a level or equipotential surface. Deviations from this condition, if they exist, are not great enough to be detected by leveling of even the highest quality. When the mean sea levels at two tidal stations are connected the discrepancy is of such an order that it may be due to the accumulated errors of leveling.

The great advantage of having mean sea level as the datum for leveling is that the field work may start from many points; valuable checks on the results are obtained; and the leveling of neighboring countries may be joined to form a continuous net over a whole continent. These conditions would not be possible if each country adopted an arbitrary datum.

The lines of precise leveling are so interlaced that they form a complicated network, and the elevation of an interior point can be obtained by a number of different routes from the sea coast. The whole net was made consistent by an adjustment by the method of least squares, which furnished the most probable values for each of the points common to two or more lines. The elevations of the intermediate bench marks were then made to agree with the adjusted values of these junction points.

The present precise level net is considered to be of such strength and extent that the elevations resulting from this fourth adjustment can be held fixed for an indefinite time and they are, therefore, termed "standard."

It was found to be necessary to apply a correction to the field levels (the levels as actually run) to account for the non-parallelism of equipotential surfaces. In leveling the correction is an appreciable one when the distance between the surfaces is large.

The elevations are given in both feet and meters. It was thought best to abandon the custom previously followed (that is, to give the elevations in meters only), as all topographic maps in this country use the foot as the unit of elevation in contouring. It is also true that all railroads and other engineering organizations use feet entirely for elevations.

In the future any new lines of precise leveling will be adjusted to fit into the net without in any way disturbing previously adopted elevations. As each new line added to the net may have some influence on all or nearly all the elevations, adjustments will be made from time to time which will give the theoretically best values of the junction points of the net, which will be of great scientific interest and value, but such adjustments will not interfere with the standard elevations.

W. B.

GEOLOGY.—*Geology of the pitchblende ores of Colorado.* EDSON S. BASTIN. U. S. Geological Survey Professional Paper 90-A. Pp. 5, with 2 plates. 1914.

This account of the mode of occurrence of pitchblende at Quartz Hill in Gilpin County, Colorado, is published in advance of a much larger report on the same region in which many other types of ore deposits will be considered. The prevailing rocks are pre-Cambrian igneous and sedimentary rocks and tertiary intrusives mainly of monzonitic composition. The pitchblende occurs as a constituent of a number of sulphide veins which traverse both the pre-Cambrian and the Tertiary rocks.

On the basis of mineral composition the sulphide veins of this region may be divided into (1) the pyritic type and (2) the lead-zinc type. The principal primary minerals of the pyritic type are pyrite and quartz; chalcopyrite and tetrahedrite are almost invariably present in subordinate amounts, and enargite, fluorite, and rhodochrosite occur here and there. The primary minerals commonly present in the veins of the lead-zinc type are galena, sphalerite, pyrite, chalcopyrite, quartz, and calcite. Some parts of the district are characterized solely by one or the other of these types of mineralization, but in many of the veins both types are present. In such veins it has been demonstrated by repeated exposures that the lead-zinc type is somewhat later than the pyritic type and that the minerals of the former commonly line vugs or fractures in those of the latter. It is believed, however, that the lead-zinc mineralization followed close upon the heels of the pyritic mineralization, and that the two types represent merely successive epochs in one great vein-forming period. Although the mineral veins cut the monzonite porphyry dikes and stocks, it is believed that both came from a common deep-seated source, the ore-bearing solutions following the monzonite intrusion after a short interval.

Microscopic studies of the pitchblende ores indicate that they represent a local and unusual variation in the sulphide mineralization of the region. It is believed that the pitchblende was deposited during the earlier or pyritic mineralization, that it was afterward fractured, and that the fractures thus formed were filled by sulphides of the later or lead-zinc mineralization. The general geologic relations and the absence of characteristic high-temperature minerals in the deposits of Quartz Hill, as well as in those of Cornwall and the Erzgebirge, indicate that the pitchblende was deposited under conditions of moderate temperature and pressure. Unlike the European pitchblende, however, the pitchblende of Quartz Hill is not associated with nickel and cobalt minerals, which so far as known have never been found in that region even in small quantities. The occurrence of pitchblende in pegmatite as well as in mineral veins of the type here described shows that the mineral may also form under conditions of high temperature and pressure. E. S. B.

ENTOMOLOGY.—*On interspecific mating in Phengodes and inbreedings in Eros.* H. S. Barber. Proceedings of the Entomological Society of Washington **16**: 32–34. March 23, 1914.

Females of a species of Phengodes easily distinguished from *P. laticollis* in both sexes of adults and also in the larval stage were confined with males of *P. laticollis*. In most cases the male did not recognize the female; but some did, and in two instances there was mating of a short duration. One female deposited three infertile eggs; the other 48 fertile and infertile eggs. In the latter case some embryos developed but did not issue; ten larvae issued, all but two deformed and unable to feed; these two, which lived and fed for fifteen months, showed the specific characteristics of the male.

It is pointed out that most groups of insects have some obstacle tending to prevent inbreeding and that those which have no obstacle are usually somewhat degraded and inclined to form numerous local races or color forms. Observations are cited showing *Eros humeralis* to be an example of this group. In Phengodes the obstacle appears to be that the males develop after two years in the larval stage, while the females must spend three or more years as larvae. In Micromalthus the adults appear to become sexually mature only after a migratory flight. J. C. CRAWFORD.

ANTHROPOLOGY.—*Antiquities of the upper Verde and Walnut Creek Valleys, Arizona.* J. W. FEWKES. 28th Ann. Rept. Bur. Amer. Ethnology, pp. 181–220, pl. 79–102, figs. 56–68. 1912 [pub. 1913].

This is a report on a visit to the ruins of prehistoric remains of buildings in Arizona, made to determine the western limits of the agricultural Indians called Pueblos. It describes and figures fifteen ruins hitherto unknown, and points out their characteristic features. It states that buildings of two types, forts crowning the eminences and wattle-walled dwellings scattered along the river banks, coexist with cave dwellings, and that no one of these ruins resembles the typical terraced community houses commonly called pueblos. Architecturally these are more closely related to those in southern Arizona than to the pueblos. The memoir closes with a reference to the age of the ruins and an account of the probable character and kinship of their former inhabitants. J. W. F.

ANTHROPOLOGY.—*Casa Grande, Arizona.* J. W. FEWKES. 28th Ann. Rept. Bur. Amer. Ethnology, pp. 25–179, pls. 1–78, figs. 1–54. 1912 [pub. 1913].

This is a final report on the excavation and repair of the famous ruin, Casa Grande, undertaken by the Smithsonian Institution in 1906 and 1907–08. The memoir quotes at length from the various historical descriptions of the ruin from its discovery, in the year 1694, to the present time, supplementing these written accounts with legends gathered from Piman and other Indians still living in the neighborhood. It likewise contains a comprehensive description, copiously illustrated, of buildings, encircling walls, and other characteristic architectural features revealed by the excavations, and describes the methods of repair adopted for their permanent preservation. Various objects (stone axes, pottery, shell, wood, basketry, etc.) found in the course of the work are figured, described, and, where possible, interpreted. The memoir closes with general considerations of the age of Casa Grande, the kinship of the makers, and probable manners and customs of the former inhabitants, as affected by the climatic and other environmental conditions. The author regards the prehistoric dwellings as different from pueblos, and their inhabitants as culturally characteristic. J. W. F.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE WASHINGTON ACADEMY OF SCIENCES

The 87th meeting of the Washington Academy of Sciences was held at the Cosmos Club, Thursday evening, December 4, 1913. The following were elected resident members of the Academy: John F. Anderson, N. L. Bowen, R. H. Chapman, Harvey L. Curtis, Edwin Clarence Eckel, Daniel Folkmar, Frederick E. Fowle, Hoyt S. Gale, Donnel F. Hewett, Walter D. Hunter, J. F. Jameson, George W. Morey, Eugene F. Mueller, S. N. D. North, W. J. Peters, E. D. Tillyer, Percy H. Walker, Elmer G. Woodruff.

After the election of the new members the Academy, in joint session with the Philosophical Society of Washington, listened to an illustrated lecture on the *Brownian movement and molecular reality* by Prof. JEAN PERRIN, of the University of Paris. It was explained that the Brownian movement has furnished visible and experimental proof of all the principal gas laws; that it has demonstrated the reality of the molecular constitution of matter; and that it has given four of the seventeen known independent methods of determining the number of gas molecules per unit volume.

The 88th meeting of the Washington Academy of Sciences, a joint meeting with twenty other societies, was held in the hall of the Carnegie Institution of Washington, Friday evening, December 5, 1913, in memory of the late Dr. W. J. McGEE.

Mr. FREDERICK V. COVILLE presided and introduced the speakers, all of whom had been intimately associated with Dr. McGee at some stage of his career. GIFFORD PINCHOT declared that much of the success of forestry work was due to ideas advanced by Dr. McGee, and Dr. FRANZ BOAS, of Columbia University, read a paper analyzing the character and value of his work.

Other speakers included Dr. MILTON WHITNEY, N. H. DARTON, HENRY GANNETT, Col. H. C. RIZER, F. W. HODGE, and J. A. HOLMES. The speeches, letters and papers read, with other material relating to the life and work of Dr. McGee, will be printed in book form.

The societies, which took part, and their representatives were: American Anthropological Association, F. W. HODGE; American Association of Museums, FREDERICK L. LEWTON; American Civic Association, H. K. BUSH-BROWN, and RICHARD B. WATROUS; American Forestry Association, P. S. RISDALE; American Institute of Electrical Engineers, J. H. HANNA and E. B. ROSA; American Society of Mechanical

Engineers, Gen. William H. Bixby, Calvin W. Rice, and Joseph A. Holmes; Anthropological Society of Washington, D. S. Lamb, Donnel F. Hewett, and Daniel Folkmar; Archaeological Institute of America, John W. Foster, Herbert Putnam, and Mitchell Carroll; Biological Society of Washington, F. H. Knowlton; Chemical Society of Washington, F. W. Clarke, William Blum, F. K. Cameron, and W. F. Hillebrand; Columbia Historical Society, Theodore W. Noyes, W. B. Bryan, and M. I. Weller; Explorers' Club, Rear Admiral Robert E. Peary, D. L. Brainard, and Henry Brevoort Kane; Lake to the Gulf Deep Waterways Association, W. K. Kavanaugh, G. A. Buder, Edwin S. Munroe, Major Wood, T. Edward Wilder, E. S. Conway, William F. Bourland, William H. Russe, W. M. Kavanaugh, George B. Logan, John F. Messmore, J. F. O. Reller, Arthur Leach, E. H. Deffenbaugh, Lyman E. Cooley, H. H. Walker, Alexander Y. Scott, James S. Warren, and H. F. Auton; National Conservation Association, Herbert A. Smith, Philip P. Wells, and H. A. Slatterly; National Conservation Congress, Thomas R. Shipp; Philosophical Society of Washington, L. A. Bauer, J. H. Gore, and C. K. Wead; Sequoia League, Alice C. Fletcher, F. W. Hodge, C. Hart Merriam; State Historical Society of Iowa, The Hon. H. M. Towner; Upper Mississippi River Improvement Association, Thomas Wilkinson; National Rivers and Harbors Congress, Col. S. A. Thompson.

The 89th meeting of the Washington Academy of Sciences was held in the Lecture Hall of the National Museum, Thursday evening, January 8, 1914. Prof. John C. Merriam, of the University of California gave an illustrated lecture on the *Fauna of the Pleistocene asphalt at Rancho La Brea, California*. It was explained that, when cool, tar is so firm that animals can walk over it safely but that, on being warmed, especially on summer days, it softens and entraps any animal that attempts to cross it. Animals caught in this manner attract others, and thus the asphalt deposit has become filled with the bones of thousands of animals in which canid forms, such as the Great Wolf, largely predominate. Many of the species preserved in this death trap of the ages are extinct, while others, representing later catches, belong to the present fauna.

The 90th meeting of the Washington Academy of Sciences, the 16th annual meeting, was held at the Cosmos Club, Thursday evening, January 15, 1914, with President Tittmann in the chair. The following were elected officers for the ensuing year: *President*, David White; *Corresponding Secretary*, George K. Burgess; *Recording Secretary*, W. J. Humphreys; *Treasurer*, E. W. Parker. Resident *Vice-Presidents* from local societies: Anthropological, F. W. Hodge; Archaeological, Mitchell Carroll; Biological, Paul Bartsch; Botanical, F. L. Lewton; Chemical, M. X. Sullivan; Electrical Engineers, E. B. Rosa; Engineers, G. W. Littlehales; Entomological, A. L. Quaintance; Foresters, W. B. Greeley; Geological, F. L.

Ransome; Historical, J. D. Morgan; Philosophical, L. A. Fischer; Non-resident *Vice-Presidents:* Ira Remsen and J. M. Coulter. *Managers*, Class of 1917, A. H. Brooks and L. O. Howard.

The report of the Corresponding Secretary showed the total membership to be 369, an increase of 14 during the past year, and that the Academy has lost by death the following: Dr. J. R. Eastman, the first President of the Academy, Prof. Alexander Macfarlane, Dr. Robert Fletcher, and Gen. C. W. Raymond.

The Treasurer's report showed the total receipts to be $4805.69, disbursements $3657.82, cash on hand $1147.87, and investments $12,090.

The report of the Auditing Committee was also received.

President-elect White then took the chair and President Tittmann delivered an address on *Our northern boundaries.* (This Journal, **4**: 37–45. 1914.)

The following were elected to resident membership: W. N. Berg, W. R. Blair, W. Blum, C. W. Burrows, Bert S. Butler, R. O. E. Davis, L. H. Dewey, Paul J. Fox, H. C. Gore, Monroe Hopkins, J. T. Kelley, Jr., Dr. Haven Metcalf, J. F. Mitchell, G. E. Patrick, Dr. W. W. Randall, W. Salant, A. Seidell, W. W. Skinner, Dr. Erwin F. Smith, Dr. W. W. Stockberger, Rene de M. Taveau, W. H. Waggaman.

The 91st meeting of the Washington Academy of Sciences, a joint meeting with the Chemical Society, was held at the Cosmos Club, Monday evening, March 16, 1914, with Dr. M. X. Sullivan, President of the Chemical Society, in the chair.

Prof. Wolfgang Ostwald of the University of Leipzig gave a most interesting address on *The chemistry of colloids.*

The following were elected to resident membership in the Academy: E. C. Crittenden, J. H. Dellinger, D. R. Harper, 3rd., J. T. Hedrick, A. S. Hitchcock, R. S. McBride, B. McCollum, Sidney Paige, John Ryder Wellington, and Raphael Zon.

Owing to his absence from the city on official business at the times of certain of these meetings, the Recording Secretary had to impose upon the kindness of others, Mr. J. S. Diller and Dr. G. K. Burgess, to whom he wishes to express his thanks, for much of the above information.

W. J. Humphreys, *Recording Secretary.*

THE BOTANICAL SOCIETY OF WASHINGTON

The 95th regular meeting was held at the Play House on Tuesday evening, March 3, 1914, at eight o'clock, at which the retiring President, Dr. W. W. Stockberger, delivered an address on *The social obligations of the botanist* (to be published in Science).

The 96th regular meeting of the society was held at the Cosmos Club Tuesday, April 7, 1914, at eight o'clock. Messrs. Robert B.

Whitney and H. S. Westover were unanimously elected to membership in this society.

The scientific program was as follows:

Prof. A. S. Hitchcock reviewed (a) A paper by Trabut in which he states that the oat commonly cultivated in temperate regions descended from *Avena fatua*, the Algerian oat from *A. sterilis*, and *A. strigosa* from *A. barbata;* (b) a paper by Schulz on the origin of wheat, in which he states that *Triticum monococcum* descended from *T. aegilopoides*, *T. dicoccum* from *T. dicoccoides*, and *T. spelta* from an as yet undiscovered wild form; that the naked wheats are derived from the spelt wheats, *T. turgidum*, *T. durum*, and *T. polonicum* from *T. dicoccum*, and *T. vulgare* and *T. compactum* from *T. spelta*.

Dr. H. L. Shantz reviewed a paper by Sir Francis Darwin[1] describing a method by which the influence of stomatal adjustment on the rate of transpiration is eliminated. The stomata of the lower surface of the leaf are locked with cocoa butter or petrolatum and incisions made through the upper epidermis, thus connecting the intercellular spaces with the outer air. By this method transpiration was found to decrease proportionally as relative humidity increased. The straight line relation led to the conclusion that a relative humidity of 105 would be required to reduce transpiration to zero.

Mr. C. S. Scofield, *Chinese wild rice*, with lantern (to be published later).

Dr. P. Spalding, *Present status of the white pine blister rust*, with lantern (to be published as a Bulletin of the Department of Agriculture).

Mr. R. Zon, *Meteorological observations for purposes of botanical geography, agriculture, and forestry*, with lantern. The inadequacy of the present climatic data for the purposes of botanists lies not so much in the kind and character of observations that are being recorded as in the manner of their classification, their grouping, and computing.

To properly understand plant life it is essential to group meteorological data by actual periods of growth and rest. During each of these two periods plants react to temperature of the air in an altogether different way. The temperature records of the temperate region of the United States should be computed separately on the basis of the normal monthly mean not reduced to sea level for the period of rest or the period of growth, and in some localities also for a third period, the hot period. The period of rest should include all months having a normal mean temperature of 48°F. or less. In the period of growth should be included all months having a normal monthly temperature of from 50° to 72°F. The hot period in temperate latitudes should embrace months with a normal average temperature of more than 72°F.

A map showing localities with the same duration of the periods of growth and rest has been tentatively prepared.

[1] Proceedings of the Royal Society, Series B, vol. 87, February, 1914.

Aside from monthly mean temperatures the average temperatures by periods of ten days (decades) are also desirable, and also the mean temperatures for periods when the ground is covered with snow and periods when the ground is bare; similarly, the mean temperature for each period during which certain winds prevail.

Summation of temperatures as suggested by Bussengo and de Candolle do not indicate the actual requirements of plants for heat, since they overlook the existence of an optimum temperature for the development of each plant.

Groups of days with a given temperature are considered preferable, and the following classification is suggested:

1. Freezing days, with a daily average of 32° or less. These are further subdivided into: (a) freezing days without thawing; (b) freezing days with thawing.

2. Cold days, with an average daily temperature ranging from 32° to 40°F. This group should be further divided into: (a) days with frost; (b) days without frost.

3. Cool days, with an average daily temperature from 40.1° to 50°F. This group should be divided into: (a) days with frost; (b) days without frost.

The paper discussed also the temperature of the soil, humidity of the air, precipitation, snow cover, soil moisture, sunshine, and barometric pressure.

P. L. Ricker, *Corresponding Secretary.*

THE CHEMICAL SOCIETY

The 237th meeting was held at the Cosmos Club on Thursday, April 9, 1914. The following papers were read:

F. P. Dewey, of the Bureau of the Mint: *The pyrometer in the assay muffle.* This paper is an emphatic protest against the practice of stating specific temperatures for conducting assay work in the muffle. The pyrometer is an excellent guide to temperature conditions in the muffle, but the success of the work depends upon the temperature of the oxidizing lead button. This is entirely different from the pyrometer reading and is vitally influenced by conditions which have little or no effect on the pyrometer. (Author's abstract.)

Discussion: Walker inquired whether an optical pyrometer had ever been used; Dr. Dewey replied that the surface exposed is too small for any accurate measurement. A. N. Finn inquired about American pyrometers.

H. S. Washington, of the Geophysical Laboratory: *The distribution of the chemical elements in the earth's crust.* About 8500 rock analyses have been recently tabulated by the author. The distribution of chemical elements as revealed by these analyses may be considered from two viewpoints: (1) Their distribution in general over the earth's surface; (2) their distribution with respect to each other. The earth's surface is in a general way divisible into "petrographic provinces" distinguished by their relatively higher or lower percentages of certain oxides. As to relative distribution, the following facts have been established: Alumina and the alkalies usually accompany high silica while calcium and iron go with low silica. Iron is accompanied by sodium, magnesium by potassium. Calcium accompanies aluminum predominantly. Cerium and yttrium, the radioactive elements, lithium, and fluorine all occur predominantly in the sodic rocks. The iron bearing rocks are the usual habitat of nickel and vanadium. Magnesian rocks hold the chromium and the platinum metals. Rocks high in potash are relatively rare. There seem to be two kinds of association: (1) Physico-chemical; (2) association in petrographic provinces. The distribution of barium and scandium seems to be of the latter type.

Discussion: Clarke pointed out that many elements formerly considered rare are widely distributed and present in greater percentages than are those elements usually considered common. Most of these are elements of lower atomic weight than copper. In reply to questions it was stated that titanium occurs usually either as a constituent of pyroxenes or in ilmenite in ores. Beryllia is also more widely distributed than usually supposed, but its analytical separation from alumina has never been well worked out.

W. O. Emery and S. Palkin of the Bureau of Chemistry: *The estimation of antipyrin.* Presented by Mr. Palkin. The methods described depend upon the formation of an iodo-antipyrin and its reduction by sulfur dioxide in alcoholic or acetic acid solution. The widest variation by these methods is 0.8 per cent on 250 milligrams.

R. E. Lee, of the Corby Company: *The Guillaume apparatus for the distillation and rectification of alcohol.* The American apparatus for alcohol production requires two stages of rectification, while the European Guillaume is continuous. The latter also yields 90 per cent as against 60 to 65 for the American. The apparatus and process were described in detail with the aid of diagrams.

Andrews, Tolman, and others asked questions, to which the speaker replied that live and exhaust steam enter the beer column together and are at nearly the same pressure; also that the columns are not jacketed.

The 238th meeting was held at the Cosmos Club on Monday, April 20, 1914. Dr. C. E. Kenneth Mees, Director of the Research Laboratory of the Eastman Kodak Company of Rochester, spoke on *The physical chemistry of photography.* He discussed the physico-chemical principles of photographic development and the question of standard light sources for photographic research, and described the lines of work now being carried on at the Laboratory, illustrating his descriptions with lantern slides.

In the discussion which followed, questions were asked by Sosman and others about research on photographic papers. Dr. Mees replied that the principal difficulty has been in the measurement of reflecting power, for which he is now using the Bechstein illuminometer. The question of production of spots in plates by bacteria was discussed by Andrews, Sullivan and Dr. Mees.

Robert B. Sosman, *Secretary.*

REFERENCES

Under this heading it is proposed to include, by author, title, and citation, references to all scientific papers published in or emanating from Washington. It is requested that authors coöperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

ENTOMOLOGY

BANKS, N. *On a collection of neuropteroid insects from the Philippine Islands.* Proceedings of the Entomological Society of Washington **15**: 170–180, pls. 8 and 9. January 22, 1914. (Describes two new species in each of the families Psocidae, Perlidae, Myrmeleonidae, and Mantispidae, and three in the family Chrysopidae; also the new genera Tagalopsyche, Eenopsyche, and eight new species of Trichoptera.—J. C. C.)

BARBER, H. S. *Notes on a wood-boring syrphid.* Proceedings of the Entomological Society of Washington **15**: 151, 152. January 22, 1914. (*Temnostoma bombylans* was reared and comparison of the various larvae found show great differences in the armature of the spiracle, from which it appears that about four species are mixed under the single specific name.—J. C. C.)

BARBER, H. S. *Notes on Rhipidandri (Coleoptera).* Proceedings of the Entomological Society of Washington **15**: 188–193. January 22, 1914. (Describes a new species of the genus Eutomas from Panama and gives notes on the other species in the collection of the National Museum.—J. C. C.)

BUSCK, A. *Note on a barkmining lepidopteron of the genus* Marmara *Clemens.* Proceedings of the Entomological Society of Washington **15**: 150. January 22, 1914. (*Marmara fulgidella* was reared from oak, the larvae exhibiting the typical form for species of this genus.—J. C. C.)

BUSCK, A. *A new Gracilaria on Azalea.* Insecutor Inscitiae Menstruus **2**: 1, 2. January 31, 1914. (Describes one new species which possibly may have been imported from Europe.—J. C. C.)

BUSCK, A. *The chestnut bastminer.* Insecutor Inscitiae Menstruus **2**: 3, 4. January 31, 1914. (Describes *Ectoedemia phleophaga* and gives notes on the habits of the larva.—J. C. C.)

CRAWFORD, J. C. *A revision of the braconid genus Urosigalphus.* Insecutor Inscitiae Menstruus **2**: 22–27. February 28, 1914. (Gives a table of all the known species and describes eight new species, all from the United States.—J. C. C.)

CUSHMAN, R. A. *Biological notes on a few rare or little known parasitic Hymenoptera.* Proceedings of the Entomological Society of Washington **15**: 153–160. January 22, 1914. (Gives observations on *Perilitus americanus*, a parasite of adult beetles; *Paniscus geminatus* from a lepidopteron; *Polysphincta texana*, an external parasite of adult spiders; *Sphaeropyx bicolor*, a parasite of *Apatela clarescens*.—J. C. C.)

Dyar, H. G. *Two new Phycitinae from Montana.* Insecutor Inscitiae Menstruus **2**: 2. January 31, 1914.

Dyar, H. G. *Four new Lepidoptera from British Guiana.* Insecutor Inscitiae Menstruus **2**: 4-6. January 31, 1914. (Describes three hesperiids and one liparid.—J. C. C.)

Dyar, H. G. *A note on Phobolosia and Melanomma.* Insecutor Inscitiae Menstruus **2**: 8-10. January 31, 1914. (Gives a table of the North American species of the genus Phobolosia and describes one new species.—J. C. C.)

Hood, J. D. *Notes on the life history of* Rhopalosoma poeyi *Cresson.* Proceedings of the Entomological Society of Washington **15**: 145-147. January 22, 1914. (This species was found to be an external parasite of an adult jumping tree cricket, *Orocharis saltator* Uhler; nothing was previously known of the life-history of this anomalous genus.—J. C. C.)

Hood, J. D. *Notes on North American Thysanoptera, with descriptions of a new family and two new species.* Insecutor Inscitiae Menstruus **2**: 17-22, pl. 1. February 28, 1914. (Describes two new species and establishes the new family Merothripidae, based on the anomalous species *Merothrips morgani* Hood.—J. C. C.)

Hopkins, A. D. *Parallelism in morphological characters and physiological characteristics in scolytoid beetles.* Proceedings of the Biological Society of Washington **26**: 209-212. December 20, 1913.

Knab, F. *A new Pantophthalmus.* Insecutor Inscitiae Menstruus **2**: 27-29. February 28, 1914. (Describes *P. fastuosus,* the larvae of which bore in trunks of trees in Trinidad.—J. C. C.)

Lutz, A. *Forest malaria.* Proceedings of the Entomological Society of Washington **15**: 169, 170. January 22, 1914. (A further statement of the author's contention that malaria can be transmitted to man by anopheles which have not previously been in contact with man.—J. C. C.)

Rohwer, S. A. *Notes on the feeding habits of two adult sawflies.* Proceedings of the Entomological Society of Washington **15**: 148, 149. January 22, 1914. (A female of *Tenthredella lineata* was seen eating an adult perlid, *Alloperla signata; Tenthredo arcuatis* was seen feeding on stamens of an umbelliferous plant.—J. C. C.)

Rohwer, S. A. *Two abnormally developed sawflies.* Proceedings of the Entomological Society of Washington **15**: 149, 150. January 22, 1914. (Records an abnormal female of *Xenapates terminalis* and a male of a species of the genus Tenthredella.—J. C. C.)

Rohwer, S. A. *Descriptions of new parasitic Hymenoptera.* Proceedings of the Entomological Society of Washington **15**: 180-188. January 22, 1914. (Describes the new genera Stilbopoides and Helcostizidea from the United States and five new species in the Ichneumonidae, also two new species of Braconidae.—J. C. C.)

Shannon, R. C. Epimecis wiltii *Cresson and its host.* Proceedings of the Entomological Society of Washington **15**: 162. January 22, 1914. (The larva of this species is an external parasite of spiders.—J. C. C.)

Shannon, R. C. *Feeding habits of* Phlebotomus vexator *Coq.* Proceedings of the Entomological Society of Washington **15**: 165, 166. January 22, 1914. (Observations tend to show that this species feeds normally upon reptiles rather than upon warm-blooded animals.—J. C. C.)

SNYDER, T. E. *Changes during quiescent stages in the metamorphosis of termites.* Proceedings of the Entomological Society of Washington **15**: 162–165, pls. 6 and 7. January 22, 1914. (Observations of the molting soldier larvae of *Leucotermes flavipes*, *L. virginicus* and *Termopsis angusticollis* show that the differentiation of the soldier caste takes place during a quiescent stage rather late in the life cycle, the larva being previously, to all external appearances, undifferentiated.—J. C. C.)

TOWNSEND, C. H. T. *New muscoid flies, mainly Hystriciidae and Pyrrhosiinae from the Andean Montanya.* (Continuation.) Insecutor Inscitiae Menstruus **2**: 10–16. January 31, 1914. (Describes, in the family Exoristidae, the new genera Neaphria, Xenoplagia and Gymnochaetopsis, and two new species.—J. C. C.)

WRIGHT, W. S. *Notes on certain Californian Lepidoptera.* Insecutor Inscitiae Menstruus **2**: 6–8. January 31, 1914.

ORNITHOLOGY

BANGS, O. *The green heron of the Maldives.* Proceedings of the Biological Society of Washington **26**: 93, 94. May 3, 1913. (Describes *Butorides albidulus*, sp. nov.—W. R. M.)

BANGS, O. *A new warbler from western China.* Proceedings of the Biological Society of Washington **26**: 95, 96. May 3, 1913. (*Reguloides pulcher vegetus*, subsp. nov., is described from western Szechwan.—W. R. M.)

COOKE, W. W. *Bird migration in the District of Columbia.* Proceedings of the Biological Society of Washington **26**: 21–26. February 8, 1913.

HOWELL, A. H. *Descriptions of two new birds from Alabama.* Proceedings of the Biological Society of Washington **26**: 189–202. October 23, 1913. (*Corvus brachyrhynchos paulus* and *Pipilo erythrophthalmus canaster*, subspp. nov., are described.—W. R. M.)

MEARNS, E. A. *Description of a new African grass-warbler of the genus Cisticola.* Smithsonian Miscellaneous Collections **60**[20]: 1, 2. February 14, 1913.

MEARNS, E. A. *Descriptions of three new African weaver-birds of the genera Estrilda and Granatina.* Smithsonian Miscellaneous Collections **61**[9]: 1–4. July 31, 1913.

MEARNS, E. A. *Descriptions of four new African thrushes of the genera Planesticus and Geocichla.* Smithsonian Miscellaneous Collections **61**[10]: 1–5. August 11, 1913.

MEARNS, E. A. *Descriptions of five new African weaver-birds of the genera Othyphantes, Hypargos, Aidemosyne, and Lagonosticta.* Smithsonian Miscellaneous Collections **61**[14]: 1–5. September 20, 1913.

MEARNS, E. A. *Descriptions of ten new African birds of the genera Pogonocichla, Cossypha, Bradypterus, Sylvietta, Melaniparus, and Zosterops.* Smithsonian Miscellaneous Collections **61**[20]: 1–8. November 29, 1913.

MEARNS, E. A. *Descriptions of eight new African bulbuls.* Smithsonian Miscellaneous Collections **61**[25]: 1–6. February 16, 1914. (Describes 1 species and 7 subspecies in 4 genera, from British East Africa.—W. R. M.)

NELSON, E. W. *Two new subspecies of birds from the slopes of Mount Pirri, eastern Panama.* Smithsonian Miscellaneous Collections **60**[21]: 1, 2. February 26, 1913.

Nelson, E. W. *A new subspecies of nun bird from Panama.* Proceedings of the Biological Society of Washington **26:** 67, 68. March 22, 1913. (Describes *Monasa pallescens minor*, from Marraganti, eastern Panama.—W. R. M.)

Phillips, J. C. *Two new African birds.* Proceedings of the Biological Society of Washington **26:** 167, 168. June 30, 1913. (Describes *Caprimulgus eleanorae*, from the Blue Nile, and *Passer domesticus Chephreni*, from Egypt.—W. R. M.)

Riley, J. H. *A new hummingbird of the genus Chlorostilbon from Brazil.* Proceedings of the Biological Society of Washington **26:** 63, 64. March 22, 1913. (Describes *Chlorostilbon puruensis*, sp. nov.—W. R. M.)

Riley, J. H. *The king rail of Cuba.* Proceedings of the Biological Society of Washington **26:** 83–86. March 22, 1913. (The resident form of the king rail in Cuba is described as a new subspecies, *Rallus elegans Ramsdeni*.—W. R. M.)

Riley, J. H. *The Bahama barn owl.* Proceedings of the Biological Society of Washington **26:** 153, 154. June 30, 1913. (Description of the Bahaman barn owl as a new subspecies, *Tyto perlatus lucayanus*.—W. R. M.)

Todd, W. E. C. *Preliminary diagnoses of apparently new birds from tropical America.* Proceedings of the Biological Society of Washington **26:** 169–174. August 8, 1913. (There are here described 33 new subspecies and species in 32 genera, including one new genus, Microstilbon, with a single known species, *M. insperatus*, from Bolivia.—W. R. M.)

ANTHROPOLOGY

Bushnell, D. I., jr. *Archeological investigations in Ste. Genevieve County, Missouri.* Proceedings of the U. S. National Musuem **46:** 641–668, text figs. 1–8, pls. 50–57. March 4, 1914.

Hough, W. *Culture of the ancient pueblos of the upper Gila River region, New Mexico and Arizona.* (*Second Museum-Gates Expedition*). Bulletin 87, U. S. National Museum, pp. 1–144, pls. 1–29, text figs. 1–348. March, 1914.

Hrdlička, A. *Early man and his "Precursors" in South America.* Anatom. Anzeiger **43**^{1}: 1–14. 1913.

Hrdlička, A. *A report on a collection of crania and bones from Sorrel Bayou, Iberville Parish, Louisiana.* Journ. Acad. Natural Sciences, Philadelphia **16:** 95–99. 1913.

Hrdlička, A. *Artificial deformations of the human skull, with special reference to America.* Actas del XVII Congreso Internacional de Americanistas. Sesion de Buenos Aires, 1912, pp. 147–149. Published August, 1913.

Hrdlička, A. *Anthropological work in Peru in 1913, with notes on the pathology of the Ancient Peruvians.* Smithsonian Miscellaneous Collections **61**^{18}: 1–69, figs. 1–3, pls. 1–26. 1914.

JOURNAL
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PHYSICS.—*The measurement of the refractive index of a drop of liquid.* FRED. EUGENE WRIGHT, Geophysical Laboratory.

Of the many optical characteristics of a substance, the refractive indices are the most important and fundamental, and from them a number of the other optical constants can be derived. In determinative work, moreover, substances are classified and distinguished within narrow limits by their refractive indices. In modern petrographic microscope analysis great emphasis is placed on this optical property, and tables have been prepared in which the minerals are arranged according to the refractive indices. Simple methods are available by means of which the refractive indices of an irregular mineral grain, 0.01 mm. in diameter, can be readily measured with an accuracy of ± 0.001, a degree of precision which is sufficient for all practical purposes. In these methods, liquids of known refractive index are used; finely powdered grains of the mineral are immersed in a liquid and the refractive indices of the grains compared with that of the liquid. For routine work, sets of such liquids are usually prepared by mixing liquids of known refractive index and then measuring the refractive index of the liquid mixture, either on a total refractometer or a spectrometer. In many instances, only a drop or two of the liquid is available, and it is essential that its refractive index be measured accurately. In this paper, the more important methods for this purpose (except those based on the Abbe refractometer) are considered with respect to their accuracy, and ease and range of application, especially in petrographic microscope work. Several new methods are described; also certain details of manipulation of the standard methods which the writer has found convenient and satisfactory in practice.

Sources of light. For most refractive index work with minerals, the practice among mineralogists has been to use as monochromatic light sources the salts of lithium ($\lambda = 671\mu\mu$), sodium ($\lambda = 589\mu\mu$), and thallium ($\lambda = 535\mu\mu$) in the Bunsen flame. In addition to these the lines of a mercury lamp ($\lambda = 435.8$, 491.6, 546.1, 576.9, $579\mu\mu$) are convenient, especially if used in conjunction with a carbon bisulfide prism or the Wratten ray filters, which isolate effectively the green line, 546.1 (mercury green filter), and also the two yellow lines, 577 and 579 (Wratten E filter No. 22). Other useful light sources are helium and hydrogen tubes and cadmium and iron arcs, but ordinarily the mercury light is a sufficient addition to the salts mentioned.

Uniform illumination from all these light sources can be readily obtained by means of a finely ground glass plate (frosted glass), placed between the source of light and the measuring instrument. The glass plate enables the observer to overcome, without further inconvenience, the ordinary troubles of a flickering flame, which quickly tires the eyes. In this Laboratory, a ground glass plate (25 x 35 cm.), mounted in a simple upright wood frame is placed directly in front of the Meker burners in which the salts are volatilized. The salt is contained in a platinum crucible into which a wick of fine platinum wires extends. This wick carries the melted salt (kept melted by a Meker burner) into the hot flame of a second Meker burner.[1] A hood carries off the vapors and thus shields the instruments from attack by the salts. By this method an intense and lasting flame is produced which burns for hours without further attention. In routine work, too much stress cannot be placed on the satisfactory performance of such details; the above light sources and glass diffusing screen have been proved by long usage in this Laboratory to be convenient and entirely satisfactory.

[1] F. E. Wright, Am. J. Sci. (4), **27**: 195. 1909; **31**: 185. 1911; Carnegie Institution of Washington, Pub. **158**: 88. 1911.

We may now consider the methods for the measurement of the refractive index of a single drop of liquid.

Method 1. A method based on a new type of hollow prism. (Accurate to the fourth decimal place.) This prism (fig. 1) consists of two optically plane parallel glass plates (10 x 20 x 2 mm.) held in place against a 30° glass prism (10 x 10 mm.) by means of a brass clamp (fig. 1). The liquid is introduced between the glass plates and is held in place by capillarity. The semicircular notch in the glass plate (fig. 1) prevents the liquid from creeping up along the ridge formed by the glass plates, and thence into the prism support. The dotted lines in figure 1 indicate the size of the prism of liquid obtainable by this method. It measures over 5 mm. on a side.

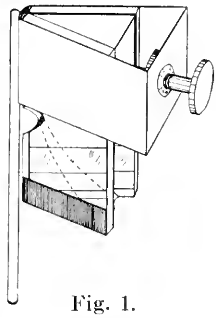


Fig. 1.

With this prism the Abbe method of measurement is used. Autocollimation is obtained by the use of a thin cover glass total reflecting prism[2] in the rear focal plane of the field lens of the telescope of a spectrometer or goniometer. The path of the rays is indicated in figure 2. In order that the reflected rays be as intense as possible the two plates of figure 1 are silvered on the back along a narrow strip 2 mm. wide as indicated by the shaded area on the front glass in figure 1. The measurements are made, after proper adjustment of the prism, by setting first on the normals to the two plates and then on the refracted and reflected beams (fig. 2). In the course of a complete rotation of the prism two readings of the angles i and r (fig. 2) are made.

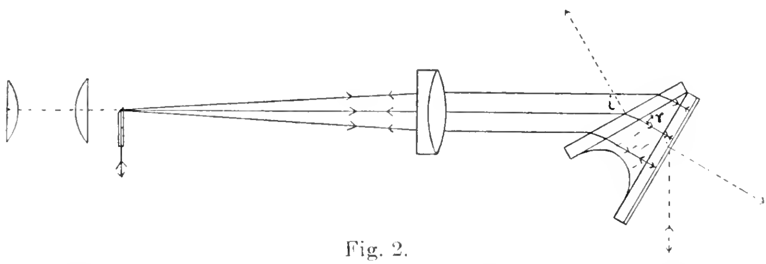


Fig. 2.

The refractive index is then computed directly from the usual equation $n = \frac{\sin i}{\sin r}$. This method is accurate to the fourth decimal place, provided a spectral line source, as mercury, helium or hydrogen light, is used and the circle of the goniometer or spectrometer is accurately divided. The values obtained by this method should be as accurate as any measurements by the standard prism methods with larger quantities of liquid.

[2] F. E. Wright, J. Wash. Acad. Sci., **3**: 234. 1913.

Method 2. The thin plane parallel plates can also be used with a small 60° glass prism (10 x 10 mm.) and the measurements made by the minimum deviation method. In this case both a telescope and a collimator are required. The liquid is held in place by capillarity and prevented from running up along the ridge into the prism support by a notch in the glass plate, as in figure 1. The glass plates are not, however, silvered as in the first method. In this form the prism is somewhat similar in form to the glass prism used first by H. G. Madan[3] for the measurement of the refractive indices of piperine. Madan cemented two thin plane glass plates to the sides of a prism of dense flint glass, allowing the glass plates to project above the top of the glass prism. Into the angle between the glass plates he poured the melted piperine and thus obtained the desired prism of piperine. The same purpose was accomplished later by H. E. Merwin[4] of this laboratory by fusing together at one end two strips of cover glass or object glass under an angle of about 60°. Such strips are not perfectly flat and plane-parallel and the degree of accuracy obtainable by their use is, of course, less than it would be, were plates of better quality used. The cover glass prisms are, however, sufficiently accurate for ordinary purposes and can be prepared in a few minutes.

Method 3. By the use of a small accurately ground 60° glass prism, 5 mm. on a side and 10 mm. long, and three thin plane parallel glass plates (5 x 20 x 2 mm.), a three sided liquid 60° prism can be obtained and the measurements made by the very accurate method which Gifford[5] employed so successfully with large glass prisms.

In the last three methods the regulation of the temperature is not easy but the temperature at which the measurements are made should be carefully noted as a rise of 2° or 3°C. produces an average decrease of 0.001 in the refractive index of a liquid. The refractive index of liquids changes, moreover, on an average 0.001 in refractive index for a change of 6 to 12 $\mu\mu$ change in wave length. Measurements, therefore, even to the fourth decimal place have little significance unless the temperature be accurately recorded and monochromatic spectral line sources be employed.

Method 4. Measurements with the Abbe-Pulfrich crystal total-refractometer (accurate to one or two units in the fourth decimal place). The methods for use with this refractometer are described at length in the standard textbooks and need not be repeated here. Several new details of manipulation, however, which have been found of value, may be recorded briefly. The best readings are made when the light enters at grazing incidence. In this case the field is divided into two halves, the one light, the second dark; the boundary line between the two is so sharp that accurate settings are easily made. With a single drop of liquid, however, this method of grazing incidence has not been applicable heretofore and recourse has been had to the method of total

[3] Jour. of the Chem. Soc. Transactions, **79**: 922–927. 1901.

[4] J. Geol., **20**: 495. 1912.

[5] Proc. Roy. Soc., **70**: 329–340. 1902.

reflection whereby the field is divided into a brightly illuminated half and one slightly less bright. In this case the boundary line is often very difficult to see and accurate settings can rarely be made. If a cover glass be used to cover the drop of liquid, interference bands appear in the field and increase still further the difficulty of making satisfactory settings. These interference bands can be eliminated by tilting the cover glass slip or by grinding its surfaces to a matt velvet finish.

There is, however, a still better method, by means of which the advantages of the method of grazing incidence can be had even on single drop of liquid. To accomplish this a sheet of ordinary thin tin foil, used for wrapping purposes, is first prepared by pressing it with a rubber eraser against a finely ground glass plate. By this process the surface of the tin foil is covered with fine pits, too fine to be distinguished by the unaided eye but relatively large when compared with the wave length of light. If now a drop of liquid be placed on the plane surface of the glass hemisphere of the refractometer and then covered by a sheet (10 x 20 mm.) of the prepared tin foil and monochromatic light be reflected into the hemisphere at an angle less than the critical angle (fig. 3), then the irregular surface of the tin foils reflects and diffracts the light rays back into the glass hemisphere at all possible angles with the result that the effect is strictly that of grazing incidence (light and dark field) and without disturbing interference bands. This method has proved of the greatest assistance in this laboratory in the routine measurement of the refractive indices of liquids.

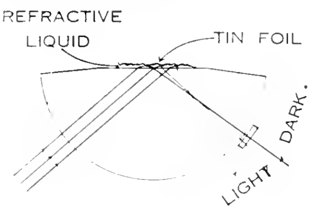


Fig. 3.

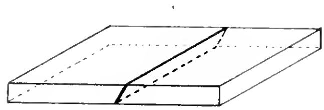


Fig 4.

New petrographic microscope stage refractometers. In many instances petrographers are unable to use the immersion methods for the measurement of the refractive indices of mineral grains, because of the lack of a suitable refractometer and, as a result, neglect such measurements altogether, even though they recognize the importance of quantitative optical work in petrography. In view of this situation, it has seemed to me worth while to try to devise a simple method for use with the petrographic microscope by means of which the refractive index of any liquid can be measured with an accuracy of $\pm$ 0.001, which is adequate for ordinary determinative purposes. A number of such methods are suggested below and with one or two exceptions, are based on the fact that the petrographic microscope, equipped with the usual Bertrand lens and a micrometer eye-piece, is a device for measuring the angle of inclination of an incident ray (as in the measurement of of the optic axial angle); and, furthermore, that its sensitiveness to slight angular differences in inclination between incident rays increases with the focal length of the objective used.

Method 5. For this method a plane-parallel plate of highly refracting lead glass (n_{Na} = 1.92) with one plane polished and one plane matt finished edge inclined at an angle of 60° is required. This plate (20 x 20 x 4 mm.) after grinding is cut into two halves at right angles to the beveled edge (fig. 4). The two halves are then placed in contact with the polished edge of the one half above the matt ground edge of the second half. A drop of liquid between the two plates is held in place by capillarity and its refractive index ascertained by observing the position (16 mm. objective, Bertrand lens, positive eye-piece with micrometer scale) of the limiting refracted ray between the light and dark fields as indicated in figure 5. This limit between the light and dark halves of the field is sharply imaged in the plane of the micrometer scale by means of which its position can be read off directly.

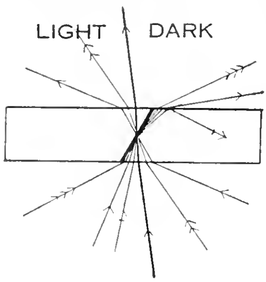


Fig. 5.

The scale is calibrated empirically once for all by the use of substances of known refractive index. Three substances, which can be had in powder form and which melt at low temperatures, can be used for calibration purposes because of constancy of refractive index for sodium light; they are "Kollolith, n_{Na} = 1.5354; benzophenon, n_{Na} = 1.598 and piperine, n_{Na} = 1.682. Liquids of known refractivity can also be used but, unless controlled by measurements on a refractometer, the refractive indices of commercial liquids are not sufficiently uniform to serve as calibration standards. After the scale has been calibrated and the points plotted, a curve can be passed through the observed points, as indicated in figure 6, which represents the values actually observed by the writer on liquids of known refractivity. The curve is a small part of a simple sine curve and is sufficiently accurate for refractive index determinations to the third decimal place. The measurements were made with a 16 mm. Zeiss apochromat objective, Bertrand lens and 0.1 mm. coördinate scale in the focal plane of a positive eye-piece. One-quarter of a division of the scale could be easily read and was equivalent to 0.001 in refractive index. With a higher power eye-piece or a moving micrometer eye-piece still more accurate readings can be made and more

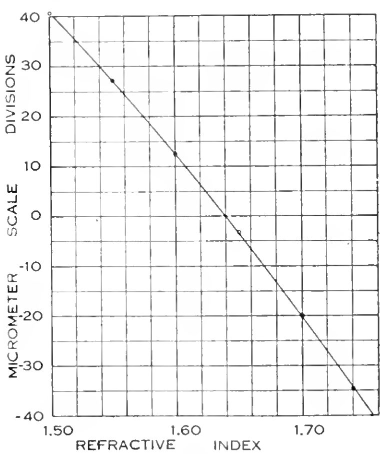


Fig. 6.

precise refractive index determinations obtained, but for most purposes the third decimal place is sufficiently exact. Still greater accuracy can be had by using plates of different refractive index, the beveled edges of which are so cut as to give the greatest sensibility to slight differences in angular inclination. In this case a lower power objective can be used and, if necessary, one or two units in the fourth decimal place obtained. The phenomena of total reflection take place at the surface of the upper plate as illustrated in figure 5. It is not essential, therefore, that the second glass plate be of the same refractivity as the first. The disturbing interference fringes, caused by internal reflection, are eliminated either by making the slope of the beveled edge of the lower plate different from that of the upper or by grinding it to a matt finish. This method is simple in principle, easy to apply and sufficiently accurate for most purposes.

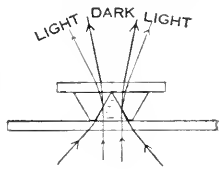


Fig. 7.

Method 6. This method is a variation of method 5. A prism of liquid is formed between a plane-parallel base plate and two small prisms of lead glass cemented to a thin plane-parallel glass plate. The path of the rays is shown in figure 7. The method of measurement is identical with that of method 5 except that here the distance between two boundary lines is taken instead of the distance of one boundary line from the center. The accuracy of this method is not appreciably greater than that of method 5; it is, moreover, less convenient to apply and, to that extent, less satisfactory.

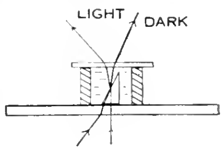


Fig. 8.

Method 7. This method is similar in principle to 5 but instead of a prism of refractive index higher than that of the liquid a prism of lower refractivity is used. A prism of fluorite (n = 1.434) or of silica glass (n = 1.459) is cut so that the inclined edge includes an angle of 65° with the horizontal face (fig. 8). The prism is placed on a small glass plate (plate glass) inside a small brass ring cemented with shellac to the glass plate. This ring is then filled to the top with a few drops of the liquid and covered with a thin plane-parallel plate. The path of the rays is indicated in figure 8. By the use of glass prisms of different refractive indices and slopes, it is possible to obtain determinations accurate to one or two units in the fourth decimal place. Ordinarily, however, with a 65° prism of fluorite it is possible to measure the refractive indices of all liquids ranging in refractive index 1.45 to 1.80 with an accuracy of ±0.001. This method requires more liquid than method 5 and is less convenient to use because of the bother of cleaning the liquid from the prism and the brass ring.

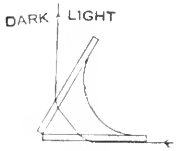


Fig. 9.

Method 8. This method involves the use of the hollow prism of method 2. Light is admitted as indicated in figure 9 and the inclination of the emergent ray is ascertained as in method 5. This method is comparable in accuracy to 5 but it is not always easy to apply because of the wide angled prisms which are required (between 70 and 80°). It is, however, less convenient than method 5, especially as the liquid in the flat lying prism tends to spread and to smear the glass plates and prism as well. For a range of refractive indices 1.50 to 1.75 at least two such prisms are necessary unless the prism be mounted on another prism so that its lower surface is inclined at an angle with the horizontal. Thus a 60° prism of liquid is obtained by grinding the one face of the prism at an inclination of +22°, and the second face at −38° with the horizontal base. The inclination of the emergent ray for a liquid of refractive index 1.50 is then +10° 06′, while for a liquid of refractive index 1.75 it is −10° 03′. Under these conditions the accuracy is identical with that of method 5, namely ±0.001. Although this method is less simple than method 5, it is theoretically superior to it in one respect; namely, it is free from any error introduced by the dispersion of the glass prism; practically this is of no significance because the refractive indices of the glass prism are definitely known for the different wave lengths.

Method 9. The device on which this method is based is illustrated in figure 10. It consists of a thick glass plate with one edge beveled by two flat surfaces, the one inclined 25°, the second at 60° to the horizontal base (fig. 11). A plane parallel glass plate (8 x 15 x 1 mm.)

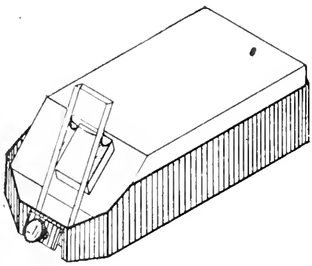


Fig. 10.

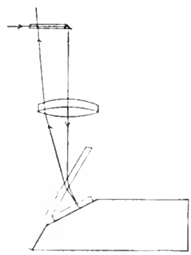


Fig. 11.

is clamped to the 60° surface by a screw clamp; while on the 25° surface a plane-parallel plate (6 x 8 x 1 mm. and silvered on the back) rests with its edge in contact with the first plate (fig. 10). A drop of liquid is held by capillarity in place as a liquid prism between the two plates. The rays from a thin total-reflecting cover glass prism[6] in the rear focal plane of a 16 mm. objective are reflected, after refraction in the liquid, back into the objective where the illuminated line image of the cover glass prism edge is viewed simultaneously with the prism edge, through a Bertrand lens and positive eye piece fitted with the micrometer scale as described in method 5. The exact position of the bright line is read off directly on the micrometer scale and thus the refractive index of the liquid ascertained for the particular wave length of light employed. As in the fore-

[6] J. Wash. Acad. Sci., 3: 234. 1913.

going methods the micrometer scale is first calibrated by means of liquids of known refractive indices. This method is slightly more accurate than method 5 but it is less convenient and requires considerably more apparatus. It is, however, not encumbered with an error, due to the dispersion of the glass.

I have also tried to apply the method of total reflection on a single inclined edge of a plate of lead glass, in imitation of the method noted in method 4 but the phenomena obtained were too faint and indistinct to be of service and no satisfactory measurements were made.

Method 10. Methods of Clerici and Viola.[7] These are based on the difference in refraction between a liquid and a small submerged glass prism (fig. 12). They are noted here simply for the sake of completeness and do not compare in accuracy with the new methods 5 to 9 described above. I have tested Clerici's methods and also Viola's modification of the same and verified Clerici's statement that his methods are accurate to ±0.005, while Viola's modification is possibly slightly more accurate, namely ±0.004. The methods are simple and easy to apply. An improvement is to use a set of fluorite or silica glass prisms (low dispersion), cut at such angles that a large deviation is obtained for slight differences in refractive index, each prism to be cemented above a 0.1 mm. scale.

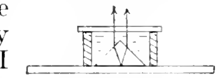


Fig. 12

Method 11. Method of Piltschikow.[8] This method is based on the focal length of a lens system, one of the components of which is the liquid whose refractive index is to be measured. The liquid is introduced into a hollow plano convex lens and the focal length of the combination measured. To increase the accuracy of setting on the exact focus only the marginal zone is used. This method requires monochromatic light and under favorable conditions should be fairly accurate. Modifications of this method were suggested by Smith[9] and Clay.[10] The writer has not had opportunity personally to test the method of Piltschikow but it is evidently less simple and accurate than method 5 described above.

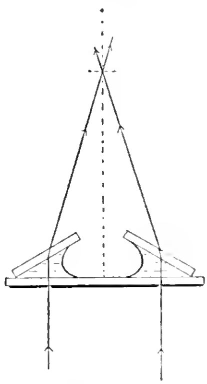


Fig. 13.

Method 12. Similar results can be obtained by the use of two hollow prisms as indicated in figure 13 or by means of a lead glass plate with two beveled edges (fig. 14). An incident beam of parallel monochromatic light and two narrow slits placed symmetrically with respect to the two prisms are required. The focus is then the line of intersection of the two refracted beams. The distance of this focus

[7] E. Clerici, Atti della Reale Academia dei Lincei, Roma, **16**: 1, 336–343. 1907; **18**: 1, 351–355. 1909; C. Viola, Ibid., **19**: 1, 192–197. 1910.

[8] J. Russ. Chem. Soc., **13**: 393. 1881.

[9] Amer. Mon. Microsc. Jour., **6**: 181–182. 1885.

[10] Treatise on Practical Light. London. 143. 1911.

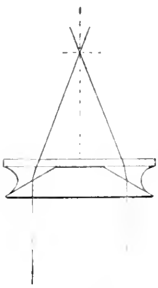


Fig. 11.

from the prisms varies with the refractive index. Its position can be fixed by means of a scale on the side of the draw tube of the microscope. For two prisms of angle 15° the variation in distance between the focal points for liquid of refractive index 1.50 to one of index 1.75 is 25.0 mm. If it were possible to focus sharply to 0.01 mm. on the indistinct bands of light, the probable error would be ±0.001 but this is not the case. The bands of light are not sharp and the exact point of central overlap is not easy to recognize. At best one might obtain the second decimal place by this method which is not satisfactory and neither the hollow prism nor the glass plate method of this paragraph are to be recommended.

SUMMARY

The refractive index is the most important optical constant with which the petrographer has to do, since its determination on a single mineral grain enables him practically to identify the mineral within narrow limits. The determination of the refractive indices of irregular mineral grains measuring 0.01 mm. in diameter is best accomplished by means of the immersion method, in which the refractive indices of the mineral grain are compared with that of the liquid in which it is immersed. In the preceding pages the measurement of the refractive index of a single drop of liquid is considered in some detail. The accuracy of the standard methods (with the exception of the Abbe refractometer methods) for this purpose is discussed and certain new modifications are suggested which render the application of such methods to a single drop of liquid possible. The use of a diffusing screen in front of monochromatic light sources is emphasized. A new type of hollow prism is suggested which has proved satisfactory and convenient, and with which accurate measurements (accurate to the fourth decimal place) can be made either by a method of autocollimation or by the minimum deviation method or by Gifford's method. The use of a cover of specially prepared tin foil on a drop of liquid to be measured on the Abbe-Pulfrich crystal total-refractometer is suggested as a satisfactory method for obtaining the phenomena of grazing incidence even on a thin film of liquid. Five new methods are also described for measuring the refractive index of a drop of

liquid with the petrographic microscope. Of these methods, method 5 which requires solely a plane-parallel glass plate of high refractive index, with one edge beveled at an angle of 60°, is the simplest and most convenient. With it the refractive index of the liquid can be easily measured to the third decimal place, an accuracy which is sufficient for all determinative purposes. The other methods are interesting and of about the same order of accuracy but they are less simple and therefore less useful. The methods of Clerici, Viola, Piltschikow, Smith and Clay are presented briefly but they are also without exception less simple and less accurate than method 5, which is accordingly the method recommended, especially as the cost of the glass plate required is slight and the amount of liquid necessary for a measurement is a very small drop. It is of the greatest importance to the science of petrology that the materials, of which it treats, be studied in a quantitative way; the refractive indices of the rock making minerals, many of which are isomorphous mixtures, are fundamental optical constants which should be measured and included in every detailed description of a rock.

PHYSICS.—*The emissivity of metals and oxides. I. Nickel oxide (NiO) in the range 600 to 1300°C.* G. K. BURGESS and P. D. FOOTE. (To appear in full in the Bulletin of the Bureau of Standards.)

The object of the present investigation has been the determination of the monochromatic (E_λ) and total emissivity (E) of nickel oxide (NiO) in the range 600 to 1300°C. This oxide forms a tough, smooth layer on the surface of nickel when subjected to high temperatures in air. Two methods were employed for the determination of the emissivity for red light: (a) that of microscopic melts, and (b) a direct comparison by a spectrophotometer of the intensity of light emitted by the glowing NiO and by a black body at the same temperature.

In the method of microscopic melts, minute specimens of NaCl, Na_2SO_4, and Au were placed on the oxide which was electrically heated until these substances melted, as observed with a microscope, and the "apparent" temperatures at the instant of melting were observed with an optical pyrometer. Hence, from the true and the apparent temperatures of the oxide, the emissivity can be computed.

In the spectrophotometric method, a nickel strip was folded, forming a wedge- or V-shaped cavity, and electrically heated until a coat of the oxide was formed. It has been shown by Mendenhall that the radiation from the interior of a V-shaped cavity is "black." The ratio of the intensities of the outside and inside of the wedge, properly corrected for temperature gradient through the walls, gives at once the emissivity at any particular wave length and temperature. Determinations by this method agreed with those by the method of microscopic melts. The monochromatic emissivity was found to increase linearly with increasing wave length from $\lambda = 0.5$ to 0.7μ and decrease linearly with increasing temperature from 700 to 1300°C. For example, at 1160°C, E_λ increases from 0.86_5 at 0.5μ to 0.88_2 at 0.7μ; and for $\lambda = 0.65\mu$, E_λ decreases from 0.95_8 at 800°C. to 0.84_5 at 1300°C.

The total radiation of NiO was investigated by means of twelve radiation pyrometers of the Thwing and Féry types, sighted upon the electrically heated oxide. The apparent temperature of the oxide for $\lambda = 0.65\mu$ was measured by an optical pyrometer and these values were corrected to true temperatures by means of the determinations on the monochromatic emissivity. E was found to increase with increasing temperature but the relation is not linear. Temperatures and E have respectively values as follows: 600°, 0.54; 800°, 0.68; 1000°, 0.76; 1200°, 0.85; 1300°, 0.87. Correction tables are required for reducing the apparent temperatures of NiO, observed with an optical or radiation pyrometer, to true temperatures.

PHYSICS.—*Flame standards in photometry.* E. B. Rosa and E. C. Crittenden. (To appear in full in the Bulletin of the Bureau of Standards.)

Although an agreement has been reached regarding the relative values of the units of light in use in different countries, no one primary photometric standard has been generally adopted by the various governments. In Germany preference is given to the Hefner lamp, in England to the pentane lamp, and in France to the Carcel lamp. Each of these serves in its own country both as the primary standard and as a working standard, but for the photometry of electric lamps and generally in accurate photometric work standardized electric incandescent lamps are used in all countries. In America a group of such lamps kept at the Bureau of Standards is considered as provisional primary standards serving to maintain the unit until a better primary standard shall have been devised. It is believed that the unit which has been agreed upon can be so maintained with an accuracy considerably above that with which it can be reproduced by reference to any of the so-called reproducible standards at present in use. In other words, the incandescent lamps have really been employed as primary standards, and the flame standards, which logically should play the part of primary standards, have been relegated to a subordinate position.

There is, however, a possibility of an appreciable drift in the value of the unit if there is no photometric standard accurately reproducible from its specifications which is capable of serving as a reliable check upon the electric standards. It has therefore appeared worth while to make a study of the best types of flame lamps to see how closely they would reproduce, in the Bureau laboratory, the values adopted by international agreement and also to find whether their reliability as primary standards could be increased by any changes in construction or in operation.

The Carcel lamp is by far the least reliable of the three types, and cannot be considered as a competitor for general acceptance. The Hefner and the pentane lamp as made at present divide honors; the latter is markedly superior as a practical standard, but individual pentane lamps do not agree, and until lamps can be independently made which shall give the same value the type can hardly be said to be reproducible. The Hefner lamp is so simple in construction that reproduction of lamps is relatively easy. Lamps now made show small differences due to slight departures from mean dimensions, but these differences can be made negligible by more careful construction. Great difficulty is experienced, however, in making accurate comparisons of working standards against Hefner lamps because of the very low intensity (0.9 candle) and the red color of the flame.

It is believed to be possible to apply the principle of the present pentane lamp in specially made, accurately specified lamps with interchangeable parts, and thus to obtain a closer agreement between lamps. Then by operating the lamps under definite conditions one should be able to obtain sufficient precision with either the Hefner or the pentane lamp to give a valuable check on the electric standards now in use.

PHYSICAL CHEMISTRY.—*A thermoelectric method for the determination of the purity of platinum ware.* G. K. BURGESS and P. D. SALE, Bureau of Standards.[1]

At the request of Dr. W. F. Hillebrand, Chairman of the Committee on Quality of Platinum Utensils of the American Chemical Society, experiments on the loss in weight due to continued and repeated heating of platinum crucibles of varying degrees of purity have been undertaken, in continuation of similar experiments carried out under the immediate supervision of members of the above-mentioned committee.

From some of these earlier experiments, and from the work of other experimenters on the evaporation of metals of the platinum group, it appears to have been hoped to be able to classify platinum ware as to purity in terms of its evaporation at a definite temperature, say 1200°C. This seemed plausible in view of the fact that the usually predominant impurity, iridium, is very much more volatile than platinum. Even if this method, however, would give an indication of the platinum purity, which appears doubtful in the light of some of our more recent experiments, it is at best a somewhat tedious and delicate operation to carry out.

These experiments showed the desirability of having an accurate and rapid method for determining platinum purity and one that could be applied to crucibles without defacing them.

[1] Presented at American Chemical Society, April 6, 1914.

The most exact method for the determination of purity of platinum appears to be by measurement of its temperature coefficient of electrical resistance, which quantity has a mean value of about 0.00391 per degree Centigrade for the interval 0° to 100°C. for the purest obtainable platinum, and decreases with the addition of anything to the platinum. This measurement can be made conveniently and exactly only with wires and is therefore of little interest for the determination of the purity of platinum ware such as crucibles.

The thermoelectromotive force of platinum against many of its alloys has also been determined with considerable exactness.[2]

This property may evidently be made use of, therefore, in devising a method for the determination of platinum purity and one that possesses, furthermore, the advantages of accuracy, speed, convenience, and preservation intact of the objects tested.

The method as developed for use with crucibles is shown in figure 1. To the rim of the crucible *C* are arc-soldered two *pure* platinum wires, at *e* and *f*, of small diameter (0.1 or 0.2 mm.); these wires are connected to an ordinary pyrometer galvanometer or millivoltmeter *G*; the junction *e* is heated by a small oxy-gas or other blast flame from *d* and the junction *f* is kept cool by an air blast *c*; a sheet of asbestos *A*, cut as shown, serves to prevent radiation from the heated portion of the crucible reaching the cold junction *f*.

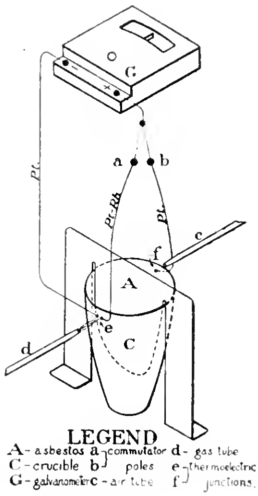


Fig. 1.

Temperatures are measured by means of a 90 Pt − 10 Rh, Pt thermocouple using the cold junction as above and a Pt − Rh wire arc-soldered to the crucible near *e*, most conveniently adjacent to (0.5 to 1 mm. distance) but not touching the Pt wire at *e*.

[2] See in particular: W. Geibel, Zs. Anorg. Ch. **69**: 38. 1910; **70**: 240. 1911; Burgess and LeChatelier, The Measurement of High Temperatures, 3d ed. 171, 1912.

Quite satisfactory results may also be obtained by simply touching the Pt wires to the crucibles at *e* and *f* without any soldering. With the apparatus once set up, a test may then be made in a few seconds and the crucible remains, of course, absolutely intact. The homogeneity of the crucible may also be determined by this method.

By means of a commutator at *a b*, measurements may be made alternately of the temperature at *e* and of the EMF developed across the crucible when *e* is at this temperature. The commutator may also be so designed as to reverse *e* and *f* if it is desired to make *f* the hot junction.

It is of course essential that the two platinum wires be made of strictly pure platinum. For this purpose, use is made of Heraeus normal thermoelement wire drawn down; this platinum has shown itself to be a standard, uniform product, which is easily controlled by the electric resistance method above mentioned.

The wires are attached at *e* and *f* by the well known arc-soldering method, which consists in making the crucible one terminal of an electric circuit of about 40 volts and a sharpened graphite pencil the other, with a rheostat in series. The operation of soldering consists in drawing a minute arc between pencil and crucible and at the same instant touching the wire to the crucible at this point. The end of the wire is thus fused to the crucibles. With a little practice this operation may be made so that there is hardly any noticeable effect on the appearance of the crucible after the wire is removed.

In the table are given the results of a series of measurements at about 1050° of the EMF of *pure* platinum against "platinum" crucibles of various makes. In figure 2 are shown the isothermal curves, at 900°, 1000° and 1100°C, for iridium content of platinum in terms of EMF against pure platinum. There is also shown the iridium equivalent of the impurities in the crucibles c, h and k of the table, in terms of their stated iridium content.

It will be noted that all impurities are, for convenience, expressed in terms of iridium content. Of particular interest is

Summary of Thermoelectric Tests of Platinum Crucibles

1	2	3	4	5	6	7	8	9	
Source or maker	Stated Ir content	Previously heated	Temperature of test	EMF: Pt *vs.* crucible	Equivalent Ir content	EMF from Pt-Ir curve (see 2 and 4)	EMF excess due to Ir or impurities	Reference letter	Remarks
	per cent	*hours*	*deg. C.*	Mv.	*per cent*	Mv.	Mv.		
Heraeus	0 0	17	1050	0 00	0 00	0.00	0.00	a	Normal thermo-element Pt
	0.7	heated	1050	2.00	0.70	2.00	0.00	b	"Tiegel platin"
	0.7	0	1050	2.60	0.90	2.00	0.60	c	"Tiegel platin"
American Platinum Works	0.2	24	1050	0.63	0.19	0.10	0.53	d	"Tiegel platin" Heraeus
	0 2	16	1050	1.00	0.35	0.10	0.90	e	"Tiegel platin" Heraeus
	0.5 to 1.5	11	1075	6.60	2.55	1.50 to 4.10	2.50 to 5.10	f	Commercial
	0.5 to 1.5	4	1085	6.40	2.50	1.50	4.90	g	Commercial
	?	0.5	1100	3.50	1.19		3.50	h	Loaned by purchaser
Baker and Company	?	10	1050	6.75	2 72		6.75	i	Commercial
	?	20	1050	6.95	2.78		6.95	j	Commercial
	2.37	0	1030	6.00	2.37	6.00	0.00	k	Special analyzed make
	0.70	12	1050	1.90	0 66	2.05	−0.15	l	Special analyzed make
	refined	0	1040	0.33	0 10		0.33	m	Specially refined
	?	3 yrs.	1100	3.00	1 01		3.00	m	Used 3 years in laboratory.
Johnston Mathey and Company	?	67	1050	0.48	0.15		0.48	n	Best crucible ware
	?	0	1070	0.68	0.23		0.68	o	Best crucible ware
	?	20	1050	0.63	0.22		0.63	p	Best crucible ware
J. Bishop	?	9 mo.*	1100	2.10	0.68		2.10	q	Loaned by purchaser
	?	0.5	1100	2.20	0.72		2.20	r	Loaned by purchaser
	refined	31	1050	0.60	0.21		0.60	s	Specially refined
Quenessen De Belmont, Legendre et Cie. . .	?	10	1050	2.79	0.98		2.79	t	
	?	0	1060	2.80	0.98		2.80	u	
	?	4	1030	1.60	0.56		1.60	v	

* Used continuously nine months.

the comparison of columns 2 and 6, the former giving the stated iridium content (and often accompanied by the statement that there are no other impurities) and the latter giving the iridium content as determined thermoelectrically by experiment and use of figure 2. In several instances, notably for the crucible of normal thermoelement platinum (a) of Heraeus and for Baker's crucible (k) of 2.37 per cent iridium, the stated and found iridium contents agree exactly. On the other hand there is a wide divergence from the supposed and actual iridium content for several of the crucibles. For example, *f* of the American Platinum Works, supposed to contain not over 0.50 to 1.5 per cent irid-

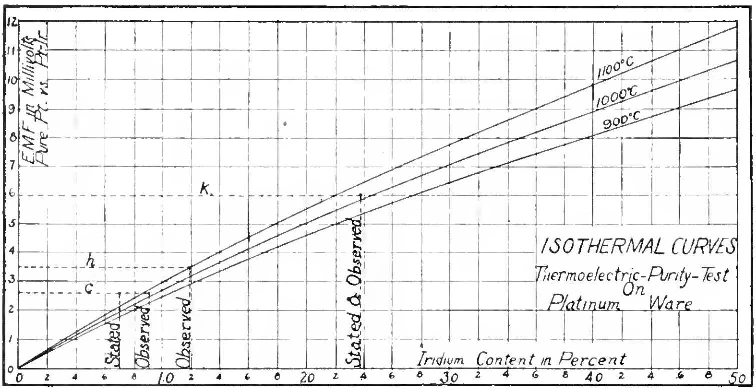


Fig. 2.

ium, actually contains an iridium equivalent of 2.50 per cent; and even in the case of refined, specially refined and best crucible ware, the equivalent iridium content is not inconsiderable. Among the 23 crucibles examined there is but one, *l* of Baker and Company, containing less iridium than stated.

In comparing the stated contents, column 2 of the Table, it should be born in mind that some of these crucibles, excepting perhaps those marked refined or specially refined, may contain iridium which is put or left in the crucible material purposely, usually for the purpose of stiffening, or in the case of commercial ware, because such Pt always carries Ir. The method here described, however, provides a delicate means of determining whether or not the desired limitation of impurity, expressed in terms of iridium content, and as measured thermoelectrically, has been met by the manufacturer. For the experimental arrangement here given, the amount of impurity is readily determined to 0.01 per cent, and this accuracy could be improved upon if necessary.

The method does not distinguish the various possible impurities from each other but is nevertheless a certain check on the platinum purity.[3] One of the most undesirable impurities often found in commercial platinum ware is iron; this is readily detected by ignition and subsequent washing with hot HCl and applying the usual color test for Fe. Iron, if present in relatively considerable quantity, will also discolor the crucible on ignition.

It would probably be advantageous to substitute rhodium for iridium in platinum crucibles when stiffness is desired and when exact weighings have to be taken before and after ignition, for the reason that rhodium is far less volatile than iridium, and somewhat less so than platinum, although it appears not yet to have been proven that the more volatile metals alloyed in small amounts with platinum retain their volatility independently of the presence of the platinum.

The above described thermoelectric method alone will not distinguish between small amounts of rhodium and iridium, but a combination of the thermoelectric and loss of weight methods might be devised that would be satisfactory. An electric discharge method operated at high temperatures might possibly be made sufficiently selective to differentiate between platinum alloys of iridium and rhodium. There is evidently room for much more work along these lines.

[3] All the metals found associated with platinum, such as palladium, iridium, rhodium, etc., when alloyed with platinum (up to 90 per cent only of palladium) give, at high temperatures, an E. M. F. of the same sign against pure platinum. Therefore there is no ambiguity or balancing one impurity against another.

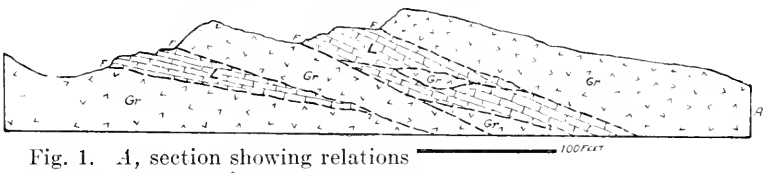
GEOLOGY.—*A peculiar fault in southwestern New Mexico.*[1]
N. H. DARTON, U. S. Geological Survey.

In a detailed study of the geology of Luna County, New Mexico, I have found a very remarkable overthrust fault which causes a sliver of granite to penetrate a mass of limestone. At first sight the relations appeared to indicate an intrusion, but closer inspection showed that the relation was caused by complex faulting.

The region is one of scattered mountain ranges and buttes rising out of wide desert plains or bolsons. Florida Mountain, in which the fault occurs, lies southeast of Deming and is one of the most prominent features in the area. This range consists of pre-Cambrian granite overlain by a succession of sandstone and limestones of Cambrian to late Carboniferous age, with a thick mass of volcanic agglomerate at its northern end. The contact of granite and basal Cambrian sandstone is exposed at various places, showing unmistakable unconformity with well-marked shore-line conditions. Much of the granite is very massive and of coarse texture, similar to the greater part of the pre-Cambrian granite of the Southwest. The range is traversed by numerous faults, many of them of great throw and with planes at various inclinations. The fault to which this paper relates is on the southwestern slope of the range, 18 miles south-southeast of Deming and nearly 2 miles due south of Gym Peak. The limestone mass penetrated by the granite is one of three small wedges overthrust onto granite and considerably isolated by erosion. The limestone contains fossils of the Pennsylvanian series of the Carboniferous. Underlying Silurian and Ordovician limestones and Cambrian sandstone are believed to be faulted out, for their presence a mile or so north apparently precludes the chance of unconformable overlap. The relations at the overthrust are represented in the following sections which show that there was a complex movement of such character that wedges of limestone are partly included in the granite and that a sliver of granite projects through one of them, as shown on a larger scale in the section B.

[1] Published with permission of the Director of the U. S. Geological Survey.

Some of the details of the relations are obscured by talus, but many of the features are clearly exposed, especially the contacts of the included sliver of granite. The latter is red, coarse-grained, and massive, of the sort which constitutes a large part of the range, and while it is greatly broken and crushed it shows no fining of grain such as occurs at igneous contacts. The limestone near the contact is not in the least metamorphosed. It is shattered and brecciated and for a foot or more includes small angular fragments of granite of various sizes, mingled with broken fragments of limestone as if the two materials had been rolled together along many subordinate fault planes. The precise



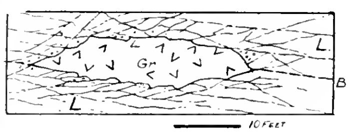


Fig. 1. *A*, section showing relations of granite to limestone at southeast end of Florida Mountain, 2 miles south of Gym Peak, southeast of Deming, New Mexico, looking east; *L*, limestone; *Gr*, granite. *B*, sliver of granite from same (larger scale).

mechanism of the faulting of the included granite sliver cannot be fully ascertained, for erosion has severed the connection on the outcrop side and the mass extends into the ridge on the other side. It is evident, however, that the granite is a wedge-shaped mass between two principal fault planes with many minor ones, along which it was carried forward into the limestone. The latter is one of several large, wedge-shaped bodies overthrust onto the granite by fault planes of low inclination. These faults are similar to one crossing the range a mile north but with planes nearer the horizontal so that erosion has removed much of the block, leaving only a few outlying masses of limestone to indicate the nature of the overthrust.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal, and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

BACTERIOLOGY.—*Pasteurization in bottles and the process of bottling hot pasteurized milk.* S. Henry Ayers and W. T. Johnson, Jr. Journal of Infectious Diseases **14**: 217–241. March, 1914.

The investigations show that very satisfactory bacterial reductions may be obtained by pasteurization in bottles for thirty minutes at 145°F. In order to obtain the best results the bottles should be steamed for two minutes before filling with milk. During heating the temperature of the milk should be recorded by a thermometer the bulb of which is one-half inch from the bottom of the bottle. When seal caps are used care must be taken to use only bottles with perfect tops for leaking caps might cause dangerous infections from polluted water. A method is given for detecting leaking caps. The advantages and disadvantages of pasteurization in bottles is discussed.

Experiments were also made on a new process for pasteurization which consists in bottling the pasteurized milk while hot in steamed bottles. It is then proposed to cool the milk by means of blasts of cold air. Excellent bacteriological results were obtained by this process. While the process of cooling by forced air draft was found to be slow as compared with the ordinary methods of cooling, the bacterial content was not affected even when five hours were required to cool the milk from 145° to 50°F.

The authors point out that this process is only in an experimental state and that further experiments are to be made on a commercial scale. L. A. Rogers.

ZOOLOGY.—*A contribution to the study of the ophiurans of the United States National Museum.* René Koehler. Bulletin 84, U. S. National Museum. Pp. i–vii, 1–173, pls. 1–18. April 9, 1914.

The present work summarizes the results of a study of a large collection of ophiurans chiefly from the West Indies and the southeastern

United States, but including a few from other localities. The richness of the material has enabled the author to describe twenty-four new species and a new genus, *Ophiomisidium*, and to make critical studies of several species which were imperfectly known up to this time.

To make the record complete for the West Indian ophiurans in the National Museum, a list is appended of those species identified many years ago by the Hon. Theodore Lyman, with the localities for each.

MARY J. RATHBUN.

ZOOLOGY.—*Monograph of the shallow-water starfishes of the North Pacific coast from the Arctic Ocean to California.* ADDISON EMERY VERRILL. Harriman Alaska Series, vol. XIV. Smithsonian Institution, Publication 2140. City of Washington, April 30, 1914. Part I: Text. Pp. i–xii, 1–408, text figures 1–16. Part II: Plates. Pls. 1–110.

This, which is the first volume of the Harriman Alaska Series to be published by the Smithsonian Institution, is based on collections from the Harriman Expedition, the Canadian Geological Survey and various museums and individuals. The introduction deals with the richness of the fauna and the food, migrations, larval stages, senses and variations of starfishes. More than half of the systematic part is devoted to the family Asteriidae, for which there is given an analytical table of the genera and species, etc., occurring in the region. Discusses the relations of this and other faunae and closes with a bibliography.

Seventeen new genera and many new species, subspecies and varieties are described. MARY J. RATHBUN.

ZOOLOGY.—*Notes on some specimens of a species of onychophore* (Oroperipatus corradoi) *new to the fauna of Panama.* AUSTIN HOBART CLARK. Smithsonian Miscellaneous Collections **63**[2]: 1, 2. February 21, 1914.

Four specimens of *Oroperipatus corradoi* (Camerano), collected by Mr. James Zetek at Ancon, Panama Canal Zone, are described in detail and a list is given of all the species of onychophores which are known to occur in the Canal Zone. A. H. C.

ZOOLOGY.—*A monograph of the foraminifera of the North Pacific ocean: Part III, Lagenidae.* JOSEPH A. CUSHMAN. Bulletin 71, U. S. National Museum. Pp. i–ix, 1–125, pls. 1–47. December 12, 1913.

The present volume, which is the third of a series dealing with the foraminifera of the North Pacific ocean, relates wholly to members of the family Lagenidae, distributed among 5 subfamilies and 12 genera, all of these previously recognized. The method of treatment is uniform with that of the preceding parts. Comparatively few species are described as new. W. R. M.

ANTHROPOLOGY.—*Culture of the Ancient Pueblos of the Upper Gila River region, New Mexico and Arizona. Second Museum-Gates expedition.* WALTER HOUGH. Bulletin 87, U. S. National Museum. Pp. i–xiv, 1–139; pls. 1–29; figs. 1–348. February 13, 1914.

This paper is a study of the material collected by the second Museum-Gates expedition on the upper Blue, San Francisco, and Tularosa rivers, New Mexico and Arizona.

The expedition was singularly fortunate in collecting a large series of articles from a ceremonial cave on Blue River, Arizona, and from a cave on Tularosa River which had been filled with debris from habitations built across its opening. Excavations were made also in several open air Pueblos, notably a large group at Blue P. O., Arizona. In this way a rather wide view of the culture of this region was obtained. A great many articles relating to natural history were secured also, and the discussion of these forms the first chapter of the book. Following this the objects of stone, bone, and shell, of pottery, of wood, and of textiles, and religious objects are described. The concluding section describes a number of mummied human remains from the ruins.

The Pueblos in this region have evidently been extinct for many centuries. Coronado traversed this region in 1540 and found no inhabitants. The culture here was mainly homogeneous with the ancient culture of other parts of the Pueblo region, some resemblances and differences being noticeable. Perhaps the culture was little higher than that of the northern area in certain respects.

Wherever it was possible in discussing religious objects these are correlated with surviving customs among the modern tribes. This branch of the work is necessarily very incomplete, since there is a deplorable lack of information with regard to the existing Pueblos. Nevertheless such comparisons as can be made show a surprising continuity of religious customs and paraphernalia down to the present.

W. H.

REFERENCES

Under this heading it is proposed to include, by author, title, and citation, references to all scientific papers published in or emanating from Washington. It is requested that authors coöperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

AGRICULTURAL CHEMISTRY

ALWOOD, W. B. *Crystallization of cream of tartar in the fruit of grapes.* Journal of Agricultural Research **1**: 513, 514. March 25, 1914.

CHAPIN, R. M. *The reduction of arsenic acid to arsenious acid by thiosulphuric acid.* Journal of Agricultural Research **1**: 515–517. March 25, 1914.

COX, J. H. *A special flask for the rapid determination of water in flour and meal.* Bulletin of the U. S. Department of Agriculture, No. 56. Pp. 1–7. January 28, 1914.

SKINNER, J. J., and SULLIVAN, M. X. *The action of manganese in soils.* Bulletin of the U. S. Department of Agriculture, No. 42. Pp. 1–32. April 3, 1914.

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SHOREY, E. C. *The presence of some benzene derivatives in soils.* Journal of Agricultural Research **1**: 357–363. February, 1914.

TURRENTINE, J. W. *The fish-scrap fertilizer industry of the Atlantic coast.* Bulletin of the U. S. Department of Agriculture, No. 2. Pp. 1–50. December 27, 1913.

BOTANY

DORSETT, P. H. *Experiments in bulb growing at the United States bulb garden at Bellingham.* Bulletin of the U. S. Department of Agriculture, No. 28. Pp. 1–21. November 11, 1913.

FAIRCHILD, D. *Experiments with udo, the new Japanese vegetable.* Bulletin of the U. S. Department of Agriculture, No. 84. Pp. 1–15. April 16, 1914.

GRIFFITHS, D. *Behavior, under cultural conditions, of species of cacti known as Opuntia.* Bulletin of the U. S. Department of Agriculture, No. 31. Pp. 1–24. December 30, 1913.

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MANN, A. *Coloration of the seed coat of cowpeas.* Journal of Agricultural Research **2**: 33–56, figs. 1, 2, pl. 6. April 15, 1914.

MARSH, C. D., and CLAWSON, A. B. *Cicuta, or water hemlock.* Bulletin of the U. S. Department of Agriculture, No. 69. Pp. 1–27. March 28, 1914. (A review of the literature on the poisonous action of *Cicuta vagans*, and results of tests of its poisonous effect on sheep and cattle.—C. S. S.)

Piper, C. V., and others. *Alfalfa seed production; pollination studies.* Bulletin of the U. S. Department of Agriculture, No. 75. Pp. 1–32. April 8, 1914.

Sampson, A. W. *The reseeding of depleted grazing lands to cultivated forage plants.* Bulletin of the U. S. Department of Agriculture, No. 4. Pp. 1–34. October 27, 1913. (An account of experiments made in several National forests.—C. S. S.)

Sampson, A. W. *Range improvements by deferred and rotation grazing.* Bulletin of the U. S. Department of Agriculture, No. 34. Pp. 1–16. December 31, 1913.

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FORESTRY

Betts, N. deW., and Heim, A. L. *Tests of rocky mountain woods for telephone poles.* Bulletin of the U. S. Department of Agriculture, No. 67. Pp. 1–28. March 17, 1914.

Frothingham, E. H. *White pine under forest management.* Bulletin of the U. S. Department of Agriculture, No. 13. Pp. 1–70. February 24, 1914.

Maxwell, H. *Uses of commercial woods of the United States.* Bulletin of the U. S. Department of Agriculture, No. 12. Pp. 1–56. October 11, 1913. (Gives physical properties, sources of supply, and commercial uses of the species of beech, birch, and maple.—C. S. S.)

Shinn, C. H. *An economic study of acacias.* Bulletin of the U. S. Department of Agriculture, No. 9. Pp. 1–38. December 5, 1913. (Discusses uses of the commercial products of Acacias and recommends species and methods of planting, chiefly in California.—C. S. S.)

Sterrett, W. D. *Forest management of loblolly pine in Delaware, Maryland, and Virginia.* Bulletin of the U. S. Department of Agriculture, No. 11. Pp. 1–59. January 23, 1914.

Williamson, A. W. *Cottonwood in the Mississippi valley.* Bulletin of the U. S. Department of Agriculture, No. 24. Pp. 1–62. December 31, 1913. (Gives methods of planting, rate of growth, and commercial uses of the cottonwood, *Populus deltoides.*—C. S. S.)

Zon, R. *Balsam fir.* Bulletin of the U. S. Department of Agriculture, No. 55. Pp. 1–68. March 25, 1914. (An account of the distribution of *Abies balsamea,* its economic importance, methods of lumbering, structure of the wood and rate of growth, with data on yield, volume and weight of lumber and wood.—C. S. S.)

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 282d meeting was held at the Cosmos Club, March 25, 1914.

INFORMAL COMMUNICATIONS

Reactions of nickel arsenides with silver salts: Chase Palmer.

An occurrence of chrysotile asbestos at Ash Creek, 35 miles northeast of Globe, Arizona: J. S. Diller.

Concave exfoliation: F. E. Matthes. Concave exfoliation in massive granite under the bed of Yosemite Creek, in the Sierra Nevada, was described as an illustration of the diversity of form which shells resulting from superficial exfoliation may exhibit. Such shells, far from being always spherical may be plane, or even concave, according to the configuration of the surface upon which they develop.

Radial barite concretions from the Cretaceous of southeastern Montana: C. A. Bonine.

REGULAR PROGRAM

Stratigraphy of the Red Beds in New Mexico (illustrated): N. H. Darton. In this communication there was presented an outline of the results of study of the central and western parts of the Red Beds area in New Mexico during the past summer. The investigation was primarily a search for evidence which might lead to the discovery of potash deposits in the Red Beds, and this part of the work is not yet finished. Close attention was given to the stratigraphy, especially as to relations and succession of gypsum deposits and other desiccation products, with a view to determining areas in which chemical deposition had continued longest. Much new light was obtained on the relations and development of a great series of alternating limestones and gypsum deposits, the San Andreas limestone of Lee, which separates a thick lower formation of red beds from an upper formation of red beds in a wide area in central New Mexico. Some attention was given to the separation of the Triassic portion of the Red Beds in part of the area. Evidence was obtained as to the possible extension of Jurassic rocks into the region, and the probable Morrison formation was traced far to the south and southwest in New Mexico.

Moraine Dome and the moraines of the Little Yosemite Valley (illustrated): F. E. Matthes. Moraine Dome is a low granite dome on the north side of the Little Yosemite Valley, in California, of interest chiefly for the moraines and other glacial features associated with it. The ice of the last glacial epoch, when at its highest, split upon the northeast end of the dome and pushed a short lobe through the saddle to the north, as is shown by the successive moraines doubling around the eminence.

The course of these moraines throughout exhibits an independence of the trough edge, suggesting strongly that the formation of the trough was not the work wholly of the ice invasion represented by the moraines in question. The trough evidently existed previous to the advent of the later ice and was only modified by the latter. In this regard, the indications of the moraines of the Little Yosemite Valley are similar to those in other localities in the Yosemite region. Accordingly valley troughs hewn one within the other are not to be correlated with separate ice invasions, but appear to have been traversed and enlarged by each of these in succession.

Moraine Dome is of interest, further, in that it affords approximate measures of the depth of denudation suffered by its mass since the later as well as the earlier ice epochs. Old surface shells preserved from disintegration by the uppermost moraine of the later ice, and recently uncovered by rain wash, show that since the moraine was deposited a thickness of about 3 feet of granite has disappeared from the surface of the dome.

On the crown of Moraine Dome a vertical dike of aplite has weathered out in the form of a little wall, eight feet high. Several large erratics near by, composed of a coarsely porphyritic granite from the crestal portion of the Sierra Nevada, one of them mounted on a pedestal about 4 feet high, show beyond doubt that the dome was overridden by the earlier ice. It is clear, therefore, that the aplite dike has weathered out since the retreat of the earlier ice, and that its height may be taken as an approximate measure of the depth to which the dome has been denuded since that date.

The occurrence of carnotite in eastern Pennsylvania: EDGAR T. WHERRY. Carnotite occurs near Mauch Chunk, Carbon County, Pennsylvania, as an impregnation in a conglomerate. Analysis shows it to be high in potassium and low in calcium, the uranium and vanadium showing the usual 1:1 ratio. The features of the rock indicate that the last two metals have accumulated by local concentration of minerals containing them during sedimentation, rather than by precipitation from solution, which has been thought to account best for the features of the Colorado and Utah deposits. Investigation of the commercial value of the deposit is now in progress.

The 283rd meeting was held at the Cosmos Club, April 8, 1914.

INFORMAL COMMUNICATIONS

Correlation of the Hawthorn formation: T. WAYLAND VAUGHAN and C. WYTHE COOKE, presented by Mr. Vaughan. (See this JOURNAL, **4**: 250. May 19, 1914.)

Occurrence of the mineral hisengerite in central Idaho: D. F. HEWETT.

REGULAR PROGRAM

Petrographic evidence on the origin of the Catahoula sandstone: M. I. GOLDMAN. The object of the study was to find what lines of evidence are available for throwing light on the origin of a quartz sandstone with no striking peculiarities. Most of the determinations depended on the fact that the sandstone has an opaline cement which could be decomposed by boiling with KOH.

The features observed and their interpretation were as follows:

1. Size: Although there is a marked predominance of 0.5 to 0.25 mm. grains, it is not as pronounced as in typical beach sand, resembling rather wind blown sand such as seems to be produced by the strong winds of the tropics.

2. Degree of rounding: Some grains show wonderfully perfect rounding, thus suggesting wind action.

3. Lower limit of rounding: This is the essential factor in rounding, since it is in this that the action of wind and water are believed to differ. The smallest well rounded grains found measure 0.035 mm. diam. This corresponds to the lowest limit found by Fruh in some Pampas soil and is therefore believed to indicate aeolian origin, though the lowest limit for water rounding is not known.

4. Proportion of rounded grains: This is low (28.7 per cent) and in view of the perfect rounding of some of the grains is taken to indicate that fresh angular material was constantly added, which would correspond to the conditions in an arid region.

5. Weathering of the feldspars: Many of these seem remarkably fresh, suggesting the mechanical disintegration of an arid region.

6. Proportion of weathered feldspars: About half are weathered, which, according to Machie's studies, is too much for an arid region, but this condition may have been produced after deposition.

7. Proportion of different species of feldspar: Orthoclase 85 per cent, microcline 13 per cent, plagioclase 2 per cent. The low plagioclase suggests conditions of humid weathering which as stated under (6) may have been subsequent to deposition.

8. Ratio of feldspar to quartz: Feldspar forms 39 per cent of the mass, which is a high percentage for sandstones and like (4) suggests constant addition of fresh material as under arid conditions. It also is evidence against the production of the sizing by beach waves and in favor of wind.

9. Proportion of heavy minerals: In the portion between .05 mm. and 0.25 mm. diameter the heavy minerals amount to 1.1 per cent. This is very low for aqueous deposition, high for a mature desert dune, but might correspond to an arid region where the supply of fresh material is kept up.

10. Species of heavy minerals: The dominant heavy minerals are magnetite and zircon. Zircon is a mineral very resistant to alteration agencies, and magnetite may also be. Practical absence of epidote and chlorite indicates arid conditions.

11. Ratios of heavy minerals to each other: The insignificant quantity of fissile minerals like the micas and ferromagnesian minerals strongly indicates arid conditions.

12. Bedding: Absence of thin bedding indicates rapid accumulation by wind or water currents.

13. Arrangement of fossils: (a) Curled leaves and prints arranged at random point to burial by wind, (b) bunches of leaves fairly flat and

parallel but not on one plane indicate quiet bodies of water into which sand was blown.

14. Clay galls: Clay galls are a characteristic product of a sandy region with temporary bodies of water.

15. Pore space, or packing: The Catahoula sandstone appears loosely packed. The evidence is still very uncertain, but this seems to correspond rather with beach and dune sands.

16. Fossil evidence: The plants which are (according to E. W. Berry) nutmeg, date palm, and palm (unidentified) indicate a tropical coast. Bones of camel and rhinoceros, found near by in the same formation, also indicate a warm climate.

Conclusion: The weight of evidence is for an arid, tropical, sandy region with permanent or temporary bodies of water.

The probable mode of origin of the Lewis overthrust: M. R. CAMPBELL. No abstract.

Auriferous pocket deposits of the Klamath Mountains, California: H. G. FERGUSON. No abstract.

The 284th meeting was held at the Cosmos Club, April 22, 1914.

INFORMAL COMMUNICATIONS

Origin and mode of formation of magmatic gases: STANISLAS MEUNIER, read by C. N. Fenner. (See this JOURNAL, **4**: 213. May 4, 1914.)

So-called waterlaid loess of the central United States: E. W. SHAW. Photographs and specimens of stratified loess from southwestern Kentucky and Yazoo City and Edwards, Mississippi, were exhibited. Much of the stratified loess which has been reported appears to be some other material, though some of it has been derived by wash from nearby outcrops of loess. For example, the stratified loess reported from southwestern Indiana appeared to the speaker to consist of a stream terrace deposit, some windblown sand and some true unstratified loess. However, true loess is, in rare instances, really stratified. The stratification is of a somewhat peculiar type, apparently not involving variations in size of grain. The bedding planes are parallel to the top and base of the deposits and are marked by very thin dark bands which seem to consist of carbonaceous material and are probably the remains of layers of vegetable material, perhaps forest litter developed at times when loess deposition was interrupted, or at least unusually slow. The facts that the stratification does not involve sorting of the component grains, and that it is not horizontal, but parallel to the present and pre-loess surfaces, seems to indicate that even where stratified the loess is not a water-laid deposit. Indeed, it seems surprising that the loess, if wind deposited, does not show more general stratification of this nature because of the annual fall of forest leaves, and other interruptions in deposition.

REGULAR PROGRAM

The characteristics of the Mississippi delta in the light of some observations on Old World deltas: E. W. Shaw. Certain phenomena, particularly irregular subsidence on land and the upheavals off shore known as mud lumps, suggest that the Mississippi delta is affected by internal flowage, and in the hope of obtaining important side lights on this and other problems a brief examination has recently been made of many large and small deltas of Europe, northern Africa, and western Asia. The progress made in understanding the Mississippi delta was, however, through the observation of dissimilar, rather than similar characters, for each delta seems to be built on individual specifications. The Mississippi delta appears to be unique in the rapidity of its growth, in the fineness and arrangement of the materials composing it, and in other characters which seem related to these, such as the extreme development of the bird foot form, the narrowness, depth, and stability of its stream channels, and a condition of unstable equilibrium.

The stability of a delta appears to depend principally on its thickness, the slope of its front, the proportion of sand in the river's sediment, the extent to which this sediment is washed by the sea or lake, the rate of growth, and the degree to which the fine watery sediment is separated into layers of wide extent. In all characters favoring instability the Mississippi delta seems to lead. The thickness is thousands of feet. The front, though not steeper than that of many sand deltas, is very steep for a mud delta, and might be steeper were it not for flowage. The river delivers to the sea relatively little sand, and most of that is brought at times of high water. The sea does not sort or carry away much of the sediment, so that the delta grows rapidly and layers of sandy silt corresponding to high stages of the river are separated by layers consisting of soft flocculated clay and other fine watery material. All these factors conduce to fluidity.

The fishes of the Lahontan drainage system of Nevada and their relation to the geology of the region: JOHN OTTERBEIN SNYDER. A considerable part of Nevada and the eastern slopes of the Sierra Nevada of California are drained by rivers, the waters of which do not reach the ocean but ultimately find their way into large lakes where the inflow is balanced by evaporation. The waters of some of these lakes are so charged with mineral salts as to be practically lifeless, while others, Pyramid and Winnemucca lakes, for example, fairly teem with fishes. The more recent geological history of this region has been worked out and narrated in a masterly way by Israel Cook Russell.[1] His account begins with the Quaternary times, when Lake Lahontan covered a large area with a maximum depth of more than 880 feet, and continues down to the present, when nothing is left of the ancient lake but its desiccated remains scattered here and there over a rock-bound waste of desert sands. Two of Russell's conclusions are of particular interest when viewed in connection with the results of an investigation of the fish fauna of the system: First, that the lake had no outlet; and, sec-

[1] Russell, Israel Cook. Geological History of Lake Lahontan, a Quaternary Lake of Northwestern Nevada: U. S. Geol. Surv. Monograph No. 11, Washington. 1885.

ond, that its desiccation lately became complete and remained so to within the last three hundred years. Russell arrived at the first conclusion through a study of present conditions and a careful reconnaissance of the rim of the basin. In this he is supported by the ichthyology of the region, as nearly all of the species are indigenous, thus indicating long isolation. He was forced to adopt the second hypothesis to account for the comparatively fresh condition of the waters of Pyramid Lake. In this he receives no support from a study of the fishes, but on the contrary the facts thus derived point distinctly to the presumption that the present Pyramid and the ancient Lahontan lakes have been continuous since Quaternary times and that their waters have been constantly fresh enough to support animal and plant life.

The upper Cretaceous formations of western New Mexico and their relations to the underlying rocks: D. E. Winchester. In the area surrounding the Zuni Mountains in western New Mexico, the Upper Cretaceous is represented by the Mesaverde, Mancos, and Dakota formations, with the latter resting unconformably on older strata. In a section of these formations near the Tres Hermanos Buttes, southeast of the Zuni Mountains, the Dakota is represented by a single conglomeratic sandstone or quartzite bed, varying in thickness from 1 to 40 feet. The Mancos (1800 feet thick) is more than 60 per cent sandstone and includes four massive, persistent sandstone beds which stand out as prominent cliffs wherever exposed. In its type locality, 200 miles to the north, the Mancos is entirely shale. Between these two localities near Gallup, New Mexico, there is a large amount of drab, fissile shale, but the section is still predominantly sandy. The Mesaverde formation in the Tres Hermanos section contains no persistent massive sandstone, as it does in its type locality 200 miles to the north. In New Mexico both the Mancos and the Mesaverde formations are coal-bearing, while in their type locality in southeastern Colorado, only the Mesaverde contains coal. Lithologically, then, there is a marked change especially in the Mancos between the area about the Zuni Mountains and the type locality to the north, indicating, as has been suggested by W. T. Lee, that the mountains furnishing the sediments were located to the south of both sections.

The unconformity between the Upper Cretaceous and underlying sediments is very marked. At Zuni, on the west side of the Zuni Mountains, the Dakota rests on top of 475 feet of Zuni sandstone, while at Atarque, 23 miles south, there is only about 75 feet of Zuni sandstone beneath the Dakota. On the east side of the mountains conditions are similar, with about 450 feet of Zuni sandstone beneath the Dakota at Acoma and the sandstone entirely absent near Tres Hermanos Buttes, 22 miles south. If the Zuni sandstone is to be correlated, as apparently it should be, with the La Plata sandstone of southwestern Colorado, pre-Dakota erosion has also removed all, or nearly all, of the McElmo formation (500 to 600 feet) in the area surrounding the Zuni Mountains.

Frank L. Hess, *Secretary.*

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PHYSICS.—*The optical character of the faint interference figure observed in high power objectives between crossed nicols.* Fred. Eugene Wright, Geophysical Laboratory.

To the petrologist the appearance, under crossed nicols, of a faint, apparently uniaxial interference figure in an objective of short focal length is a matter of common observation. It was at first considered to be the result of strain in the objective lenses but Rinne[1] in 1900 gave the correct explanation of the phenomenon and ascribed it to the rotation of the vibration plane of the transmitted plane-polarized waves at the steeply inclined lens surfaces. Rotation of this kind was noted by Fresnel[2] who deduced, in 1822, for plane-polarized waves transmitted through an isotropic plane parallel plate, the equation

$$\cot B = \cos^2 (i - r) \ . \cot A, \tag{1}$$

in which the angle of rotation B is expressed as a function of (a) the angle of incidence i, (b) the azimuth A of the plane of vibration of the incident plane-polarized light wave, and (c) the refractive index of the glass plate (contained in the expression $i - r$, r being the angle of refraction). This equation has been frequently verified by experiment and found to represent the observational data satisfactorily.

From Fresnel's equation it is evident that: (1) in case the vibration direction of the incident wave is parallel or normal to the plane of incidence ($A = 0°$ or $90°$) the vibration plane of the

[1] Centralblatt f. Miner. 1900, 88–89; see also C. Césaro, Bull. de l'Acad. Roy. de Belgique, Cl. d. Sci. 1906, 459; and F. E. Wright, Amer. J. Sci. (4), **31**: 187. 1911; Carnegie Inst. of Washington, Pub. **158**: 74–76. 1911.

[2] Oeuvres, **1**: 441–799.

incident wave is not rotated on transmission ($B = 0$); (2) for a given angle of incidence i the maximum rotation is obtained when the wave front normal is included in the diagonal plane between the principal planes of the crossed nicols (azimuth angle $A = 45°$); (3) the angle of rotation increases with the angle of incidence i.

Now a spherical surface may be considered to consist of a series of minute planes inclined at all angles with the vertical and in all azimuths. The rotatory effect of such a surface on transmitted plane-polarized light waves is, therefore, different in different directions, the result being a distinct uniaxial cross with quadrants whose intensity of illumination increases with the distance from the center. This is, in brief, the explanation of the faint uniaxial cross which appears in all high power objectives between cross nicols. The plane polarized light waves whose normals are parallel to the principal planes of the nicols suffer no rotation, while all others are rotated to an increasing extent as their azimuth A increases until the maximum rotation at 45° is reached. The reasons why these phenomena are so much more distinct in high power than in low power objectives are, (1) the larger numerical aperture of high power objectives and (2) the fact that in such objectives the front lens of the system is a small uncorrected glass hemisphere at whose steeply inclined sides the transmitted light waves are rotated through relatively large angles.

If now a sensitive tint plate be inserted along the $NW-SE$ diagonal, between crossed nicols either below the condenser or above the objective the quadrants of the faint interference cross, observed in the upper focal plane of the objective, appear differently colored, the northeast and southwest quadrants being blue-green and the remaining two quadrants orange yellow, or vice versa if the sensitive tint plate be inserted along the $NE-SW$ diagonal. The arms of the interference cross assume the color of the sensitive tint plate irrespective of the direction along which it is inserted. These interference colors appear much more distinct when the sensitive tint plate is inserted so that its vibration directions include only a small angle (1° to 10° depending on the intensity of illumination) with the principal nicol planes.

This distribution of colors in the interference figure on insertion of the sensitive tint plate is precisely that observed on a weakly birefracting, optically positive, uniaxial mineral under similar conditions and would lead one to infer that the objective is uniaxial and optically positive in character. All high power objectives show this behavior and it is of interest to inquire into the cause of the conversion of an isotrophic substance, like glass, into an apparently uniaxial, optically positive substance. The problem can be solved both by experiment and by theoretical computation.

Experiment 1. Remove from the petrographic microscope the condenser, objective and eye piece and place a sensitive tint plate between the crossed nicols so that one of its vibration directions includes only a small angle (+2°) with the principal plane of the polarizer. Turn the analyzer through a small angle (+4°) clockwise and note that the interference color changes from the sensitive tint to a greenish hue; if now the analyzer be rotated counterclockwise to −2° the hue changes from green through the sensitive purple tint to a magenta. Further rotation of either the sensitive tint plate or the analyzer through large angles increases the illumination of the field to such an extent that the faint differences in color hue are practically masked and cannot be readily detected.

Experiment 2. Prepare fine glass beads, 0.1 to 0.5 mm. in diameter, by fusing the end of a fine glass thread in a small Bunsen flame. observe the beads under a low power objective between crossed nicols and note that interference phenomena, similar to those recorded above in the high power objective, appear when the sensitive tint plate is inserted in the different positions, especially when its vibration directions include only a small angle with the principal nicol planes. The same statement holds true for small air bubbles in Canada balsam or glycerine.

Experiment 3. Observe that on the outer margins of the glass beads of experiment 2 the color phenomena are reversed, a narrow blue-green fringe appears as a frame about the orange yellow quadrants and an orange yellow line on the periphery of the blue green quadrants. The same phenomena are clearly shown on the air bubbles in Canada balsam and glycerine. If the optical character were judged by these outlying colors alone, it would be uniaxial negative. The air bubbles and glass beads appear, in short, to be optically positive in the center and optically negative at the margins.

Experiment 4. Place small drops (0.5 to 1 mm. in diameter) of mercury on an object glass under a low power objective. Raise the condenser, so that steeply inclined rays are reflected from the equatorial zone of the upper half of the mercury drops. Observe that only the outer margin of each drop is illuminated and that the intensity of illumination is not uniform, the circular field being divided into four quadrants, the dark dividing lines corresponding to the zero isogyres of the interference figure. On insertion of the sensitive tint plate these quadrants become brightly colored, two opposite quadrants in blue green tones and the other two in orange yellow tones. The colors are remarkably brilliant and correspond in their distribution to that of a uniaxial optically negative mineral. If monochromatic light be used the angular rotation for each part of the field can be determined by rotating the upper nicol and testing the position of extinction by means of the bi-quartz-wedge plate and then, by use of Fresnel's equation for the rotation of plane-polarized light waves on reflection, the refractive index of the mercury can be computed for the particular wave length of light employed.

Experiment 5. Cement to the two sides of a small 45° total reflecting prism two strips of plane-parallel glass (carefully selected cover glass strips serve the purpose well) so that the ends of the glass strips extend 6 or 8 mm. beyond the edge of the prism. Drill a hole transversely through a brass cylinder and insert a brass rod in the same. Lacquer the inside of the brass cylinder with a matt black. Cement the hypothenuse face of the prism to this rod, so that the prism edge is at right angles to the axis of rotation of the rod (fig. 1). If now the axis of rotation be placed parallel with one of the principal nicol planes, the two glass plates can be rotated and in every position the angle of incidence i for both plates is the same while the azimuth angles A are of opposite sign.

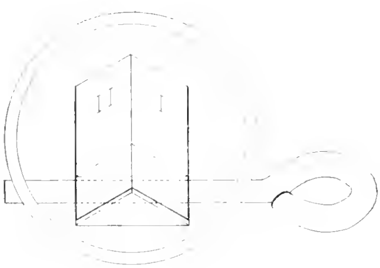

Fig. 1

The effect of this arrangement is analogous to that of a half shade apparatus, namely, that, if in the one quadrant the angle of rotation of the transmitted plane-polarized waves is $+A°$, it is $-A°$ in the adjacent quadrant. If now the sensitive tint plate be placed between the crossed nicols, the color phenomena described in the preceding experiments appear clearly marked; by rotating the prism all gradations between the undisturbed sensitive tint purple to bright green in the first quadrant and yellow in the second can be obtained. This experiment illustrates clearly the principle underlying the interference phenomena observed in the lenses of a high power objective.

Experiment 6. Since the amount of rotation of refracted or reflected light waves at inclined surfaces of an anisotropic substance depends on the difference in refractive index between the substance and the surrounding medium, it is proper to infer that, in case a glass bead be immersed in a liquid of the same refractive index, no rotation will occur and hence no color phenomena will be observed. This is approximately correct, though in many instances the color phenomena are far more distinct under such conditions than one might expect and the question arises as to the refractive index of the surface film of the glass bead. Such a film is under the influence of surface tension forces and hence is exposed to a different set of mechanical forces than that which obtains inside the bead. It is, therefore, natural that its refractive index (expression of influence of original system of forces on light wave system of forces) should be different. To test this conclusion still further a mixture of alcohol and ether on the one hand was prepared and a second mixture of water and glycerine. Now these mixtures have the same refractive index for sodium light, the same density and approximately the same dispersion. On shaking the two together the alcohol and ether form small drops suspended in the water-glycerine mixture and furnish, therefore, an excellent system for testing the idea that the refractivity index of the surface film may be different from that inside the drops. Although experiments along this line are still in progress it may be stated that the evidence so far obtained is not sufficiently definite to warrant definite statements.

The above experiments prove conclusively that the apparent optically positive character for transmitted plane polarized light rays and optically negative character for reflected rays when tested by means of the sensitive tint plate, is due to rotation of the plane of vibration at the steeply inclined surfaces of the isotropic substance. In passing from one isotropic substance to a second the direction of vibration remains, of course, in the same plane but the azimuth of the plane of vibration changes (suffers rotation) because of the change of direction of the ray (wave normal) on refraction.[3]

The phenomena exhibited by the objective on insertion of the sensitive tint plate can also be deduced by computation from the standard Fresnel formulas. The angle of rotation of the plane of vibration for any plane-polarized wave entering a plane surface of an isotropic substance of refractive index n at an angle of incidence i and an azimuth angle E is given by the equations

$$\sin i = n \sin r,$$
$$\cot B = \cos (i - r) . \cot A.$$

For a ray transmitted through a plate, equation 1 is valid. But ordinary white light consists of light of all wave lengths throughout the visible spectrum and the angle of rotation varies slightly with the change in wave length but it is so slight that for the pres-

[3] For a more complete discussion of these phenomena, see Carnegie Institution of Washington, Pub. **158**: 75–79. 1911.

ent purposes it may be neglected. Having given the angle of rotation B of the plane of vibration the problem resolves itself practically into a determination of the intensity of illumination for the different parts of the visible spectrum for different relative positions of the sensitive tint plate and the analyzer, the resulting color being the integral result of the distribution of color intensity over the entire visible spectrum.

For this purpose the standard Fresnel intensity equation

$$I = \cos^2 \varphi + \sin 2 (\varphi - \vartheta) \sin 2 \vartheta \,.\, \sin^2 \pi \,.\, \frac{d(\gamma' - \alpha')}{\lambda} \qquad (2)$$

is applicable, in which I is the percentage intensity of illumination, φ, the angle included between the two nicols, ϑ, the angle which the vibration direction γ of the sensitive tint plate includes with the principal plane of the analyzer, d the thickness of the sensitive quartz plate used, $\gamma' - \alpha'$, the birefringence of the quartz sensitive tint plate for the particular wave length λ of light employed. The results of computation by this equation of the intensity of the transmitted light for different angles φ and ϑ, and wave lengths λ for a quartz plate 0.03 mm. thick (thickness for the sensitive tint whereby the path difference for $\lambda = 550\mu\mu$ is half a wave length and $\sin^2 \frac{d(\gamma' - \alpha')}{\lambda} = 1$) cut parallel to the principal axis are listed in Table 1 and presented graphically in figure 2.

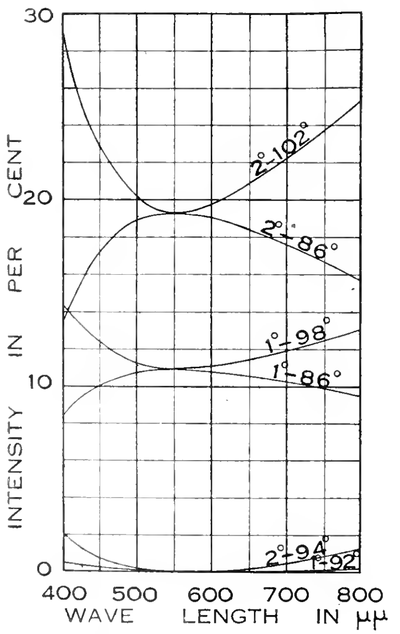

Fig. 2. The curves of this figure represent graphically the data of Table 1, namely, the intensity of the light, in per cent, for different wave lenths λ after transmission through the polarizer, sensitive tint quartz plate (0.03 mm. thick cut parallel to the optic axis which makes an angle θ with the vibration plane of the polarizer) and the analyzer whose principal plane includes an angle ϕ with that of the polarizer.

TABLE 1

λ IN $\mu\mu$	$\gamma' - \alpha'$	INTENSITY IN PER CENT $\theta = +1°$			INTENSITY IN PER CENT $\theta = +2°$		
		$\varphi = 86°$	92°	98°	$\varphi = 86°$	94°	102°
	0.00						
400	954	8.56	0.48	14.23	13.70	1.91	28.71
450	936	10.06	0.18	12.14	17.29	0.70	22.80
500	925	10.75	0.04	11.17	18.95	0.15	20.07
550	917	10.93	0.00	10.93	19.37	0.00	19.37
600	909	10.81	0.03	11.10	19.08	0.10	19.86
650	902	10.52	0.08	11.50	18.39	0.33	20.99
700	898	10.17	0.15	11.99	19.55	0.58	22.37
750	894	9.79	0.23	12.51	16.65	0.92	23.85
800	892	9.63	0.30	13.02	15.79	1.21	25.27

Table showing percentage intensity of transmitted light for different wave lengths λ after passing through polarizer, sensitive tint quartz plate (0.03 mm. thick and cut parallel to the principal axis, and including an angle θ with the principal plane of the polarizer) and the analyzer whose principal plane includes an angle φ with that of the polarizer.

Extended comment on this table and figure is unnecessary. From both it is evident that for $\vartheta = +1°$, the intensity of the transmitted light is not the same throughout the visible spectrum for a given angle φ between the nicols; thus for $\vartheta = +1°$ and $\varphi = 86°$, the intensity of illumination is greatest in the middle or green part of the spectrum about $550\mu\mu$ and the resultant color is of a greenish hue, while for $\vartheta = +1°$ and $\varphi = 98°$, the intensity of illumination for the central part of the spectrum is at a minimum and the resulting hue is of the nature of a minus green which is magenta. Similar relations obtain for the angle $\vartheta = +2°$. For still larger angles ϑ, the intensity of illumination throughout the spectrum is so great that the slight differences in percentage intensity for different wave lengths are not sufficient to dominate the hue of the total light transmitted. It is only when the average intensity of illumination throughout the entire spectrum is so slight that it approaches the limit of threshold vision and perception of color differences that the color intensity differences are most marked.

From equation 2 we find by forming the first and second differential quotients after φ, that for a given ϑ the intensity of illumination is a minimum when $\varphi = 90° + \vartheta$. This is also evident from figure 1 in which the relations appear so clearly marked that their application to the case of a system of the steeply inclined lens surfaces in a high power objective involves no difficulty except that of tedious computation in following each ray through the lens system. Such a computation is, moreover, unnecessary because we know the approximate inclinations of the different lens surfaces for the different parts of the field, and can estimate the approximate rotation of the plane of vibration of the transmitted light wave, and can deduce therefrom the resultant color. The results of such an estimation agree well with those of observation. It seems, however, unnecessary to present the details of this part of the solution of the problem as no new principle is involved and the final result can be inferred at once by analogy from the results already given.

From the foregoing it is evident that, in weakly birefracting minerals, the color phenomena produced in the objective alone on insertion of the sensitive tint plate tend to veil and to render uncertain, to a greater or less extent, the interference colors due to the mineral plate under observation; special care should be taken in such instances to test by other methods any inference regarding the optical character of the mineral under test.

It is also evident that the rotation, by the lens system, of the plane of vibration of transmitted light waves has an effect on the measurement of the optic axial angle of a crystal plate but this effect is usually not sufficiently large to interfere seriously with the accuracy of the results obtained, which at best are not of a high order of precision because of a number of factors which enter into the problem and over which the observer has little control.[4] These have been discussed elsewhere by the writer and need not be repeated here. Suffice it to state that the weak uniaxial interference cross observed between crossed nicols in high power objectives is inevitable and also the apparent optically positive

[4] Carnegie Inst. of Washington, Pub. **158**: 147–200. 1911.

character of the interference figure when tested in the usual manner by the insertion of a sensitive tint plate either above the objective or below the condenser.

PHYSICS.—*A new half shade apparatus with variable sensibility.*
Fred. Eugene Wright, Geophysical Laboratory.

The importance of variable sensibility in half shade apparatus to meet best the different conditions of illumination and observation has been frequently emphasized in recent years and several instruments have been constructed which serve the purpose more or less satisfactorily. The device described in the following paragraphs is a simple, inexpensive half shade apparatus which accomplishes its object well and merits a brief word of description. It is essentially the instrument used in experiment 5 of the preceding article in which the theory underlying its construction is outlined briefly. The essential elements of this theory are: (1) a plane-parallel glass plate of refractive index n (tilted so that it makes an angle i with the line of propagation of an incident plane-polarized light wave, and also so that the normal to the plane of incidence includes an azimuth angle A with the line of vibration of the light wave), rotates the plane of vibration of the transmitted light wave through an angle B which can be computed from the Fresnel equation, $\cot B = \cos^2 (i - r) . \cot A$; both experiment and theory prove that the angle of rotation increases with the refractive index n of the substance and with the angle of incidence i; also with the azimuth angle A up to 45°; when A = 0°, 90°, 180°, the rotation is nil. For a given angle i the rotation angle is a maximum for $A = 45°$. If, therefore, a plane-parallel glass plate be mounted so that it can be rotated about a horizontal axis in the first (NE) quadrant midway between the principal nicol planes, the azimuth angle A for incident waves from the polarizer is 45° for all angles of incidence i and the angle of rotation of the transmitted waves can be calculated from the simplified Fresnel equation, $\cot B = \cos^2 (i - r)$. If now a second glass plate be taken and rotated about an axis in the second (NW) quadrant, the azimuth angle of the incident light waves from the polarizer is $-45°$ and the Fresnel equation reduces to $\cot B = -\cos^2(i-r)$. For a given angle of incidence the angle of rotation produced by the glass plate in the second quadrant is accordingly equal in value to that in the first quadrant but opposite in sign. Thus in a glass plate of refractive index 1.615 the angle of rotation of the plane of vibration of plane polarized waves incident at 40° under an azmuth angle 45° is 1°57′ while the rotation angle in a second plate for the same light wave incident at 40° under an azimuth angle −45° is −1° 57′ (fig. 1). If now two glass plates be so mounted that they meet in a fine line they form a half shade apparatus of a definite angle of rotation. On varying the angle of incidence i by rotating the system, we can change the rotation angle B and thereby introduce the principle of variable sensibility into our system.

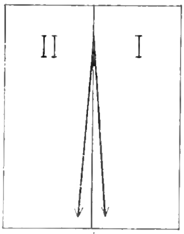

Fig. 1

Although there are a number of methods possible for rotating the two glass plates simultaneously, the simplest method which has occurred to the writer is illustrated by figure 2. Into a brass cylinder (telescope or microscope tube) a diametral hole is bored transverse to the axis and into this a rod is fitted so that it can be rotated about its axis. Two plane-parallel thin plates are mounted on the sides of a small right angled total-reflecting prism so that their ends project beyond the prism any desired amount depending on the size of field to be covered. The edges of these plates are beveled at 45° and the ridge is cemented with Canada balsam, thus producing a fine division line between the two glass plates. In case plane-parallel polished glass plates are not available thin cover glass plates may be selected and serve the purpose satisfactorily. The glass prism is then cemented to the rotating bar in the tube as

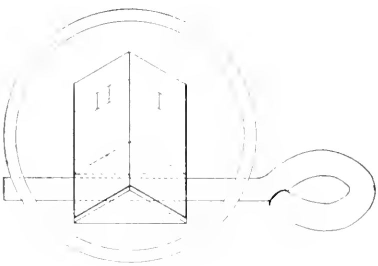

Fig. 2

indicated in figure 2, care being taken to have the prism edge perpendicular to the axis of rotation.

The axis of rotation is placed in an $E - W$ position parallel to one of the principal nicol planes. In this position the glass plates make equal and opposite angles with the $N - S$ principal nicol plane; the angles of rotation for the different angles of tilting are equal and of opposite sign and are listed in Table 1 (computed by the Fresnel equation), and are represented graphically in figure 3.

TABLE 1

Table showing angular rotation of plane of vibration of light wave transmitted through half shade apparatus for different angles of rotation about horizontal axis. The values of the angular rotation are listed for the adjacent quadrants (glass plate I and glass plate II, fig. 2) both for a single glass plate and also for two superimposed glass plates of refractive index $n = 1.515$ and $n = 1.920$.

ANGLE OF ROTATION	$n = 1.515$				$n = 1.920$			
	SINGLE PLATE		TWO PLATES		SINGLE PLATE		TWO PLATES	
	Quadrant I	Quadrant II	Quadrant I	Quadrant II	Quadrant I	Quadrant II	Quadrant I	Quadrant II
0°	0°00′	0°00′	0°00′	0°00′	0°00′	0°00′	0°00′	0°00′
5	0 29	−0 29	1 00	−1 00	0 56	−0 56	2 03	−2 03
10	0 58	−0 58	2 01	−2 01	1 53	−1 53	4 07	−4 07
15	1 29	−1 29	3 05	−3 05	2 52	−2 52	6 12	−6 12
20	2 01	−2 01	4 11	−4 11	3 53	−3 53	8 21	−8 21
25	2 35	−2 35	5 22	−5 22	4 57	−4 57	10 36	−10 36
30	3 12	−3 12	6 37	−6 37	6 02	−6 02	12 48	−12 48
35	3 53	−3 53	8 01	−8 01	7 17	−7 17	15 08	−15 08
40	4 39	−4 39	9 32	−9 32	8 35	−8 35	17 31	−17 31
45	5 40	−5 40	11 31	−11 31	10 03	−10 03	20 04	−20 04
50	6 30	−6 30	13 03	−13 03	11 33	−11 33	22 29	−22 29
55	7 37	−7 37	15 05	−15 05	13 14	−13 14	25 02	−25 02
60	8 54	−8 54	17 21	−17 21	15 06	−15 06	27 36	−27 36
65	10 22	−10 22	19 48	−19 48	17 08	−17 08	30 06	−30 06
70	12 03	−12 03	22 29	−22 29	19 18	−19 18	32 31	−32 31
75	13 58	−13 58	25 18	−25 18	21 41	−21 41	34 50	−34 50
80	16 03	−16 03	28 10	−28 10	22 09	−22 09	36 58	−36 58
85	18 40	−18 40	31 16	−31 16	26 58	−26 58	39 00	−39 00

The values given in Table 1 are the angles computed from Fresnel's equation above. The actual situation is a little more complex than one might infer from the equation alone, because of internal reflections and surface-film effects but the values listed in Table 1 indicate the order of magnitude of the angular rotation of the vibration plane of a plane-polarized light wave for different angles of inclination of the half shade apparatus. Since the effects of such factors, as internal reflection and surface films, affect both glass plates equally, they do not appreciably disturb the sensitiveness of the apparatus. The values are listed for angles of rotation of the apparatus up to 85°; in actual practice, however, rotation angles above 60° are not used and hence are not represented in figure 3.

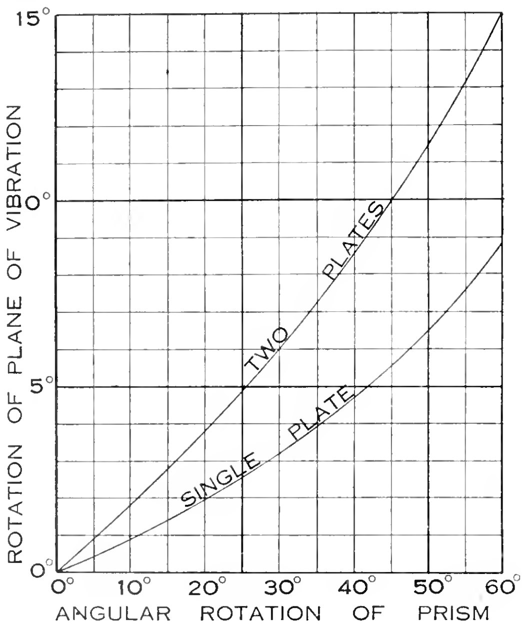

Fig. 3. Curves showing angular rotation of the plane of vibration of a beam of plane-polarized light on passage through glass plates of half shade device for different angles of rotation of apparatus about horizontal axis.

Instead of rotating the apparatus through large angles, it is simpler and better to mount two superimposed plane-parallel glass plates to each side of the right angled prism. The angles of rotation with this arrangement are listed in Table 1.

With this apparatus, which is applicable both to white and to monochromatic light, the half shade principle with variable sensibility is attained. In petrographic microscope work extinction angles can be measured by its use, when it is placed in the lower focal plane of the positive eye piece, with an accuracy nearly equal to that of the writer's bi-quartz wedge plate.[1]

The bi-quartz wedge plate is, however, superior to the present device because its action is independent of the direction of the line of junction between the two halves of the plate. The adjustment of the tilting glass plates is, however, not difficult between crossed nicols and this form of half shade apparatus has the advantage of slight cost and ease of preparation, it being possible to construct the complete apparatus in two or three hours time. The differences in angle of rotation for different wave lengths for a definite position of the apparatus are small and practically negligible for most work, the result being, that even for large angles of tilting of the apparatus, the field remains uncolored and of a light gray hue. In this respect it differs from the bi-quartz wedge plate and for certain purposes may be superior to it.

PHYSICS.—*A transmission and reflection photometer for small areas.* P. G. NUTTING and L. A. JONES. (Communication No. 15 from the Research Laboratory of the Eastman Kodak Company.)

In many optical investigations it is desirable to measure the brightness of small areas—1 mm. square or less. The instrument here described was devised to measure the brightness of optical images, the local densities in photographic negatives, and the reflecting powers of different parts of photographic prints and other pictures. It has proved exceedingly convenient and precise, and so nearly all that may be hoped for in this type of photometer that a description may be of general interest.

The chief advantages secured in our instrument are the following:

1. The elimination of errors due to fluctuation in the comparison source by using the same source for comparison light and for the source of transmitted or reflected light.

[1] F. E. Wright, Am. J. Sci. (4), **26**: 377–378. 1908. Carnegie Inst. of Washington, Pub. **158**: 139. 1911; see also M. Berek, Neues Jahrbuch f. Mineral., B. B., **33**: 583–661. 1912.

2. The elimination of corrections for shift of zero by providing easy means of balancing the two beams with an open system.

3. A direct view of the object sighted upon at all times during measurement. This is obtained by focusing an image of that object at the dividing line of the photometer cube.

4. An open linear scale, reading directly from zero to 100 per cent provided by a rotating comparison beam and stationary sector. The photometer head used is, in fact, that of the Bechstein illuminometer. The ease and rapidity of setting provided by this means of varying the comparison beam are known to all who have used it.

A plan of the optical parts of the photometer is shown in the figure as used for determining transmissions.

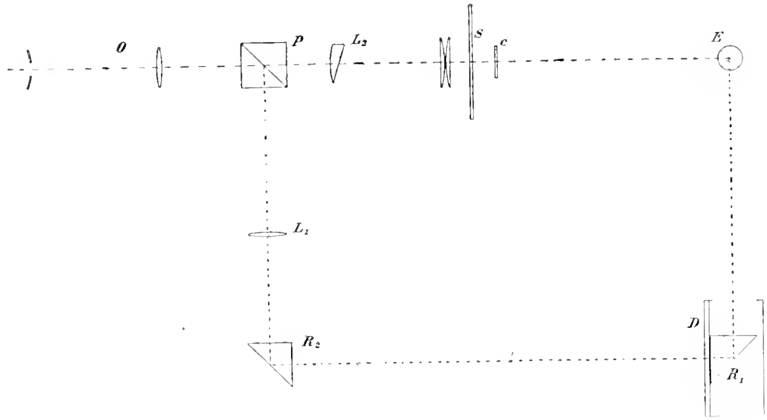

Fig. 1.

The source of light E is a condensed filament, 100-watt tungsten lamp run on the lighting circuit. Light from this illuminates the comparison screen c of thin, solid opal glass. This screen is viewed through the ocular O, the photometer cube P, the rotating excentric lens L_2, and stationary sector S. Light from E also passes to the photometer cube through the path ER_1R_2P. R_1 is a reflecting prism within a metal box mounted on a stand. The front face of this box is a plate of flashed opal glass D, serving as a secondary source by diffusing the light. The plate whose transmission is to be determined is placed directly in front of this diffusing screen, thus eliminating errors due to diffusion in the transmission measured. An image of the plate to be observed is thrown on the photometer cube P, by means of the lens L_1, and the reflecting prism R_2. These latter pieces are mounted on an arm carried by the instrument itself, the lens L_1 being adjustable in position.

In use, the sector S is first set to read 100 and the source E moved toward or away from C until a balance is secured without the plate to be measured. The instrument will then read percentage transmission from nothing to 100 per cent directly, with but a very slight zero correction.

For determining reflecting powers, R_1 and D are not used and R_2 is rotated to face downward (instead of horizontally, as shown). The surface upon which observations are to be taken is placed directly under R_2 on the table and the lens L_1 focussed upon the surface which is illuminated directly by the source E at an angle of about 45°. Ordinarily, it is diffuse reflecting power that is desired, and the surface is placed horizontal—specularly reflected light not entering the instrument.

The zero adjustments for measuring reflecting powers are similar to those made in measuring transmissions. If only relative values are desired, as in measuring up a photographic print, clear paper is placed in the field, the sector set to read 100 per cent and the source E adjusted to give a match at the cube. If actual reflecting powers are desired, a mat surface, say a block of magnesium carbonate, whose reflecting power has been determined on an absolute reflectometer,[1] is placed in position, the sector S to read its absolute reflecting power, and the source E adjusted as before. The instrument will then give directly the diffuse reflecting power of any other surface placed in the field. If specular reflecting power is to be determined, total reflecting power is measured on the absolute instrument and diffuse reflecting power measured as just described.

The instrument, as a whole, is easily, quickly, and permanently adjustable; readings may be taken with it as rapidly and accurately as with any kind of visual photometer, and we have not yet detected any systematic errors in its readings. For months it has been in constant use by a number of observers in the sensitometry of photographic plates and papers. With a magnifying ocular it has even been used as a microphotometer of low power.

[1] P. G. Nutting, Journ. Wash. Acad. Sci. **2**: 505. December 19, 1912.

CHEMISTRY.—*The iodine number of linseed and petroleum oils.*[1] W. H. SMITH and J. B. TUTTLE, Bureau of Standards. Communicated by G. K. Burgess.

The iodine number of linseed and petroleum oils was determined according to the Hanus method. Each of the three factors, weight of sample, time of absorption, and amount of Hanus solution, was studied for a series of burnt linseed oils and petroleum oils. Variations of weight of the raw linseed oil shows that a constant volume is obtained for weights of the oil up to 0.25 gram. Beyond this value the iodine number decreases with increasing weight. For burnt linseed oils the range of weight over which the iodine value is constant decreases with increased burning of the oil. Petroleum oils on the contrary approach a constant value when 0.6 gram or more of the sample is taken. Varying the time of absorption from five to sixty minutes shows that the reaction approaches a maximum in about ten minutes. Thereafter absorption is slow, and a few minutes one way or another has little effect on the value obtained. When the amount of Hanus solution is varied from 20 to 75 cc the results indicate that the oil with the highest iodine number does not require the greatest excess of iodine to reach maximum absorption value. The effect of temperature on the value obtained is more marked for burnt linseed oils than for boiled or raw oils. The results as a whole indicate that concordance is obtained only when a prescribed procedure is followed with exactness. To obtain comparable results a standard procedure should be followed in which the limits are strictly defined. This is particularly true of burnt linseed oils.

CHEMICAL TECHNOLOGY.—*The determination of ammonia in illuminating gas.*[2] J. D. EDWARDS, Bureau of Standards. Communicated by G. K. Burgess

The method generally used for the determination of ammonia in purified illuminating gas depends upon the absorption of the ammonia in a standard acid solution, the amount of ammonia absorbed from a measured volume of gas being determined either by

[1] To appear in full as Bureau of Standards Technologic Paper No. 37.

[2] To appear in full as Bureau of Standards Technologic Paper No. 34 (in press).

titration of the acid remaining unneutralized or less frequently by allowing gas to pass until a change is shown by the indicator used.

The choice of the proper indicator to use for this determination is of greater importance than the choice of apparatus. The indicators which were found to be most suitable for the determination of ammonia in gas were sodium alizarinsulphonate, cochineal, and paranitrophenol. The presence of glass beads which are used in some of the absorption apparatus may lead to erroneous results for two reasons: First, the beads may yield alkali on contact with the absorbing liquid; second, washing of the beads may be incomplete. It is recommended that the operator test the solubility of any beads he may use; the method of washing out the apparatus should also be tested.

Five different forms of apparatus were tested: The Referees apparatus, the Emmerling tower, the Lacy apparatus, the common form of gas wash bottle, and a modified form of the Cumming gas bottle. The relative efficiency, and from this the probable accuracy, of the different forms of apparatus was determined by running them in parallel, using gas from a common supply. As a result of this comparison it was found that the Emmerling tower gave results which were somewhat higher than those obtained with the other forms and that the wash bottle gave results consistently lower. With careful operation any one of the five forms of apparatus tested would ordinarily give results that are well within the limits of accuracy required for this determination, either for commercial control work or for the purpose of gas inspection.

PHYSICAL CHEMISTRY.—*The influence of atmospheric conditions in the testing of sugars.*[1] F. J. BATES and F. P. PHELPS. Communicated by G. K. Burgess.

A simplified form of Marvin's evaporation equation has been applied to the evaporation of raw sugar solution during filtration. Marvin's formula reduces to $\frac{dQ}{dt} = C\ (P_s - P_a)$ or $Q = C\ (P_s - P_a)\ T$, which, it is shown, fits the observations satisfactorily. Q = the change due to evaporation in the time T, P_s = the vapor pressure of the sugar solution, P_a = the saturation vapor pressure in the air at the temperature of the dew point.

[1] To appear in full as Bureau of Standards Scientific Paper 221 (in press).

The constant, C, has been determined for a number of different cases: (1) When the solution is poured back upon the filter after all has run through; (2) when it is poured back after about one-half has run through; (3) when it is not poured back at all. Observations were made by two methods: First, by weighing the solution at intervals during the filtration; second, by observing the change in polarization. In the polarization method one tube was filled, as a reference tube, with solution that had been covered during filtration, since filtration could not be avoided. It is shown, however, by weighing, that the evaporation in this case is quite negligible. Other tubes were filled with solution which had not been covered during filtration. The difference in polarization between these tubes and the reference tube is the change due to evaporation. This was done under various atmospheric conditions.

The observations were made in a thermostated room where the amount of moisture present in the air, as well as the temperature, could be varied at will, the range of adjustment being $(P_s - P_a) = 4$ mm. of Hg to $(P_s - P_a) = 41$ mm. of Hg. In practice $P_s - P_a$ rarely exceeds 22 mm.

It was found that in the case where the solution was not poured back upon the filter the change in polarization due to evaporation is so small as to be quite negligible in ordinary sugar testing. The change is represented by $Q = 0.00017 (P_s - P_a) T$. However, in case a portion of the solution is poured back, the change due to evaporation is not negligible in ordinary testing but must either be prevented, by covering the funnel, or corrected for by the equation $Q = 0.0006 (P_s - P_a) T$.

CRYSTALLOGRAPHY.—*The crystallographic and optic properties of magnesium and manganese pyrophosphates.* OLAF ANDERSEN, Geophysical Laboratory. Communicated by Fred. E. Wright.

Crystals of magnesium and manganese pyrophosphates were obtained by melting the substances[1] and cooling the melts.

[1] The pyrophosphates were produced by heating magnesium (or manganese) ammonium orthophosphate. The thermal examination of these and other substances is dealt with in a different paper. $Mg_2P_2O_7$ melts at 1383°C., $Mn_2P_2O_7$ at 1196°C.

Complete crystallization always resulted, no matter how quickly the cooling took place and from the cavities some measurable crystals could be picked out.

MAGNESIUM PYROPHOSPHATE

The magnesium pyrophosphate ($Mg_2P_2O_7$) forms tabular crystals of variable size, the tables generally having an orientation perpendicular to the surface of the melt and roughly parallel to each other or radiating from a few centers near the sides of the crucible. The measurable crystals were of the average size 3 x 2 x 1 mm. They were, however, always formed by parallel (or subparallel) intergrowths of a number of small individuals and the signals reflected from the faces of such crystals were multiple and indistinct. Fairly sharp signals could be obtained by stopping off the light from all the subfaces except the two joining in the little edge selected for measurement. In this way one crystal often yielded a number of measurable edges between the same two faces. The two circle goniometer (Goldschmidt's) was accordingly used as a one circle instrument.

The crystals proved to be monoclinic belonging to the prismatic class. From the average of the measurements the axial ratios were calculated as follows: $a : b : c = 0.7947 : 1 : 1.0880$; $\beta = 75°49'$. Referred to these axial ratios the following forms were observed: *c* (001); *z* (110); *r* ($\bar{1}01$); *x* ($\bar{1}12$).

The results of the measurements are listed in Table 1 containing the values obtained from 14 crystals, some of which gave only one measurable edge, while from others several edges for each pair of faces were obtained.

Figure 1 reproduces the general shape of a composite crystal. The predominating forms are always *c* and *z*, the crystals being tabular parallel to *c* or sometimes short prismatic along *z*, while the other two forms *r* and *x* only occur as narrow truncations of the edges; *r*, however, is sometimes broad enough to give fairly good signals. The prism *z* is not observed except as bright and smooth cleavage faces. The other forms occur as natural crystal faces always fairly bright and without striation.

The subindividuals of the larger crystals are arranged so as to make the bases form steps descending in the direction of the negative a-axis. By this arrangement the composite crystals often approximate an orthorhombic shape. Sometimes the crystals are grown together in a way indicative of polysynthetic twinning. No definite twinning law however could be inferred from these intergrowths. The crystals are colorless and of a glassy luster. The hardness is a little less than 4. Cleavage perfect after the faces of the prism z and also good parallel to c. Density determinations with pycnometer gave $G(\frac{25}{4}) = 3.058$.[2]

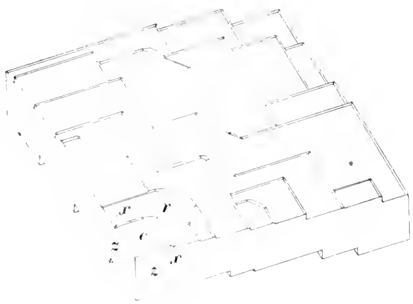

Fig. 1.

Optical properties. Because of the good cleavages most of the attempts to grind oriented sections of the small crystals failed. Only one thick slice approximately parallel to (010) was obtained. The optical properties have therefore been studied chiefly on fine powder or small cleavage pieces under the microscope. The results are accordingly incomplete and only of approximate accuracy.

The refractive indices were determined by the immersion method in sodium light with the following results: $\gamma_{Na} = 1.615 \pm 0.003$; $\beta_{Na} = 1.604 \pm 0.003$; $\alpha_{Na} = 1.602 \pm 0.003$.

According to these determinations the maximum birefringence is: $\gamma - \alpha = 0.013 \pm 0.005$ The optical character is positive. The axial angle was determined under the microscope on small grains showing both axes near the center of the field. Average of 4 determination of reasonable sharpness gave $2V = 20\frac{1}{2}°$ ($2E = 33°$). The optical orientation is the following: $Bx_a = \gamma$ approximately parallel to a-axis. β parallel to b-axis. $Bx_o = \alpha$ forming approximately 15° with c-axis in obtuse angle (i.e., being nearly perpendicular to c (001).

[2] G. W. Clarke (Amer. Journ. Sci. III. **14**: 281. 1877) gives $G = 2.598$ (22°) and 2.559 (18°). These values, however, can not refer to the crystallized substance, but may represent the density of the amorphous powder.

TABLE 1

ANGLES MEASURED ON CRYSTALS OF MAGNESIUM PYROPHOSPHATE

	(001):(110)	(001):(1$\bar{1}$0)	(001):($\bar{1}$01)	(110):(1$\bar{1}$0)	(001):($\bar{1}$12)
	77° 53′	78° 3′	64° 0′	75° 5′	45° 10′
	78° 8′	77° 56′	64° 21′	74° 59′	45° 22′
	78° 4′	78° 3′	64° 14′	74° 56′	
			64° 7′	74° 59′	
			64° 21′	74° 50′	
			63° 56′	74° 59′	
			63° 45′		
			64° 7′		
			64° 3′		
			64° 6′		
Mean............	78° 1′.5	78° 0′.5	64° 6′	74° 58′	45° 16′
Average.........	*78° 1′		*64° 6′	*74° 58′	
Calculated.......			(001): (112) = 45° 21′		

* Angles used in calculation of axial ratios.

The plane of symmetry (010) is accordingly the plane of the optic axes. As the acute bisectrix γ is nearly parallel to (001) and the obtuse axial angle is very large, basal sections show no axial interference figures when examined in convergent light. Sections parallel to (010) extinguish nearly parallel to the cleavage lines of (001) and at an angle of about 15° with the c-axis (i.e., cleavage lines of (110).

MANGANESE PYROPHOSPHATE

The manganese pyrophosphate ($Mn_2P_2O_7$) forms small prismatic crystals composed of a great number of thin prisms in parallel intergrowth. The crystals are monoclinic and, as far as the measurements go, show very nearly the same crystallographic properties as the magnesium pyrophosphate. Only two independent angles could be measured, however, and the complete axial ratios could not be established. The following incomplete axial ratios were calculated: $a:b:c = 0.7834:1:?$; $\beta = 74°9'$.

The forms c (001); a (100), and z (110) were observed on 4 measured crystals. The angles are given in Table 2.

TABLE 2

ANGLES MEASURED ON CRYSTALS OF MANGANESE PYROPHOSPHATE

	(001):(110)	(001):$(1\bar{1}0)$	(110):$(1\bar{1}0)$	(100):(110)
	79° 49′	79° 49′	74° 2′	37° 16′
	79° 58′	79° 52′	73° 59′	37° 12′
	79° 56′	79° 48′	74° 2′	36° 50′
	79° 50′	79° 53′		
	79° 53′	79° 50′.5		37° 6′
Average....................	*79° 51′		*74° 1′	
Calculated angle.............		(100): (110) = 37° 0′.5		

* Angles used in calculation of axial ratios.

Figure 2 shows the general appearance of a complex crystal. The prism *z* is always the prevailing form. The small faces of *c* terminate the narrow prisms. The pinacoid *a* only occurs as very narrow truncations of some of the edges *z* : *z*. The faces were all bright, especially *z*, which was observed both as crystal faces and cleavage faces and gave good signals.

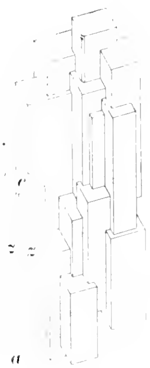

Fig. 2.

The color of the crystals is brownish pink; the powder is light pink. The luster is glassy. Hardness about 4. Cleavage perfect along the prism *z* and poor parallel to *c*. The density determined with pycnometer is $G(\frac{25}{4}) = 3.707$.[3]

Optical properties. Cleavage pieces and fine powder only were examined under the microscope. No material for more elaborate examination was available. The refractive indices for sodium light were determined by the immersion method $\gamma_{Na} = 1.710 \pm 0.003$; $\beta_{Na} = 1.704 \pm 0.003$; $\alpha_{Na} = 1.695 \pm 0.003$ from which the birefringence $\gamma - \alpha = 0.015 \pm 0.005$ is deduced.

The optical character is determined as positive.[4] The axial

[3] G. W. Clarke (Amer. Journ. Sci. III. **14**: 281. 1877) states G = 3.5847 (20° and 3.5742 (26°). These low values may be due to impurities.

[4] From the determinations of the refractive indices giving γ-β<β-α a negative optical character should be inferred. It is however plainly seen that a variation of the indices within the limits of error may change their relation so as to make the optical character positive.

angle is, however, so large that most of the grains observed under the microscope allow no conclusion whatever as to the optical character, the dark bar being apparently straight. Only a few favorable grains rendered the determination certain, these grains showing a bar with a slight though distinct curvature.

Attempts to determine the axial angle under the microscope failed on account of the difficulty in finding grains with proper orientation. Owing to the good cleavage most of the grains were oriented along a cleavage face not showing any optic axis, and in the few cases of an optic axis appearing in the field it was in a position not favorable for satisfactory measurements (e.g., too near the center of the field). It may, however, be concluded from the curvature of the dark bar that the axial angle is not much less than 90°. A probable estimation is $2V$ = about 80°. The optical orientation is as follows: $Bx_a = \gamma$ forming approximately 20° with *a*-axis in obtuse angle β; β parallel to *b*-axis. $Bx_o = \alpha$ forming approximately 4° with *c*-axis in acute angle β. The plane of symmetry is thus the plane of optic axes and sections parallel to this plane have an extinction angle of about 4° in acute angle β against cleavage lines.

Thick cleavage pieces show faint pleochroism: α light pink; β, γ nearly colorless with a faint yellowish tinge.

A comparison of the properties of the two compounds described in the preceding pages shows that they are isomorphous; a comparison with other crystals proves that they belong to a new group of isomorphous substances not hitherto described.[5] As to the crystallography of the other members of this group (probably the pyrophosphates of different bivalent metals) nothing is known.

The isomorphism[6] of the two compounds is here established on the basis of similarity of chemical constitution, crystal form

[5] The only anhydrous pyrophosphate whose crystallographic properties are known, the Thallopyrophosphate $Tl_4P_2O_7$ has an entirely different axial ratio. Lamy and Des Cloizeaux, Ann. Chim. Phys. (4) **17:** 325. 1869. See Groth's Chem. Cryst.

[6] For an exhaustive discussion of the different meanings of the term isomorphism see Hlawatsch, Zs. Kryst. **51:** 417. 1912.

and structure as revealed by the chemical formula, the axial ratios and the properties of cohesion (cleavage).

It is seen that the two compounds form monoclinic crystals whose axial ratio $a : b$ and angle β are very nearly of the same magnitude. As to the ratio $b : c$ nothing can be said owing to the lack of a sufficient number of angles in the manganese pyrophosphate crystals. The agreement in internal structure of the crystals is evident from the presence of cleavage along the same faces. Both kinds of crystals have a perfect cleavage along the prism z and in both there is a cleavage parallel to c though not equally good in both. It may also be worth mentioning that there is agreement in other physical properties. The hardness is the same and the specific gravity of the same order of magnitude in the two substances. Altogether it seems on the basis of the chemical composition and the crystallographic properties, entirely justified to rank the two substances together as isomorphous.

Isomorphism is, however, sometimes defined so as to imply miscibility in the solid state (solid solution, mix-crystals). In order to examine whether the two phosphates here considered were isomorphous also in this extended sense a few experiments were carried out:

Three intermediate mixtures containing 75, 50 and 25 per cent $Mn_2P_2O_7$ (and a corresponding amount of $Mg_2P_2O_7$) were prepared. With these mixtures heating curves were run and the substances were examined under the microscope. The results are listed in Table 3, where also the melting points and refractive indices of the pure compounds are given for comparison.

It is plainly seen that there is a gradual transition from one component to the other, both in "melting point"[7] and mean refractive index. The heating curves showed no breaks other than those corresponding to the melting points and the microscopic examination proved that only one solid phase was formed by crystallization of the melts.

[7] The breaks on the heating curves of the mixtures correspond to points between the liquidus and the solidus. In the present case these points probably fall very near the liquidus. This may be inferred from the sharpness of the breaks.

In the mixtures containing 50 and 75 per cent $Mg_2P_2O_7$, some of the crystals showed an undulatory extinction indicating zonal structure. This is what should be expected of crystals formed from melts where perfect equilibrium did not obtain through all the period of crystallization. The lack of equilibrium was evident from the fact that the crystallization of these melts took place with a considerable undercooling. At any rate, the inhomogeneity of the mix-crystals due to zoning is not nearly great enough to arouse suspicion of the separation of two distinct phases. The mixture containing 25 per cent $Mg_2P_2O_7$ shows perfectly homogeneous crystals and the undercooling of the melt is insignificant.

TABLE 3

COMPOSITION		BREAKS ON HEATING CURVE (MELTING POINTS)	MEAN REFRACTIVE INDICES
$Mn_2P_2O_7$	$Mg_2P_2O_7$		
		deg. C.	
100	0	1196	1.70
75	25	1242	1.67
50	50	1286	1.65
25	75	1340	1.63
0	100	1383	1.60

The optical character of all the mix-crystals is positive. The axial angle varies according to composition. It is large in the mix-crystals containing 75 per cent $Mn_2P_2O_7$; medium in the 50 per cent crystals and small in the 25 per cent crystals.

The facts stated prove conclusively that the two phosphates are perfectly miscible in the solid state and that the system $Mg_2P_2O_7$:$Mn_2P_2O_7$ belongs to Roozeboom's Type I, the type without a maximum or minimum.

BOTANY.—*The name of the wood-apple, Feronia Limonia.* WALTER T. SWINGLE, Bureau of Plant Industry.

The wood-apple of India, Ceylon, and Farther India is a deciduous tree with odd-pinnate leaves and globose fruits about the size of an orange, with a hard, woody rind. It belongs to the orange subfamily, Citratae, of the Rutaceae and is one of the typical hard-shelled citrous fruits, a group including the genera Feroniella, Aegle, Chaetospermum, Balsamocitrus, and Aeglopsis, with a range from Indo-China and the Philippine Islands to West Africa.

The wood-apple was first given a binomial name by Linnaeus in 1753 as *Schinus Limonia* (Sp. Pl. **1**:389), with citation to a rather full description drawn up by Linnaeus himself and published, in 1747, in his account of Hermann's herbarium of Ceylonese plants (Fl. Zeyl., pp. 77, 78, No. 175). Hermann's herbarium, now in the Botanical Department of the British Museum, shows that the specimens studied by Linnaeus and labeled by his own hand consist of two sterile twigs of the wood-apple. In addition to this material there are in Linnaeus' own herbarium two twigs with flowers and loose leaves of this plant, labeled "Limonia" in Linnaeus' handwriting. It is clear that Linnaeus studied both flowers and foliage from his description in Flora Zeylanica which he concludes as follows: "Ex flore & facie ad hoc genus plantam retuli."

Now, Linnaeus attempted to collate in his Flora Zeylanica what had been published previously on tropical and especially East Indian botany and in this case added references to some seven previously published descriptions which he considered to be synonymous but which represent three or four distinct species belonging to as many genera. Two plates are cited, one in Rumphius (Herb. Amboin. **2**: 134, *pl. 43*) representing a branch of the wood-apple with flowers and young fruit, and one in Rheede (Hortus Malabaricus **4**: 31, *pl. 14*) representing a branch with flowers and mature fruits (also a section of fruit and seeds) of quite a different plant, *Hesperethusa crenulata* (Roxb.) Roemer, commonly but erroneously called *Limonia acidissima* L.

The type of *Schinus Limonia* L. is certainly the plant described by Linnaeus in his Flora Zeylanica, the wood-apple, notwithstanding the citation of quite different species of previous authors as synonyms. This is shown unmistakably not only by the type specimens in the Hermann and Linnaean herbaria but also by Linnaeus' description in Flora Zeylanica (p. 78) which says: "foliola . . . . *emarginata*" which phrase cannot possibly apply to any of the other plants of which descriptions are cited by Linneaus in the synonomy. This fact was first pointed out by Trimen,[1] in 1887, on the basis of the specimens preserved in Hermann's herbarium. Apparently he did not know of the existence of the flowering specimen in Linnæeus' own herbarium.

In 1762, Linnaeus, in the first volume of the second edition of his Species Plantarum, abandons the name *Schinus Limonia*, restricting the genus Schinus to the Peruvian pepper trees and creating a new genus, Limonia, for the wood-apple which he calls *Limonia acidissima*. He does not cite the *Schinus Limonia* of the first edition of Species Plantarum as a synonym, but his use of the former specific name as the generic name and the reference to his previous description in Flora Zeylanica make it clear that *Limonia acidissima* L. is merely another name for *Schinus Limonia* L. The original specific name could not be retained without forming a duplicate binomial, a barbarism which Linnaeus never countenanced.

Four citations are given under *Limonia acidissima*. The first is to Burman's Thesaurus Zeylanicus, p. 143, which includes two or more species, one of them being very probably the common lime *Citrus aurantifolia* (Christm.) Swing. The second citation is to his own Flora Zeylanica, p. 77, 78, and certainly applies to the wood-apple. The third citation is to Rumphius Herbarium Amboinense, vol. 2, *pl. 43*, which is also the wood-apple or a closely allied species. The fourth citation is to Rheede, Hortus Malabaricus, Pt. 4, *pl. 14*, and is *Hesperethusa crenulata* (Roxb.) Roem.

Linnaeus thus confused several very distinct plants under his *Limonia acidissima*. Unfortunately, practically all post-Linnaean authors apply this name to a small-fruited Indian tree, *Hesperethusa crenulata* (Roxb.) Roem., while the wood-apple is commonly called *Feronia elephantum* Corrêa.

Fortunately, the confusion that would be caused by changing the current application of the name Limonia and applying it to the wood-apple can be avoided, because the name Limonia proves to

[1] Trimen, H. Hermann's Ceylon Herbarium and Linnaeus's "Flora Zeylanica," in Journ. Linn. Soc. Bot., **24**: 142 (n. 160, 28 Nov. 1887).

be invalid, being a mere variant of Limonium. Linnaeus in the 1754 edition of Genera Plantarum, (ed. 5, p. 135) reduced the latter name to a synonym of Statice, and consequently this name or any variant of it cannot be revived for any plant not congeneric with the type of the original Limonium.[2] As a matter of fact, Limonium has recently been resuscitated in its original sense and is now so used by many taxonomists.

Even if we assume that Linnaeus with his well-known aversion to barbarous names[3] had latinized the name Limon, the usual pre-Linnaean name of the lemon, we would still be forced to conclude that he had brought it into a correct Latin form, just as he did in changing Anona, derived from an aboriginal American name, to Annona, a classical Latin word.[4] This would mean that he had transferred Pliny's Latin name Limonia[5] to a quite different plant, the East Indian wood-apple, in accordance with a reprehensible practice often followed by him. In this case, the Latin name Limonia would still be a mere variant of Limonium, even though derived indirectly from the barbarous word Limon.

Limonia then being invalid, the next oldest generic name must be taken up. This is Feronia, published by Corrêa in 1800, the name now commonly used.

Since the wood-apple was first published as *Schinus Limonia* by Linnaeus in 1753, the oldest valid name of the wood-apple is *Feronia Limonia* (L.) n. comb.

[2] Cook, O. F. Nomenclature of the Sapote and the Sapodilla, in Contrib. U. S. Nat. Herb. **16**: 282 (no. 11, December 13, 1913).

[3] Linnaeus, C. Philosophia Botanica, p. 163, ¶ 229, Stockholm., 1751.

[4] Safford, W. E. The genus Annona: The derivation of its name and its taxonomic subdivisions. This JOURNAL **1**: 118 (n. 4, September 19, 1911).

[5] Limonia and Limonium were both used by Pliny as names of plants and were derived from the Greek *λειμωνία* and *λειμώνιον*, the feminine and neuter forms of the adjective *λειμώνιος* from *'ο λειμών* a grassy plain, meadow, prairie. The Greeks used both the feminine and the neuter forms as substantives, *'η λειμωνία* being a kind of anemone, *τὸ λειμώνιον* a Statice, both plants characteristic of meadows. The feminine and neuter forms of the adjective were so differently accentuated in Greek that there was no danger of confusing the two words when used as substantives. In Latin this difference in accent was lost and confusion rendered possible. It is noteworthy that even in Greek only one of the similarly accented masculine and neuter forms of the adjective (*λειμώνιος* and *λειμώνιον*) was used as a noun.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal, and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Mineral resources of southwestern Oregon.* J. S. Diller. U. S. Geological Survey Bulletin 546. Pp. 147, 11 plates, 26 figures, maps, sections, and views. 1914.

The rocks of southwestern Oregon, the northern portion of the Klamath Mountains, with a northeast strike toward the Blue Mountains are pre-Devonian, Devonian, Carboniferous, Jurassic, Cretaceous, and Eocene to Pleistocene inclusive. Paleozoic and Mesozoic lavas and intrusives, including greenstones, serpentines, granodiorites, and a variety of dike rocks cut the crushed sediments. The fissuring was general instead of being concentrated in narrow belts. The final veining of the rocks and the accompanying ore deposition formed many small though commonly rich ore bodies instead of a few large ones.

The deep weathering of the rocks during the late Mesozoic and Tertiary concentrated the heavier metals in the residual mantles that gave much to the auriferous gravels of (1) the invading Cretaceous sea (beaches) encircling the Klamath Mountains, (2) the enlivened streams of the Klamath Peneplain, (3) streams of the Sherwood Peneplain, and (4) streams of today. Under favoring conditions the deep weathering of the later geologic periods may have contributed to the secondary enrichment of the "pockety deposits" for which southwestern Oregon is well known.

The overturning of the folded strata and the overthrust of the Devonian upon the Jurassic toward the sea on the northwest is apparently a fundamental structural feature of the Klamath Mountains. J. S. D.

PALEONTOLOGY.—*The Upper Cretaceous and Eocene floras of South Carolina and Georgia.* EDWARD W. BERRY. U. S. Geological Survey Professional Paper 84 Pp. 200, with maps, sections, and 29 plates. 1914.

Upper Cretaceous plants are found in the Middendorf arkose member of the Black Creek formation in South Carolina. This member represents the initial phase of littoral and perhaps partly continental deposits after the widespread interval that succeeded the Lower Cretaceous. The flora contains 76 species in 49 genera, 36 families, and 26 orders and is believed to indicate conditions comparable with those existing in the warm temperate rain-forests of the present. The flora is part of an association that extends from Texas throughout the Atlantic coastal plain, reappearing in the Atane beds of western Greenland. It is shown to have been contemporaneous with the deposition of the upper Tuscaloosa formation of the eastern Gulf area and with the Magothy formation of the northern Atlantic coastal plain and with a part of the Turonian stage of European geology.

A somewhat similar but in part younger fossil flora is described from the Eutaw and the basal beds of the Ripley formation in western Georgia. The deposits range from littoral to marine and yield a total flora of 32 determinable species which indicate conditions essentially similar to those mentioned for the Middendorf flora.

A small but highly interesting flora is described from the Congaree clays of eastern Georgia. These are of middle Eocene age and are known officially as the Congaree clay member of the McBean formation of the Claiborne Group. The plants indicate that the deposits are to be correlated with the Lutetian stage of the Paris basin. The flora contains swamp ferns (Acrostichum) of tropical affinities and several types of plants of modern mangrove associations, as well as palms and numerous coastal types. It is fittingly compared with the existing costal floras of southern peninsular Florida and Central America and furnishes exceedingly important data for phylogenetic speculations, as well as for the elucidation of the climatic and geologic history of the Mississippi embayment area. E. W. B.

MAMMALOGY.—*Treeshrews: An account of the mammalian family Tupaiidae.* MARCUS WARD LYON, JR. Proceedings of the U. S. National Museum **45**: 1–188, pls. 1–11, text figs. 1–15. November 29, 1913.

This extensive monograph of the insectivorous mammals included in the family Tupaiidae is based on an examination of about 800 specimens, a great part of all the material preserved in the museums of the world. The U. S. National Museum alone furnished 324 specimens, including 29 types, almost all of which were collected and presented by Dr. W. L. Abbott.

The treeshrews are here divided into two subfamilies, one containing the treeshrews proper, 5 genera, and the other only the aberrant pentail (Ptilocercus), with two subspecies. The generic names Anathana for the Indian species and Tana for the long-snouted Malay forms are new. In the restricted typical genus Tupaia there are 48 forms, 5 of which are new; in Anathana 3, 2 of which are new; in Tana 12, 6 new; and in the Philippine Urogale only a single species. The remarkable pentail shrew (Ptilocercus), though described in 1848, is still so rare in collections that only twelve specimens are known to the author.

In addition to the systematic account of the genera and species, the paper includes a history of the animals, their discovery, systematic history, geographical distribution, and habits. The osteology and visceral anatomy are described at length. Details of the skull and teeth of each genus are illustrated by text figures, and the external appearance, the skeleton, and skulls of groups of species are shown on plates. The geographical distribution of each form is shown by maps, and there are extensive tables of measurements of specimens. N. HOLLISTER.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE CHEMICAL SOCIETY

The 239th meeting was held jointly with the Baltimore Branch, on May 2, 1914, at Johns Hopkins University. Dr. Penniman of the Maryland Board of Health exhibited a vacuum regulator for distillation in vacuo. Discussed by Acree, Bunzel, Sosman, and others.

The following papers were read:

W. W. Randall, of the Maryland Board of Health: *The determination of camphor in spirits of camphor.* The method depends upon the salting out of the camphor by concentrated solution of calcium chloride, followed by its solution in a measured volume of gasoline, and measurement of the volume of the resulting solution. The dissolving of camphor in gasoline is not accompanied by any change in total volume. Discussed by Engelhard, Penniman, Caspari and Acree.

J. H. Shrader of the Gibbs Preserving Company: *The reactions of propyliodide with both the ions and the molecules of sodium phenolate.* Discussed by Bunzel, Acree, Sosman, Phelps.

F. M. Boyles, *Secretary Baltimore Branch.*

The 240th meeting was held at the Cosmos Club, May 14, 1914, at 8:15 p.m. The following papers were read: R. C. Wells, of the Geological Survey, *The electromotive behavior of soluble sulfides.* The speaker measured the potential of the sulfur ion in concentrations ranging from 10^{-23} N to 0.09 N and worked out mathematical relationships correlating the values obtained. The agreement between the calculated and observed values for E is very good. The divalent sulfur ion is far more reducing than even the iodine ion. The electromotive force measurements do not show the existence of disulfides and trisulfides in polysulfides.

Discussion. Acree inquired about the constancy of the values obtained with the calomel electrode. It was stated that the experiments were only made with an accuracy of 0.01 volt, so that the small fluctuation of the calomel electrode could be overlooked. The calomel electrode is much more constant than the sulfur electrode.

S. F. Acree, of Johns Hopkins University: *The reactions of both ions and molecules of acids, bases and salts.* The speaker studied about 30 reactions experimentally and as many more from the data of others, and calculated separately the velocity constants of the reactions due to the molecules and those due to the ions. This was done with widely varying concentrations and at different temperatures. In all cases both ions and molecules were shown to enter into the reaction.

H. H. Bunzel, *Acting Secretary.*

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 738th meeting was held on March 14, 1914, at the Cosmos Club, President Fischer in the chair; 60 persons present.

The evening was devoted to a symposium on photography. Mr. E. D. Tillyer spoke on *Photographic lenses and plates*. He discussed the old and new types of glass used for lenses and described briefly the methods of correcting for spherical aberration, coma, astigmatism, curvature of field, distorsion, and chromatic aberration. Various types and combinations of photographic lenses were illustrated by lantern slides. Requirements of plates for different purposes as regards emulsion, rapidity, and grain were discussed. Paper was discussed by Mr. Humphreys.

Mr. K. Burns spoke on *Astronomical photography and the Schumann region*. The Schumann region is so-called because before his investigations observations could not be made in regions where wave lengths are less than 1800 Ångström units. For astronomical use plates must usually be rapid at low intensities. The application of refractors and reflectors to astronomical photography was discussed at length and lantern slides shown of instruments and photographs of interesting celestial regions. For wide fields the refractor is limited by the coma. The paper was discussed by Messrs. Rines and Humphreys, particularly as to photographs giving details of planetary surface markings.

Mr. F. E. Wright presented a paper on *Color photography* and illustrated his paper by some excellent specimens of this work. Color photography is based on Helmholz's trichromatic theory. Present practical methods are three: By taking three exposures simultaneously through three films, one red, one blue, and one green, and superimposing the three negatives by use of prisms; by use of screen ruled alternately with red, green, and blue lines about $\frac{1}{200}$ inch apart; and Lumière's method by use of very small starch grains dyed red, green, and blue and mixed together and mounted on back of sensitized plate, the back being placed next the lens when photograph is taken. The slides exhibited were taken by the second method. The paper was discussed by Messrs. Bauer, Priest, Tillyer, and Humphreys. At 10:05 the meeting adjourned.

The 739th meeting was held on March 28, 1914, at the Cosmos Club, President Fischer in the chair; 36 persons present.

Mr. R. Y. Ferner presented a paper on *A reasonable performance of a high grade watch*. He outlined the methods of tests used in four prominent foreign observatories and gave the criterions and tolerances by which the performances of watches under test are judged. It was pointed out that for the determination of the true quality of the position adjustment of a watch it is desirable to eliminate, by the method of test, the gradual progressive change of rate which is evident in practically all watches. Lantern slides giving curves of results of isochronism tests were shown, and the desirability of this test pointed out. An outline of the test which will be applied to watches at the Bureau of Standards was then shown, together with the tolerances which have been adopted for the granting of certificates of the watches' performances. In conclusion, some results of pocket tests of watches made by Mr. F. M. BOOKWALTER were shown and the principal uses and value of a laboratory test in later use and care of one's watch pointed out. The paper was discussed by Messrs. BOWIE, FISCHER, and WELLS.

Mr. W. P. WHITE then spoke on *Calorimeter jacket design* The two difficult features of calorimetric work are temperature measurement and cooling rate determination. The more nearly the cooling rate is proportional to change in temperature, the better is the result. The general conclusion was reached that cooling rate has not so much to do with distance between two surfaces of calorimeter as with shape of cavity. The paper was discussed by Mr. DICKINSON.

Mr. W. BOWIE communicated informally the initiation by the Canadian government of an extended gravity survey of Canada. He also stated that the Coast and Geodetic Survey has found that Western Union noon time signals may be relied upon to $0^s.1$; this means that cost of gravity work may be much reduced, there being no further need of field time observations. At 10 p.m. the meeting adjourned.

The 740th meeting was held on April 11, 1914, at the Cosmos Club, Vice-President EICHELBERGER in the chair; 42 persons present.

Mr. W. D. LAMBERT presented a paper entitled *The motion of falling bodies*. The author discussed the effect of the Earth's rotation on the motion of a body falling from rest and particularly as regards the component of the motion parallel to the plane of the meridian. The problem was treated in two ways, first by considering the falling body as a satellite of the Earth and, second, by the method of moving axes. The first method is not limited to short intervals of time but neglects the effects of the Earth's equatorial protuberance. If the displacement parallel to the plane of the meridian be expanded in powers of time, t, and terms involving powers of ω higher than ω^2 be neglected, ω being the angular velocity of the Earth's rotation, then there is no term in the expansion with a power of t lower than the sixth. The second method may be arranged to take account of the Earth's ellipsoidal form, the changes in the direction of gravity being allowed for in successive approximations. The second method verifies result of the first as to term in ω and brings out a very small southerly deviation (reckoned from the direction of gravity at the starting point) due to the ellipsoidal form of the Earth. The result may be analyzed in the following manner, speaking for the northern hemisphere: The direction of gravity changes during the fall of the body, first from the change in centrifugal force, which tends to give a northerly deflection; second, from the change in attraction of the equatorial protuberance, which tends to give a southerly deflection. There is, however, also a relatively large easterly deflection, and the velocity with which this takes place gives rise to an apparent force due to the Earth's rotation and tending to swing the easterly deviation to the right (northward); this is just sufficient to neutralize that arising from change in centrifugal force and leaves outstanding that due to Earth's equatorial protuberance.

The paper was discussed at some length by Mr. WOODWARD, particularly as regards the surface of reference, and by Messrs. BOWIE, GRAY, and BUCKINGHAM.

Mr. BOWIE made a brief informal communication showing evidence of nearly perfect isostasy in India from reductions at 14 gravity stations.

The usual hour of adjournment being at hand, it was moved and carried to extend the time to permit the reading of the second paper of the evening by Mr. W. J. HUMPHREYS *On thunderstorms*. The author discussed the mechanism of storms and applied in this connection the conclusion from W. Simpson's work in India that electricity with rain is essentially positive. The paper was illustrated by lantern slides showing, among other things, in particular the barometric conditions accompanying different types of storms. At 10:50 p.m. the meeting adjourned.

The 741st meeting was held on May 9, 1914, at the Cosmos Club, President FISCHER in the chair; 30 persons present.

Mr. L. W. AUSTIN spoke on *Recent experiments in the reception of radio-telegraphic signals*. The greatest obstacle not yet overcome in wireless signaling is the presence of atmospheric disturbances which confuse and often drown out signals being received; this difficulty is becoming greater as the receiving apparatus is becoming more sensitive. The author described methods to do away with this disturbance and in particular recent experiments with tuning spark apparatus. The most recent and interesting development is the improved oscillating audion and ampliphone of De Forest. The paper was discussed by Messrs. WHITE, BOWIE, BAUER, HUMPHREYS, MARVIN and DELLINGER as to automatic receiving apparatus, greater facility of transmission for north-south than east-west direction, latest ideas of causes of atmospheric disturbances, height of path, and amount of energy expended in sending, compared with amount received. Mr. AUSTIN stated there seemed to be no certain evidence as to greater ease of transmission in any particular direction; the disturbances are of local type and those at a distance, as discharges between clouds; there has been no close connection noted between weather and receiving conditions.

Mr. R. A. HARRIS then spoke *On periodic quantities, especially motions*. This communication was concerned with a series or aggregation of periodic terms, or with several such series considered simultaneously. A term of the form $ae^{i(at+\alpha)}$ is regarded as representing the simplest kind of periodic function because as t increases uniformly the function of t represented will describe a circle about its origin at a uniform rate. When there are several such terms, additional concepts arise, as amplitude ratios, speed differences, relative phases, and quantities in which these concepts are involved. A series of terms having the imaginary exponential form represents epicyclic motion. The simultaneous use of two series of terms where both commensurable and incommensurable speeds occur is exemplified in the new tide-predicting machine. Three series of periodic terms are suitable for space in general. At 10:10 p.m. the meeting adjourned.

The 742d meeting was held on May 23, 1914, at the Cosmos Club, Vice-President BURGESS in the chair; 27 persons present.

Mr. E. BUCKINGHAM presented a paper on *The interpretation of experiments on models.* The speaker began by deducing a general theorem regarding the form which physical equations must have in order to satisfy the requirement of dimensional homogeneity. The theorem may be stated as follows: If a relation subsists among a number of physical quantities, and if we form all the possible independent dimensionless products of powers of these quantities, any equation which describes the relation is reducible to the statement that some unknown function of these dimensionless products, taken as independent arguments, must vanish. The method of determining the number and forms of these products was explained. This theorem may be regarded as a convenient general summary of the requirement of dimensional homogeneity. It may be looked at from various standpoints and utilized for various purposes. The speaker gave several illustrative examples to show the practical operation of the theorem. The paper was discussed by Messrs. HERSEY, WHITE, BURGESS, and HUMPHREYS.

Mr. G. K. BURGESS spoke informally on *The allotropy of iron,* calling attention to recent advances made with particular reference to β-iron. The communication was discussed by Mr. WHITE.

Mr. W. J. HUMPHREYS spoke informally on *Is lightning discharge of direct or oscillatory character?* The speaker concludes that it cannot be oscillatory. The communication was discussed by Messrs. WHITE, AGNEW, and C. A. BRIGGS. At 10 p.m. the meeting adjourned.

J. A. FLEMING, *Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At the 472d regular meeting of the Society held at the National Museum, Tuesday, February 17, 1914, at 4:30 o'clock, Mr. J. N. B. HEWITT gave an address entitled, *The psychology of the myth.* A myth is the utterance of savage man; it is a naive creative concept. A myth treats of one or more of the "elder people," the familiar "first people," whom men of later times call "the gods." The subject-matter of myths is not human activity; for none relate to human beings, and none treat of things done since the appearance of man on earth. A myth is fictitious only in form and letter; but it is true in substance and spirit; truth is eternal, universal.

In terms of human form, attribute and activity, myths explain from the premises of their makers in just what manner the present order of things arose from one or more antecedent orders of things, and just how the present order is maintained.

The epos is the later dress or adornment of the mythos concept in poetic form as legend, saga, or story.

The logos is the still later literary criticism—the analytic and synthetic treatment—of the mythos and the epos; it is the intelligent, interpretative analysis and exegesis of the concept expressed by the mythos; it is logical, scientific; so mythology may be defined as the logic of the mythos. The first men had only myths; and whether as cosmogony or as religion they were final, conclusive.

Hence, mythos and epos and logos, all translatable as *word*, represent three well-defined stages of human thought in the development of opinions. Whatever, therefore, the ultimate terms or concepts may be in which man may define his gods, the process of his reasoning is always quite the same; the "unknown" is defined, though perhaps, unconsciously, in terms of the "known;" but the "known" quantity here is man, whatever this concept may signify at the time and place.

The phenomena, the bodies and the processes of nature are personified, and so humanized—a process of thought which is called anthropomorphism. So that all powers and functions and attributes characteristic of man—no matter whether good or evil—are ascribed to the gods in a more or less idealized form. Not only this, but the arts of men and the social and religious institutions of men are in like manner unconsciously attributed to the gods; and so the social and the religious institutions of the gods are ever an exact reflex of the human society over which these self-same gods preside.

By so doing, men give, in their myths and epics, though unconsciously perhaps, a faithful picture of the early culture and civilization of their own ancestors. In this manner, in brief, the gods in later times become the revealers of all history, the divine teachers of the arts and the crafts, and the founders of the institutions—human and divine—of a people. Here is found the true source of prophecy and inspiration; for these divine beings are the offspring of the interaction of the powers and the bodies and the phenomena of nature and the mind of man in its three-fold activities—the conscious, the subconscious and the superconscious. (*Author's abstract.*)

A special meeting of the Anthropological Society of Washington was held Tuesday, March 3, 1914, at 4.30 p.m., in the new National Museum Building, the President, Mr. Stetson, in the chair; 37 persons present.

Mr. W. E. Safford, Economic Botanist of the Department of Agriculture, read a paper on *The pan-pipes of ancient Peru*. Several specimens and figures on vases were shown and compared with ancient syrinxes, or fistulas, from Greece and Rome. (See this Journal, **4**: 183–191. April 19, 1914.)

At a special meeting of the Society held March 4, 1914, at the National Museum, Dr. A. B. Lewis gave an address on his *Travels in the South Seas and New Guinea,* illustrated with excellent lantern slides. The four years of 1909–1913 were spent in the South Pacific in the interest of the Field Museum of Natural History, Chicago, studying the natives and collecting ethnological material. The region chiefly concerned was in Melanesia, which includes the island groups extending northwest from Fiji and New Caledonia through the New Hebrides and Solomon Islands to New Guinea. Many of these islands are large and mountainous.

covered with a dense tropical forest, and only partially explored. Though all are claimed by different European powers, only the smaller islands and the coasts of the larger are under control. The traveler is perfectly safe, however, except in a few regions which are well known. Transportation is the great difficulty, and if one wishes to get away from the few settlements it must be by small launches or sailing craft belonging to the scattered traders and planters, or by native canoes. In one of the last the speaker traveled more than 100 miles, stopping at the native villages, sleeping in the native huts, with only natives as attendants and guides.

The condition at present varies much in the different islands; Fiji is the most civilized. The natives of Fiji are all professing Christians and read and write their own language. Excepting the ordinary things of everyday life, there is little of the old left. The native Fijian population is about 90,000 and the European 3,500, while there are 40,000 to 50,000 Indian coolies on the sugar plantations. Industrially, Fiji is far in advance of any of the other groups. New Caledonia was for years a French penal colony, and the natives are reduced to about 30,000 living on reservations, much as our American Indians. The New Hebrides are under the joint rule of France and England, but some of the large islands are still wild and unsafe. To the ethnologist, Malekula is the most interesting. Over twenty languages are spoken on this one island, to say nothing of dialects. The natives, houses, and dancing grounds, with huge carved drums and wooden figures, were illustrated by views. The Solomon Islands are mostly English, but two are under Germany. Including missionaries, there are probably not over three hundred Europeans in the group. Some of the islands still are unsafe, even to land on the shore, except where there is a mission station or government post. New Guinea is the largest and most interesting island of all. Except Greenland, it is the largest in the world, and the least known; for while even Greenland has been crossed several times, New Guinea has never been crossed except near the ends, where quite narrow. More time was spent on New Guinea than anywhere else. A considerable portion of the coast was visited and short trips were made toward the interior. There are but few Europeans in New Guinea, the greater number (about 1000) being in the British portion of the island, known officially as Papua. A considerable number of these are gold diggers. In German New Guinea (Kaiser-Wilhelmsland) there are about 200 Europeans, and in the Dutch portion not over 50. The old condition of warfare among the natives has been stopped as far as the government can extend its influence. The natives, as a rule, are friendly and hospitable. Many weeks were spent alone with them in their villages, with only native attendants. The habits, customs, and general appearance of the natives, while similar in general aspects, vary greatly in detail. Views illustrating the native villages, the people themselves with their characteristic dress and ornaments, and phases of native life, were shown from a number of different places, so that a general idea of their character and variety could be obtained.

At the 473d regular meeting of the Society, held March 17, at the National Museum, Dr. J. Walter Fewkes delivered an address, illustrated with lantern slides, on his *Egyptian experiences.* He considered especially the significance of certain parallelisms in cultural objects of the Stone Age of Egypt and the Gila Valley, Arizona. These resemblances he ascribed in part to the influence of an artificial system of irrigation in the evolution of an agricultural stage in development.

Dr. Fewkes began with an account of the unique shape and cultural isolation of the Nile Valley in Neolithic times and showed how man was isolated by deserts which protected him from outside marauders. His social advancement at the dawn of history, mainly due to the influx of foreign ideas from the East, can be traced to the coöperation between clusters of villages or nomes, this union having been effected in order to irrigate more effectually the narrow valley of the Nile. The coöperation of the rulers of Neolithic Egypt led to a ruler over all, a Great House, or Pharaoh, who later became King of Upper and Lower Egypt. To this coöperation in constructing irrigation ditches may be traced a system of enforced labor or corvée in which the Pharaoh not only acquired all cultivated land, and the water which alone made agriculture possible, but also controlled all labor of the inhabitants. To these rights acquired from the rulers of the nomes in very early times may be traced the powers exercised in constructing the magnificent monuments that are the world's wonders.

In Neolithic Egypt, there was a succession of villages strung along the river, each independent of the other, like a cluster of pueblos in Arizona. The remains of architectural constructions at this early epoch still remain and are sometimes, as at El Kab, well preserved. They are rectangular, massive, walled forts with an encircling wall of clay not unlike the compounds at Casa Grande and the Great Houses elsewhere on the Gila. Within these enclosures in Egypt and Arizona were mud or clay built temples, public buildings, and houses of priests, while around them were clusters of rude hovels in which lived the people like the present Egyptians.

The dead were buried in neighboring mounds, placed with the knees drawn to the chin and surrounded by mortuary offerings. These graves were rude excavations with floor of straw and roof of mud and boughs. Many resemblances between archæological objects from the Stone Age in Egypt and the Gila Valley were pointed out. Among these are weapons, stone implements, pottery and its symbolic decorations, flat basket trays, bone and other specimens.

Certain common conditions of environment and the necessity for artificial irrigation had led the Stone Age people of different races without connections, to develop a parallel culture.

At a special meeting of the Society held March 24 at the National Museum, Dr. Albert Hale, of the Pan-American Union, addressed the Society on *Modern Argentina,* illustrating his remarks with lantern slides.

After a description of the geographic relations of the Río de la Plata region, with an outline of its ethnical and anthropological conditions, the speaker traced the history of Argentina only so far as it had an immediate bearing upon material progress, and then gave a comprehensive survey of the republic as at present,—its principal cities, its industries, its products, and its activities. One of the interesting features about the republic is that in it is repeated a development quite comparable to that which has been so characteristic of the United States in North America. In fact, this immense area in South America is the one most easily understood by the Anglo-Saxon who looks back upon the history of material progress and conquest in his own country.

The ethnical elements of the population may be studied in the immigration statistics of Argentina more satisfactorily than in its census. In fact, no census has been taken since 1895, when the total population was 3,954,911. In 1911 it was estimated to be over 7,000,000. The total number of immigrants arriving in the years 1857–1912 was 4,248,355. It is interesting to note that more than half this number, or 2,133,508, were Italians. The Spaniards were scarcely more than half as numerous as the Italians, or 1,298,122. Other European races were represented by much smaller numbers than these. The French numbered only 206,912 and the "Russians" 136,659. Next to these came a race from Western Asia, the Syrians, with a total of 109,234; then the "Austrians" and "Germans" with 80,736 and 55,068, respectively. The "Britons" numbered nearly as many as the "Germans," or 51,660. The Swiss, Belgians, and Portuguese numbered about 20,000 or 30,000 each; the Danes and Dutch 7000 each; the "North Americans" 5500; the Swedes 1700, and "others" 79,251.

The relative proportions of Italians and Spaniards arriving during the last year of this period, 1912, were about the same as during the entire period, or 165,662 of the former to 80,583 of the latter. It is worthy of note that the "Russians" and Syrians rose to the next two places in the list, with a total for the year of about 20,000 each. No doubt the "Russians" and "Austrians" in Argentina, as in the United States, are largely Poles and Slavs of other races than the true Russian, together with a certain proportion of Hebrews. The "North Americans" arriving during 1912 numbered about 500. The total immigration for the year was 323,403.

A high tide of immigration reached Argentina at about the same period as the United States, in the decade 1881–1890, when a grand total of 846,568 immigrants arrived in Argentina. This number was, however, exceeded in the last half-decade, 1906–1910, when 1,238,073 arrived in Argentina, or a larger proportion than came to the United States during that period.

At a special meeting of the Society, held April 7, at the National Museum, Señor F. A. Pezet, Minister of Peru, read a paper on *Contrasts in the development of nationality in Latin and Anglo-America.* Each of these populations, he said, has its special traits of character, born with the individual or developed through the environment. He first considered the relative conditions, at the time of the discovery, of the territories now known as the United States and Latin America; and, second, the type of the first settlers. The discoverers found Latin-American territories organized into semi-civilized states but Anglo-American territory occupied by savages. Two very different types came to America. The Anglo-Americans were oppressed and persecuted by religious intolerance; the Latin Americans were adventurous soldiers of fortune. The former came to build up new homes; the latter, to tear down, to destroy, and to carry away everything they could lay their hands upon. The first Latin Americans were valiant, but ignorant and unscrupulous, principally from a country where religious bigotry was rampant. They were an admixture of virtues and vices and in marked contrast to the men who came to the shores of New England. Whereas the Anglo-Americans acquired the land as settlers and drove the natives westward, the Latin-American military forces overthrew native governments and established themselves as the governing class, reducing the Indians often to slavery.

While the Anglo-American settlers brought their families, the Latin Americans did not until many years after the Conquest, but took to themselves Indian women. The offspring became the "mestizos," a mixed race that the pure Castilians of Spain never countenanced. Later the creoles came into existence, the offspring of European parents born in America. The mixing of races was finally encouraged by the Spanish monarchy, the idea being to create a great middle class of uniform race. Soldiers were allowed a great amount of liberty. Before 1800 A.D. the mestizo population of Peru exceeded 250,000. While some mestizos received an education and were brought up with creole children, most were kept in ignorance. While Anglo-Americans readily acquired the art of self-government, the Latin-American peoples did not; they knew how to rule, not how to govern. So, for more than two centuries, the Europeans and the creoles ruled the mestizos and the Indians. The mestizo is nearer the Caucasian than the Indian; physically and morally he is superior to the Indian. Although of less active intelligence than the European or the creole, he is more strong-willed and painstaking. In the early days the mestizo who had one parent of rank was placed on an equal footing with the creole; but as the mestizos became more numerous, the Spaniards began to distrust them and prevented them from obtaining certain social positions or much education. All these years the Indians were oppressed, even by the mestizos. After two hundred years of hatred and distrust these elements eventually, out of sheer exhaustion, became apparently reconciled to their respective conditions. The colonial nationality, which was finally evolved, was thus formed of creoles and mestizos and might have been a beneficent one if it had had time to develop. Ideas of republicanism were adopted from the United States and from France without preparation for self-government, such as the people of the United States had. In the later nationality of the Latin-American countries there were, therefore, racial divisions: The creoles and the Spaniards formed the governing class; the mestizos strove to be on an equal footing with these; and, a long way down in the social scale, came the Indians, considered inferior even to the African slaves. The same laxity permitted the mixing of the African with the other races. The Indian population, so long neglected, is now a matter of deep concern in many of the Latin-American countries; for example, in Peru, where there is a larger percentage of pure Indian and of mestizo blood.

At a special meeting of the Society, held April 14 at the National Museum, Mr. S. M. Gronberger read a paper on *The origin of the Goths.* The ancient home of the Goths was undoubtedly situated, he said, on both the northern and southern shores of the Baltic, and at the beginning of the Christian era this people had settled chiefly along the river Vistula in northeastern Germany. Previous to the Christian era, another division of this race had immigrated into Scandinavia (about 200–300 B.C.) probably across the Danish isles. Somewhat later, at the time of the earliest Gothic movement southward, about 215 A.D., the migrants were probably joined by their Scandinavian brethren who emigrated from "Scandza" (mentioned by Jordanes, the Gothic historian), and to this period the Gothic saga of Jordanes should be assigned. This emigration of the Goths from Scandinavia was probably due to some signal defeat in the savage warfare then carried on by them with the Swedes or "Svear" of the Scandinavian peninsula. Names of regions and localities in Scandinavia testify to their association with the Goths, and the names of Ostrogoths, or East Goths, and Visigoths, or West Goths, are recognized in the Sweden of today. Mediaeval Swedish history tells of constant conflicts between the Swedes and Goths, the latter of whom were the more ancient inhabitants. The two races are now merged together and constitute the modern Swedish nation. The Anglo-Saxon poem "Beowulf," by an unknown author, furnishes powerful testimony as to the early home of the Goths in the Scandinavian peninsula and the Danish islands. The Baltic island of Gotland received its name from the Goths, and great numbers of Roman and Byzantine coins and other objects which have been unearthed in that island afford further proof of the Scandinavian migrations. In addition to Jordanes, Cassiodorus, upon whose history that of the first named was based, Tacitus, Procopius, and Paulus Diaconus, not to mention the earliest though doubtful evidence of Pytheas of Massilia (now Marseille), who had the advantage of having personally visited the regions he described, testified to the Scandinavian or Baltic origin of the Goths. The most ancient tradition relating to the Goths was that they had come originally from Asia, the cradle of mankind, by way of southeastern Europe under the leadership of their legendary hero and deity, Odin, or Wothan.

One of the most remarkable runic inscriptions in Scandinavia is that of the so-called Rök stone, located in western Ostrogothia, Sweden, which is of great importance in connection with the early history of the

Goths. It contains an epitaph and dates back to 830–840 A.D., or the time of the introduction of Christianity into Scandinavia by St. Ansgar. The inscription contains an allusion to Theodoric the Great, who ruled as Ostrogothic King of Italy. Another part of the inscription refers to four kings of the Danish island of Zealand. The names of these four, who were brothers, and their sons, can be identified with names mentioned in Jordanes' saga. The Rök runic inscription affords one of the most important fragments of historical evidence connecting the Ostrogothic kindgom of Italy with the Goths of Scandinavia, and contains more points of resemblance with Jordanes' saga than any known historic source.

The evidence of relationship between the Gothic and Scandinavian languages, found in the modern Germanic and Scandinavian tongues, is also of great importance. The most essential point of resemblance between these languages is the mutual retention in certain cases of "gg" before "w" and "J" ("ggj" was changed into "ddj" in Gothic); as, for instance, in the genitive plural Old English *tweza* (two), Danish *twaeggie*, Gothic *twaddje*, modern Swedish *twegge*. Compare also the English *true* with Swedish, Danish, and Norwegian *trygg*, Icelandic *tryggr*, Gothic *triggws*.

At the adjourned 474th regular and 35th annual meeting of the Society held at 4 o'clock, May 5, at the National Museum, Dr. Edgar J. Banks, field director of an expedition to Babylonia in 1903–1905 under the auspices of the University of Chicago, read a paper, illustrated with lantern slides, on *Bismya; or, the Lost City of Adab*. Bismya flourished in central Babylonia throughout a period of two thousand years previous to 2000 B.C. The mounds extend a mile or more along the bed of an ancient canal, about halfway between the Tigris and Euphrates rivers, and five days' journey south of Bagdad. The highest of the mounds reach about fifty feet above the level of the desert. The surface is covered with pottery fragments. The workmen employed were Arabs of the hostile Bedier tribe. An agreement was entered into with the chief of the tribe to employ workmen only from him, and in return he promised to protect the excavators from the depredations of surrounding tribes. At the head of each gang was a pickman who loosened the dirt and searched through it for antiquities. With him were two scrapers with triangular hoes with which they scraped the dirt into baskets. The scrapers received sixteen cents a day and the basket men twelve, but the pay of each man was doubled for the day on which he found an antiquity of value. Near the surface were found bricks of the temple wall having on their under side the inscription of Dungi, King of Ur, of about 2200 B.C., and below them bricks bearing his father's name, Ur-Engur. At a lower level was found a gold inscription of Naram-Sin and bricks of his father Sargon, the first known Semitic kings, of about 2800 B.C. Until recently the date of these kings was supposed to be about a thousand years earlier.

Beneath the ruins representing these Semitic kings were the traces of the earlier civilization of the Sumerians, a cultured people who had occupied Mesopotamia for several thousand years. From them the wedge-shaped characters of the language and many of the Semitic religious forms were borrowed. An important discovery was a perfect, large marble statue of a Sumerian king called Lugal Da-udu of about four thousand years before the Christian era. Large numbers of stone vase fragments were found; some were inscribed with the names of the kings of the fifth millennium before Christ; others were engraved with intricate designs; and a few of them were inlaid with ivory and bright stones. One bore the picture of the temple power; one had the oldest representation of a musical instrument known to exist. Far down the shaft was discovered a long spike of pure copper terminating in a crouching lion. Lowest down, on the undisturbed desert level, were found large numbers of pottery fragments, showing that perhaps fifteen thousand years ago a people with considerable civilization occupied that spot. An ancient Sumerian crematory was found. It was a circular chamber with an oval platform connected with a furnace. The ashes of the dead were brushed into the pit beneath the platform. The Semite dead were buried in small house-like tombs of sun-dried bricks. In these were found the pottery to contain food and drink for the spirits of the dead, the jewelry of the women, and the seal cylinders of the men. Several palaces were found and in them small collections of clay tablets containing the business documents of the people. In one large chamber were about five thousand of the tablets in a heap. In the residential portion of the city were found the very narrow winding streets lined with houses of but a single room. Many of the houses were provided with vertical drains reaching into the ground forty feet or more, and with cisterns. Frequently there had survived the oven in which the bread was baked, the mortar for pounding the grain, the images of the household gods which were supposed to drive away disease, the toys of the children, the needles and knives of the women, and many other things necessary to life in those days. A public bath was found in the residential section of the city, provided with a vertical drain beneath the floor of bitumen, a furnace for heating the water, and a cistern high up in the building. The people of Bismya were among the oldest who have left us evidences of a highly developed civilization, and the first occupants of the place, ten or fifteen thousand years ago, were as civilized as the present occupants of the surrounding desert.

Mr. James Mooney was elected President of the Society for the ensuing year, and the following officers were re-elected: Vice-President, Dr. John R. Swanton; Secretary, Dr. Daniel Folkmar; Treasurer, Mr. J. N. B. Hewitt; Councilors: Mr. Felix Neumann, Dr. I. M. Casanowicz, and Mr. Francis LaFlesche.

Daniel Folkmar, *Secretary.*

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METEOROLOGY.—*American temperatures and European rainfall.* W. J. HUMPHREYS, Weather Bureau.

It appears to be very definitely established that the average temperature over the entire earth varies from year to year, that it tends to follow inversely the sun spot cycle—to be lowest at spot maxima and highest at spot minima; that it is invariably decreased by the presence of volcanic dust in the high atmosphere; and that actually it follows closely the resultant of these two influences.[1] If then the average temperature over the earth does vary, it would seem logically certain that many if not all other meteorological elements, such as evaporation (increases with temperature), total precipitation (equals total evaporation), amount of cloudiness, thunderstorm frequency, barometric pressure, total wind movement, and the like, together with all the things that they in turn affect, must also vary according to the same period. But in the case of natural phenomena it often happens that, owing to unsuspected imperfections in the premises, there are surprising differences between the "logically certain" and the "statistically sure." Hence the above inter-relations, however certain one may feel as to what they "ought" to be, are being examined statistically as rapidly as possible, and several interesting results, all confirmatory of natural and simple deductions, have already been obtained, though the investigation as a whole is scarcely more than begun.

[1] Abbot and Fowle. Annals of the Astrophysical Observatory of the Smithsonian Institution, **3**: 211. 1913. Humphreys, Journal Franklin Institute, **177**: 131. 1913. Bulletin Mount Weather Observatory, **6**: 1. 1913.

One of the most interesting of the inter-relations between climatological factors so far shown by this study is the close relation between the annual average temperature of the eastern United States and the total annual precipitation over a large portion of northern Europe. Since the prevailing winds across the North Atlantic are from America to Europe it would seem that when the annual average temperature of the eastern United States is high these winds should reach Europe relatively heavily laden with moisture (evaporation increases rapidly with increase of temperature) and give to it a correspondingly large annual total precipitation. On the other hand, when the annual average temperature of the eastern United States is below normal one might reasonably expect the corresponding annual precipitation of Europe also to be below its normal.

This argument is exactly the same as that which would lead us to anticipate an increase of world-wide precipitation following a universal, or practically universal, increase in the average temperature; but as it applies to well known and restricted regions it is far more easily tested statistically. To this end the averages were taken for each year from 1874 to 1913, inclusive, of the annual average temperatures of 30 rather evenly scattered United States Weather Bureau stations east of the 90th meridian, and the results compared with the average of the annual precipitations at 21 stations widely scattered over Germany. The temperature data were furnished by the Climatological Division of the U. S. Weather Bureau, Mr. P. C. Day in charge; and the rainfall data from 1874 to 1900, inclusive, were obtained from Hellmann's Die Niederschläge in den Norddeutschen Stromgebieten, volume 1, pages 336 and 337. The subsequent precipitation data were derived from official meteorological publications relative to the same stations in the library of the U. S. Weather Bureau. Both sets of data, the temperature and the rainfall, were "smoothed" according to the equation, commonly used for this purpose,

$$b' = \frac{a + 2b + c}{4}$$

in which b' is the "smoothed" value for the year in question, and a, b, and c the observed values, respectively, for the next preceding, the actual and the next succeeding year.

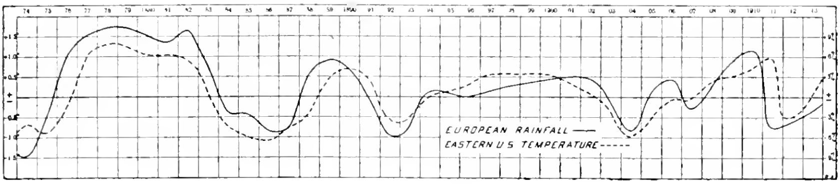

Fig. 1.

The results of this study are represented graphically by the two "smoothed" curves of the accompanying illustration, the one of American (eastern United States) temperatures, the other of European (German) rainfall, or, rather, water equivalent of the total precipitation. Obviously, as the curves show, in this case at least, the statistical results fully support and confirm the previous logical deduction, namely: That high annual average temperatures in America must lead to correspondingly heavy precipitation in Europe and, conversely, that persistently low average American temperatures must be accompanied by more or less correspondingly light European precipitation.

In addition to the rainfall of Germany that of the north slope of the Alps, and also of Holland, were independently examined, and, as might have been suspected, all three found to vary in substantially the same manner.

As above implied, this result is only an earnest of the many important meteorological inter-relations which the complete investigation may reasonably be expected to reveal.

PHYSICS.—*Physically similar systems.* E. Buckingham, Bureau of Standards.

1. Let n physical quantities, Q, of n different kinds, be so related that the value of any one is fixed by the values of the others. If no further quantity is involved in the phenomenon characterized by the relation, the relation is complete and may be described by an equation of the form

$$\sum M Q_1^{b_1} Q_2^{b_2} \cdot \cdot \cdot \cdot \cdot Q_n^{b_n} = 0 \tag{1}$$

in which the coefficients M are dimensionless or pure numbers. No purely arithmetical operator, such as *log* or *sin* can be applied to an operand which is not a pure number; and whenever functions that are not expressible as sums of terms of the form (1) occur in physical equations, their arguments are always dimensionless numbers. The results of the indicated operations are therefore also dimensionless numbers, and such functions, when they appear, may be included in the dimensionless coefficients M.

2. Upon dividing equation (1) through by any term we have

$$1 + \sum N Q_1^{a_1} Q_2^{a_2} \cdot \cdot \cdot Q_n^{a_n} = 0 \tag{2}$$

All the terms of a physical equation must have the same dimensions, and the N's are of zero dimensions; hence the exponents a, of each term, must be such that a dimensional equation

$$\left[Q_1^{a_1} Q_2^{a_2} \cdot \cdot \cdot Q_n^{a_n}\right] = [1] \tag{3}$$

is satisfied.

Let π represent any dimensionless product of the form defined by equation (3). Then π^x is also dimensionless; and if $\pi_1, \pi_2, \ldots\ldots \pi_i$ are all the independent dimensionless products which can be made by combining powers of the Q's, equation (2) may still satisfy the dimensional requirement by having the more general form

$$1 + \sum N \pi_1^{x_1} \pi_2^{x_2} \cdot \cdot \cdot \cdot \pi_i^{x_i} = 0 \tag{4}$$

Since the number of terms and the values of the N's and x's are indeterminate, the Σ is merely some entirely unknown function of the independent arguments $\pi_1, \pi_2, \ldots\ldots \pi_i$. Hence the most general form that equation (1) can have, subject to the dimensional conditions, is

$$\Psi\left(\pi_1, \pi_2, \cdot \cdot \cdot \cdot \pi_i\right) = 0 \tag{5}$$

3. Let k be the number of fundamental units needed in an absolute system for measuring the n kinds of quantity: then among the n units required, there is always at least one set of k which are independent and not derivable from one another, and which might therefore be used as fundamental units, the remaining

$(n-k)$ being derived from them. Let $[Q_1],....[Q_k]$ be such a set, and let $[Q_{k+1}],....[Q_n]$ be denoted by $[P_1],....[P_{n-k}]$. Each unit $[P]$ is connected with or derivable from the $[Q]$'s by a dimensional equation which may be written in the form

$$\left[Q_1^{\alpha} Q_2^{\beta} \cdot \cdot \cdot \cdot Q_k^{\kappa} P\right] = [1] \tag{6}$$

Since there are $(n-k)$ of the P's, there are $(n-k)$ independent equations of this sort, and no more.

If in equation (6) we substitute for $[P]$ and the $[Q]$'s their dimensional equivalents in terms of any convenient fundamental units—which will necessarily be k in number—the requirement that the exponent of each fundamental unit shall vanish separately furnishes k independent linear equations which suffice for the determination of the exponents α, β, etc. If, after determining these exponents for any particular $[P]$, we set

$$\pi = Q_1^{\alpha} Q_2^{\beta} \cdot \cdot \cdot Q_k^{\kappa} P \tag{7}$$

π satisfies the condition of being a dimensionless product of the required form. There are $(n-k)$ independent equations of the form (6), one for each of the quantities P, and the same number of independent π's; hence $i = n-k$.

4. We have hitherto confined our attention to a relation among quantities that are all of different kinds. If several quantities of any one kind are involved in the relation to be described, they may all be specified by the value of any one and the ratios r', r'', etc., of the others to that one. Dimensional considerations cannot tell us anything about the manner in which these dimensionless ratios r appear in the equation which describes the relation; but their possible influence must be indicated, and this may be done in an entirely general way by introducing them as additional independent arguments of the unknown function Ψ. The limitation imposed by the requirement of dimensional homogeneity upon the possible forms of physical equations may therefore be conveniently summarized in the following statement:

Any complete physical equation which describes a relation subsisting among quantities of n different kinds, of which k kinds are independent and not derivable from one another, is reducible to the form

$$\Psi\,(\pi_1,\ \pi_2,\ \cdot\ \cdot\ \cdot\ \pi_{n-k},\ r',\ r'',\ \cdot\ \cdot\ \text{etc.}) = 0 \tag{8}$$

in which the r's are all the independent ratios of quantities of the same kind, and each π is determinable from an equation of the form

$$[\pi] = \left[Q_1^{\alpha}\,Q_2^{\beta}\ \cdot\ \cdot\ \cdot\ \cdot\ Q_k^{\kappa}\,P\right] = [1] \tag{9}$$

The independent arguments of Ψ in equation (8), including both the π's and the r's, are *all* the independent dimensionless products of powers of *all* the quantities involved in the relation, whether of different kinds or not. If the whole number of quantities is h, the number of these independent arguments is $(h-k)$. Hence any complete physical equation is reducible to the form

$$\Psi\,(X_1,\ X_2,\ \cdot\ \cdot\ \cdot\ \cdot\ X_{h-k}) \tag{10}$$

in which the X's are all the possible independent dimensionless combinations of powers of all the quantities involved.

5. In practice, the r's are evident upon inspection of the whole list of quantities; there is therefore no occasion for finding them from equations of the form (9), and equation (8) is more convenient than the symmetrical form (10), which does not distinguish between the r's, which are pure ratios with absolute numerical values, and the expressions π which, while dimensionless and independent of the sizes of the fundamental units of our system, do depend on the definitions according to which the derived and fundamental units of the absolute system are connected.

It often happens that one or more of the π's are also evident upon inspection. In this event, only the remaining π's need be found by the routine process of solving equation (9) for the exponents.

When the solution of equation (9) results in a value of π which is inconvenient to write, we are at liberty to replace the expression found, by any function of itself: for this new expression will still be dimensionless and independent of the other π's. This remark enables us to dispense with the fractional exponents which sometimes result from the solution of equation (9).

6. If equation (8) is solved for any one of the π's, e.g. π_1 it may be written in the form

$$P_1 = Q_1^a Q_2^b \cdots Q_k^\kappa \varphi(\pi_2, \pi_3, \cdots \pi_{n-k}, r', r'', \cdots) \quad (11)$$

in which

$$a = -\alpha_1, b = -\beta_1, \text{etc.}$$

If it is desired to obtain an equation of the form (11) with a particular quantity P_1 appearing separately and in the first member only, it is evident that this quantity must, from the start, be excluded from the list of quantities to be used as the $[Q]$'s in equation (9). It will then act as a $[P]$, will appear in only a single π, and will be separable.

Equation (8) may also, of course, be solved for any one of the r's, such as r', and put into the form

$$r' = \varphi(\pi_1, \pi_2, \cdots \pi_{n-k}, r'', r''', \cdots \text{etc.}) \quad (12)$$

which is sometimes useful.

7. Since equation (11) contains an unknown function φ, the form of which can not be found by dimensional reasoning, the equation does not give us any definite information in the general case when all the quantities involved in the second member vary arbitrarily. If, however, all the r's are held constant; and if the variations of the Q's and of $P_2, \ldots . P_{n-k}$ are not entirely arbitrary but subjected to the $(n-k-1)$ conditions that $\pi_2, \ldots . \pi_{n-k}$ shall remain constant; then we do have a definite statement of the dependence of P_1 on the Q's. For under these circumstances, although its general form remains unknown, the function φ degenerates into a dimensionless constant N, because its arguments are all constant. Hence equation (11) assumes the definite form

$$P_1 = N Q_1^a Q_2^b \cdots Q_k^\kappa \quad (13)$$

A single measurement of simultaneous values of P_1 and the Q's suffices to determine the numerical value of N; and by equation (13) with this value of N, the value of P_1 may be computed for any values of the Q's without further experiment.

The chief value of the principle of dimensional homogeneity is found in its application to problems in which it is possible to arrange matters so that the r's and π's of equation (11) shall remain constant and the definite equation (13) therefore be satisfied.

8. The quantities involved in a physical relation pertain to some particular physical system which may usually be treated as of very limited extent. Let S be such a system, and (11) the equation which describes a relation subsisting among certain quantities of the kinds Q and P which pertain to S, e.g. the sizes, densities, thermal conductivities, etc. of its essential parts.

Let S' be a second system into which S would be transformed if all quantities of each kind Q involved in equation (11), were changed in some arbitrary ratio, so that the r's for all quantities of these kinds remained constant, while the particular quantities Q_1, Q_2,....Q_k changed in k independent ratios. For example; if Q_1 is a length, S and S' are to be geometrically similar in all their essential parts, though other parts, of which the size and shape have no influence on the relation under consideration, are not subject to any geometrical conditions. The systems now "correspond" as regards their essential parts and may be said to be similar as regards each of the kinds of quantity Q separately, so far as such quantities are involved in equation (11).

In addition to the foregoing specifications, which relate to the changes of the Q's during the transformation of S into S', let P_2 and all quantities of that kind involved in the relation, change in such a ratio, dependent on the *arbitrary* changes of the Q's, that π_2 remains constant; and let similar conditions be imposed on P_3, P_4,....P_{n-k}, and all quantities of those kinds involved in the relation. Two systems S and S' which are related in the manner just described are similar as regards the physical relation in question.

If two systems correspond in the manner described for the k independent kinds of quantity Q, and if it is practicable to make them similar by fulfilling the conditions which relate to the quantities of the kinds P, equation (13) is satisfied by the quantities pertaining to either system, and the value of N determined by experiment on one system may at once be used for the other.

A particular form of this theorem, known as the principle of "dynamical similarity" is in familiar use for the interpretation of experiments on mechanical models; but the theorem is equally applicable to problems in heat and electromagnetics.

PHYSICAL METALLURGY.—*Observations on finishing temperature and properties of rails.*[1] G. K. BURGESS, J. J. CROWE, H. S. RAWDON, and R. G. WALTENBERG, Bureau of Standards.

Observations were taken with an optical pyrometer of ingot and finishing temperatures of rails in four representative mills. There is practical uniformity among the several mills for the rolling temperatures of ingots for steel rails, the range being from 1080°C. (1975°F.) to 1140°C. (2085°F.). There is no very considerable difference among the finishing temperatures of the rails as observed at the hot saws for the several mills, the range being about 880°C. (1615°F.) to 990°C. (1815°F.). Or, in other words, the four mills all finished their rails to within 50°C. of 935°C. (1715° F.) on the average. This temperature of 935°C. is 270°C. (520°F.) above the mean value, 665°C. (1230°F.) of the critical ranges of these rail steels. Concerning the distribution of temperature within the head of a cooling rail, it is shown that the center of the head is some 50°C. (120°F.) to 60°C. hotter than the optical pyrometer reading at 935°C.; therefore the center of the head is finished, on the average, at about 325°C. (615°F.) above the critical range for 100 lb. sections.

Chemical analyses and microphotographic examinations were also made and the mechanical properties determined for a number of samples of rail, the rolling of which had been observed. From a comparison of these few observations there appears to be not a sufficient degree of correlation to warrant associating very speci-

[1] This is a summary of a paper to be published shortly in full as a Technologic Paper of the Bureau of Standards with the following contents: 1. Introduction; 2. Importance of Limiting Temperatures of Rolling Rails; 3. Methods of Measuring Rail Temperatures; 4. Wickhorst's Experiments; 5. Measurements of Ingot and Finishing Temperatures; 6. The Samples and Chemical Analyses; 7. Mechanical Properties of Rails; 8. Melting Temperatures of Rail Steels; 9. The Critical Ranges of Rail Steels; 10. Observations on the Microstructure; 11. Temperature Distribution in a Cooling Rail; 12. The Expansion of Rail Steels; 13. The "Shrinkage Clause" in Rail Specifications; 14. Summary and Conclusions.

fically any of the characteristics defined by these three methods of examination, either with the temperatures of rolling here observed or with each other.

The following thermal properties of these rail steels were determined in the laboratory: The critical range on heating is located (maximum) to within 7°C. of 732°C. (1350°F.) for the 10 samples of O.H. and Bessemer steels examined. On cooling, the critical range lies between the limits 680°C. (1256°F.) and 650°C. (1202°F.). The melting or freezing range for rail steel extends from about 1470°C. (2680°F.) to nearly the melting point of iron, located at 1530°C. (2786°F.).

The expansion for O.H. and Bessemer steels is not the same. Above 800°C. (1470°F.) the expansion for both increases linearly with temperature, and the linear coefficient per degree centigrade has the following mean values between 0° and 1000°C.:

(1) For Bessemer Steel (Carbon .40 to .50 per cent): $\alpha = 0.0000146$
(2) For Open Hearth Steel (Carbon .65 to .70 per cent): $\alpha = 0.0000156$ to 0.0000161.

The average composition of the Bessemers was carbon = 0.40 to 0.50 and maganese = 0.76 to 0.93; of the Open Hearths, carbon = 0.65 to 0.70 and manganese = 0.66 to 0.72.

In 1909 the American Society for Testing Materials limited the shrinkage allowance on 100 lb. sections to $6\frac{3}{4}$ inches in 33 feet, or to an equivalent of 1947°F. (1064°C.) for O.H. and 2055°F. (1124°C.) for Bessemer rails, a specification which is still in force. Such a shrinkage clause, therefore, does not serve the avowed purpose of limiting the finishing temperatures to a value slightly above the critical range.

MINERALOGY.—*Mineralogical notes, Series 3.* WALDEMAR T. SCHALLER, U. S. Geological Survey.

A bulletin with this title has been submitted for publication by the U. S. Geological Survey. In order to secure priority, the following very brief abstracts are given of the original papers:

Koechlinite (Bismuth Molybdate), A New Mineral from Schneeberg, Saxony, is named after Dr. RUDOLF KOECHLIN of Vienna. The orthorhombic ($a : b : c = 0.9774 : 1 : 1.0026$) crystals are thin tabular parallel to a {100}. Formula: $Bi_2O_3.MoO_3$. *Inyoite and Meyerhofferite, Two New Calcium Borates* from Death Valley, Inyo County, California, belong to the colemanite series. *Inyoite* (named after the locality) occurs in rhombic-shaped monoclinic crystals ($a : b : c = 0.9408 : 1 : 0.6665$, $\beta = 62°37'$). The formula is $2CaO.3B_2O_3.13H_2O$. The *inyoite* crystals alter to aggregates of prismatic crystals of *meyerhofferite* (named after W. MEYERHOFFER, who made the mineral artificially), which is triclinic ($a : b : c = 0.7923 : 1 : 0.7750$, $\alpha = 89°32'$, $\beta = 78°19'$, $\gamma = 86°52'$) and which has the formula $2CaO.3B_2O_3.7H_2O$. *Lucinite a New Mineral: A Dimorphous Form of Variscite,* occurs with variscite at Lucin, Utah, in minute octahedral orthorhombic crystals.

Lucinite, $a : b : c = 0.8729 : 1 : 0.9788$
Variscite, $a : b : c = 0.8944 : 1 : 1.0919$

Analyses show the two minerals to have the same composition. *The Crystallography of Variscite* includes a redetermination of the axial ratio (just given) and an extension of the crystal forms. *Schneebergite:* A study of original material from Schneeberg, Austrian Tyrol, loaned by DR. KOECHLIN of Vienna, has shown it to have the formula $4CaO.Sb_2O_3.Sb_2O_5$, the antimony being present in two states of oxidation. Schneebergite is distinct from all other calcium antimony compounds. *Romeine* from Italy has the formula $5CaO.3Sb_2O_5$. The so-called atopite from Brazil is not that mineral but romeine. *The Natural Antimonites and Antimonates* are briefly classified. *Velardeñite, a New Member of the Melilite Group,* is tetragonal, and has the composition $2CaO.Al_2O3.SiO_2$. The so-called gehlenite from Velardeña, Mexico, is velardeñite. *The Melilite Group* of minerals can be interpreted as mixtures of velardeñite, sarcolite ($3CaO.Al_2O_3.3SiO_2$), and åckermanite ($4MgO.8CaO.9SiO_2$). *The Crystallography of Thaumasite* describes hexagonal crystals, $c = 1.09$. The *Chrysocolla Group* discusses the minerals commonly called chrysocolla which are shown to belong to several distinct crystallized species. *The Chemical Composition of Tremolite* is considered from the chemical side and the probable formula derived for the mineral is $H_2O.2CaO.5MgO.8SiO_2$. *The Probable Identity of Mariposite and Alurgite* is considered, and *The Amblygonite Group* *of Minerals*: *Fremontite* = *Natramblygonite* withdraws the name natramblygonite and substitutes for the mineral $Na(AlOH)PO_4$ the name *fremontite*, after Fremont County, Colorado.

BOTANY.—*Acacia cornigera and its allies.* WILLIAM EDWIN SAFFORD, Bureau of Plant Industry.

In the course of a recent study of the myrmecophilous Acacias in the U. S. National Herbarium the author encountered a number of undescribed species, some of which differ fundamentally from any hitherto known. Much confusion was found also in the existing classification of these plants, due largely to the fact that, in describing species, the early authors had failed to designate definite types. Thus, under *Acacia cornigera* (*Mimosa cornigera* L.) several distinct species were cited by Willdenow as possible synonyms, a fact which was recognized by Schlechtendal and Chamisso in their study of certain specimens collected in Mexico by Schiede. But these authors in turn included under their *Acacia sphaerocephala* two, if not three species, one of which has recently been described by Dr. Heinrich Schenck, of Darmstadt, under the name *Acacia veracruzensis*. To make the confusion still greater, Bentham in his Revision of the Mimoseae,[1] "redescribed" *Acacia sphaerocephala* and *A. spadicigera* but applied these names to species quite distinct from those so-called by Schlechtendal and Chamisso, while he dropped *Acacia cornigera*, a species distinct from both *A. sphaerocephala* and *A. spadicigera*, based upon a plant growing in the garden of George Clifford, a specimen of which exists in the Linnaean Herbarium (no. 4). The synonyms cited by Bentham are even more heterogeneous than those of Linnaeus.

The absence of flowers and fruits from the specimens of myrmecophilous Acacias described by the early botanists has been the chief cause of the mistakes of later authors. Fortunately the material in the U. S. National Herbarium includes specimens of fruits as well as of flowers of nearly all the species. The present writer recognized the fact that these fruits, which are of several distinct forms, offer a means of separating the species into a

[1] Trans. Linn. Soc. Lond. 30. 1875.

number of well defined natural groups. When it came to his notice that Dr. Schenck was also engaged in studying the myrmecophilous Acacias, the writer postponed the publication of his paper in deference to Dr. Schenck, from whom he received a most courteous acknowledgment.[2]

Dr. Schenck based his classification principally upon the venation of the leaflets and upon the general form of the inflorescence. In his material fruits of several species were lacking. On the receipt of photographs of further specimens of his newly established species, many of which included seed pods, Dr. Schenck realized the importance of using the latter as a basis for natural classification.[3] As it has become necessary to defer the publication of the writer's monograph of the myrmecophilous Acacias, it is thought advisable to offer the present preliminary paper, in which a classification of the group is presented together with descriptions of nine new species.

KEY TO THE GROUPS

Involucre situated near the base or at least below the middle of the peduncle; interfloral pedicelled bracteoles peltate; spines glabrous
- Pericarp indehiscent, inflated, terminating in an acute spine-like beak. . . . . I. CERATOPHYSAE.
- Pericarp dehiscent
  - Fruit a pod, opening by a dorsal and a ventral suture
    - Flowers in globose heads; pods sometimes very long and slender . . . II. GLOBULIFERAE.
    - Flowers in cylindrical spikes; pods short and relatively broad . . . . . . III. LEGUMINIFERAE.
  - Fruit a follicle, opening by a single suture. IV. FOLLICULARES.

Involucre situated at or above the middle of the peduncle, the latter pubescent or hirtellous; interfloral pedicelled bracteoles not peltate; spines puberulent when young . . . V. HEBACANTHAE.

[2] See H. Schenck, "Die myrmekophilen Acacia-Arten," Bot. Jahrb. Engler **50**: 449–487. 1914.

[3] "Die Beschaffenheit der Früchte dürfte vielleicht zur endgültigen Unterscheidung der Artengruppen der Ameisenakazien mindestens ebenso wichtige, vielleicht noch bessere Anhaltspunkte geben wie die Form der Infloreseenzen." Bot. Jahrb. Engler **50**: 480. 1914.

GROUP I. CERATOPHYSAE[4]

Pericarp indehiscent, inflated, thin, fragile, terminating in a sharp spine-like beak. Nectar glands of the petiole and often of the lower rachis, elongated, crater-like, opening by a linear aperture with a raised (marginal) rim.

Section 1. **Spadicigerae** Schenck

Flowers in spadix-like cylindrical spikes, densely crowded on a fusiform receptacle; peduncles thickened, bearing a 4-parted calyx-like involucel near the base; minute interfloral pedicelled bracteoles with peltate, acuminate laminae, in form often resembling the leaf of an Arum. Midrib and upcurved lateral nerves of the leaflets usually conspicuous beneath.

1. **Acacia spadicigera** Schlecht. & Cham. Linnaea **5**: 595. 1830; not *Acacia spadicigera* Benth. Trans. Linn. Soc. London **30**³: 514. 1875.

Type in the Halle Herbarium, collected near La Laguna Verde, State of Veracruz, Mexico, in March, 1820, by Schiede (no. 685). Photograph and fragments of type in the U. S. National Herbarium.

2. **Acacia cubensis** Schenck, Repert. Nov. Sp. Fedde **12**: 360. 1913.–Bot. Jahrb. Engler **50**: 460. 1914.

Type in the West Indian Herbarium of Krug and Urban, Berlin, collected in northern Cuba, April 21, 1863, by C. Wright (no. 2402); specimens collected by C. Wright, bearing the same number, in the Grisebach Herbarium, Göttingen, and in the Gray Herbarium.

3. **Acacia Hernandezii** sp. nov.[5] Closely related to *Acacia spadicigera* Schlecht. & Cham. and *A. nicoyensis* Schenck, but readily distinguished from the former by the subsessile flower spikes, scabrous before anthesis owing to the recurved points of the bracteoles; and from the latter by the color of the spines and the fewer nectar glands. Large spines of the vegetative branches resembling the horns of a bull, subterete, widely spreading or incurved, sometimes fascicled and interlocking as in *A. spadicigera,* but never polished, at first pale brown or olivaceous, in age chestnut-colored or, when dead, grayish brown, the largest 8 to 10 cm. long, 1.8 cm. broad at the base. Spikes borne on axillary flowering branches like those of *A. spadicigera*, often subsessile, solitary or geminate, subtended by small leaves, these with subulate stipular spines; peduncles puberulent, 2 to 5 mm. long, 3 mm. thick, with 4-toothed basal involucel like that of *A. spadicigera.* Flowers before anthesis covered by the laminae of the bracteoles, these lanceolate, very long-acuminate, peltate, scabrous on the upper surface, the margin bearing a fringe of minute straight hairs, the pedicels usually somewhat hirtellous with fine white diaphanous hairs visible under the microscope; apices of the

[4] Acaciae americanae cornigerae siliquis in spinam abeuntibus. See Hermann, Paul. Paradisi Batavi Prodromus, p. 303. 1689.

[5] The Huitzmamaxalli ("forked-thorn") of the Aztecs, described and figured in 1576 under the name *Arbor cornigera* by Francisco Hernández.

bracteoles recurved. Calyx broadly tubular, resembling that of *A. spadicigera,* ferruginous, the upper portion sparsely hirtellous; corolla barely exceeding the calyx, the aperture splitting at anthesis into 5 or 6 divisions. Fruit inflated, indehiscent, terminating in a slender sharp beak, narrowed at the base into a stipelike neck, glabrous, smooth, olive green when young, at length bright wine-colored. Seeds 12, in 2 series, broadly ovoid, compressed, embedded in a mass of sweetish pulp; testa hard, smooth, dark brown. Leaves closely resembling those of *A. spadicigera,* those of the vegetative branches with 7 to 12 pairs of pinnae; elongated nectar gland on the petiole crater-like, placed at the base of the basal pair of pinnae, sometimes with a smaller raised cylindrical gland below it, and rarely with a second, somewhat elongated gland at the base of the second pair of pinnae; leaflets 17 to 29 pairs, linear-oblong, unequal at the base, the midrib and upcurving lateral nerves conspicuous beneath, as in *A. spadicigera.* Leaves of the inflorescence smaller; pinnae 2 to 5 pairs, the petiole bearing 1 or 2 raised glands, a gland often present also at the base of the second pair of pinnae.

Type in the U. S. National Herbarium, no. 692170, collected in the vicinity of Rascon, State of San Luis Potosí, Mexico, July 19 to 22, 1905, by Dr. Edward Palmer (no. 669).

4. **Acacia furcella** sp. nov. Related to *Acacia spadicigera* and *A. Hernandezii,* but having polished black or dark brown, forklike spines with subcuneiform base and erect, slightly diverging or subparallel prongs, much abbreviated or suppressed flowering branchlets, and spikes crowded in clusters. Base of spines 12 to 16 mm. broad, the prongs terete, 50 to 60 mm. long, long-acuminate at the apex. Flowers densely crowded, resembling those of *A. spadicigera,* but more densely hirtellous. Spikes cylindrical 30 to 40 mm. long; receptacle (axis of spike) fusiform, 6 to 8 mm. thick when mature; peduncles 10 to 14 mm. long, 2 to 4 mm. thick; involucre basal, 4-toothed, similar to that of *A. spadicigera.* Calyx ferruginous, 1.4 mm. long, 0.6 mm. broad at anthesis, thickly covered with minute short straight projecting hairs; corolla 4 to 6-lobed, slightly longer than the calyx. Interfloral bracteoles brown, the laminae ovate-acuminate, peltate, sagittate at the base, scabrous above, edged with minute short straight marginal hairs. Fruit wanting. Leaves of vegetative branches not observed; those of flowering branches with 3 to 5 pairs of pinnae; rachis puberulent, 4 to 6.5 cm. long; nectar glands similar to those of *A. Hernandezii;* leaflets 13 to 24 pairs, 9 mm. long, 2 mm. broad, reddish brown when dry, the midrib and lateral nerves prominent beneath as in *A. spadicigera.*

Type in the U. S. National Herbarium, no. 692166, collected on the shore of Lake Catemaco, southern Veracruz, Mexico, at an elevation of 1000 feet, April 26, 1894, by E. W. Nelson (no. 427).

5. **Acacia nicoyensis** Schenck, Repert. Nov. Sp. Fedde **12**: 360. 1913.—Bot. Jahrb. Engler **50**: 463. 1914.

Type in the Berlin Herbarium, collected on the shore of the Gulf of Nicoya, Costa Rica, in February, 1900, by A. Tonduz (no. 13538); duplicate of type in the U. S. National Herbarium, no. 577752.

Section 2. Dolichocephalae

(*Sphaerocephalae* Schenck, in part)

Flowers in spheroid or oblong heads having a thick peduncle and ovoid or oblong receptacle; interfloral bracteoles with glabrous pedicels and ovoid, obtuse, usually ciliate laminae. Leaflets usually with only the midrib conspicuous beneath. Nectar glands of the petiole resembling those of the Spadicigerae.

6. **Acacia sphaerocephala** Schlecht. & Cham. Linnaea **5**: 594. 1830; not *Acacia sphaerocephala* Benth. Trans. Linn. Soc. London **30**[3]: 514. 1875.

Type in the Berlin Herbarium, collected at Actopan, State of Veracruz, Mexico, in March, 1820, by Schiede (no. 684), with flowers and leaves; photograph and fragments of the type in U. S. National Herbarium.

7. **Acacia cornigera** (L.) Willd. Sp. Pl. **4**: 1080. 1806 (excl. synonyms).

Type in the Linnaean Herbarium[6] from a cultivated plant growing in the garden of George Clifford, between Haarlem and Leyden, Holland, collected by Linnaeus (no. 4) and bearing his label, "*Mimosa cornigera*."

8. **Acacia veracruzensis** Schenck, Repert. Nov. Sp. Fedde **12**: 362. 1913.—Bot. Jahrb. Engler **50**: 477. 1914.

Type in Herb. Mex. Schenck, collected on sand dunes south of the city of Veracruz, Mexico, October, 1908, by H. Schenck (no. 916); fragments of the type in the U. S. National Herbarium.

GROUP II. GLOBULIFERAE

(Sphaerocephalae Schenck, in part)

Pericarp dehiscent, coriaceous or woody, more or less compressed, sometimes very long and slender, opening by ventral and dorsal sutures. Flowers in long-peduncled globose heads, with spheroid receptacle.

Section 3. Ramulosae

Flower heads borne in the axils of small subulate stipular spines on special flowering branchlets.

9. **Acacia globulifera** sp. nov. Flowers in small globose heads not exceeding 5 mm. in diameter at anthesis, clustered in 2's or 3's on solitary axillary branchlets 4 to 6 cm. long; peduncles in each cluster graduated in length, the longest at anthesis about twice as long as the diameter of the head; receptacle spheroid or broadly ovoid, not sharply constricted

[6] The writer is indebted to Dr. Alfred Barton Rendle of the British Museum of Natural History for a photograph of the type of *Acacia cornigera* (L.) Willd. A careful comparison of this with photographs and portions of the types of *A. spadicigera* and *A. sphaerocephala* proves that Linnaeus's original plant is specifically distinct from both. It resembles an Acacia collected on the shore north of the city of Veracruz, January 24, 1906, by Dr. J. M. Greenman (no. 87), allied to *A. sphaerocephala* Schlecht. and Cham., but differing from that species in its extrafloral nectaries and in the shape of the flower heads.

at its union with the thickened upper extremity of the peduncle. Flowers about 2.2 mm. long when mature, funnel-shaped, the calyx with usually 5 shallow rounded lobes, glabrous near the base, puberulous about the margin; corolla about one-fourth longer than the calyx and distinctly separate from it, usually acutely 6-lobed, coarsely puberulent outside. Interfloral pedicelled bracteoles with orbicular peltate laminae. These subentire or the margin shallowly and obtusely toothed. Fruit not observed. Large spines ivory white or ecru, **V**-shaped or spreading like the horns of an ox, terete, 4 to 5 cm. long, 7 mm. broad at the base. Small spines of the flowering branchlets acicular or subulate, 7 mm. long. Vegetative leaves with 6 to 10 pairs of pinnae, the rachis 6 cm. long or less (in the type material), puberulent, bearing a row of 2 to 7 conoid nectar glands below the basal pair of pinnae, the glands having a porelike opening surrounded by a smooth, whitish, circular or elliptical, annular margin; pinnae 15 mm. long or less; leaflets of the longer pinnae 18 to 26 pairs, 3.5 mm. long, 0.8 mm. broad, drying dark green. Leaves of the flowering branchlets much smaller, with 2 to 4 porelike glands at the base of the rachis and occasionally a gland at the apex; pinnae 2 to 5 pairs, consisting of 6 to 12 pairs of leaflets.

Type in the herbarium of the Field Museum of Natural History, no. 58707, collected at the port of Silam (Tsilam), north coast of Yucatan, April, 1895, by Dr. G. F. Gaumer (no. 1909). A second specimen from the same locality is in the same museum, no. 36458, collected by Gaumer (no. 655), apparently at the same time and from the same plant. Photographs and fragments of the type are in the U. S. National Herbarium.

10. **Acacia Donnelliana** sp. nov. Closely related to the preceding, but easily distinguished by its dark-colored polished spines and much longer vegetative leaves. Flower heads globose, long-peduncled, borne in clusters on special flowering branchlets very much as in *A. globulifera*, but with relatively longer and more slender peduncles, the diameter of the heads at anthesis 8 mm., length of longest peduncles 20 mm. Flowers and interfloral bracteoles also much as in the latter species. Fruit not observed. Large spines **V**-shaped, terete, 40 mm. long, sharply acuminate, those of the type material blackish or dark mahogany-colored, polished. Small spines subtending the flower clusters acicular, much like those of *A. globulifera*, 5 to 7 mm. long. Vegetative leaves with 14 to 18 pairs of pinnae, these 42 to 52 mm. long, composed of 30 to 40 pairs of approximate leaflets; leaflets linear-oblong, very unequal at the truncate base, rounded or subacute at the apex, slightly curved, dark reddish or bronze when dry; leaf rachis 10 to 20 cm. long, puberulent, bearing at its base 4 conoid nectar glands, each opening by a small elliptical pore with a smooth reddish margin, and in addition to these a similar gland at the base of each pair of pinnules. Leaves of flowering branches with several pores at the base of the rachis and a pore at the base of each of the 6 to 15 pairs of pinnae; these leaves sometimes rudimentary or even lacking, in such cases the flower clusters subtended by a pair of small **V**-shaped acicular spines.

Type in the herbarium of Captain John Donnell Smith, collected at San Pedro de Sula, Department of Santa Bárbara, Honduras, alt. 600 feet, March, 1888, by Dr. Carl Thieme (no. 5216); photograph of type in U. S. National Herbarium.

Section 4. Glomeratae

Flower heads crowded in clusters in the axils of large forked or hornlike stipular spines. Basal nectar gland solitary, much elongate, sunk in the grooved rachis.

11. **Acacia Cookii** Safford, Science, N. S. **31**: 677. 1910.

Type in the U. S. National Herbarium, collected at the Finca Trece Aguas, near Secanquím, Alta Verapaz, Guatemala, March 8, 1907, by G. P. Goll (no. 102), supplemented by specimens in alcohol from the same region, collected by O. F. Cook.

12. **Acacia bucerophora** B. L. Robinson, Proc. Am. Acad. **49**: 502. 1913.

Type in the Gray Herbarium, collected in British Honduras, in 1907, by Prof. Morton E. Peck (no. 632). Photograph and fragments of the type are in the U. S. National Herbarium.

GROUP III. LEGUMINIFERAE

(Spicatae Schenck)

Pericarp dehiscent along both the ventral and the dorsal sutures, coriaceous or woody, relatively short; seeds embedded in a mass of pulplike aril. Flowers crowded in long spikes on a linear axis, this thicker than the peduncle. Extrafloral nectar glands beadlike, with a round central pore, often present on the rachises of the terminal pinnae as well as upon the petiole of the leaf, but not at the base of each pair of pinnae.

Section 5. Orthocarpae

Pods straight, abruptly pointed or obtuse, tumid or subterete; seeds alternate in 2 rows. Spines usually slender, straight or curved, slightly broadened and compressed at the base.

13. **Acacia yucatanensis** Schenck, Repert. Nov. Sp. Fedde **12**: 361. 1913.—Bot. Jahrb. Engler **50**: 468. 1914.

Type in the Berlin Herbarium, collected in the forest near Chichen Itza, Yucatan, in May, 1911, by Caec. and Ed. Seler (no. 5549 [470]).

14. **Acacia Collinsii** Safford, Science, N. S. **31**: 677. 1910.

Type in U. S. National Herbarium, no. 692159, collected between Chicoasen and San Fernandino, State of Chiapas, southern Mexico, January 14, 1907, by G. N. Collins (no. 180).

Section 6. Acinaceae

Pods scimitar-shaped, or straight along the dorsal and curved along the ventral suture, the apex more or less retrocurved, usually compressed laterally; seeds in a single row. Spines more or less flattened and broadened at the base, lunate or broadly subdeltoid.

15. **Acacia Nelsonii** sp. nov. Plant with leaves much like those of *A. Collinsii*, but easily distinguished from that species by its light-colored, broadly spreading, upcurved, more or less flattened stipular spines, these about 4 cm. long, 10 mm. broad at base, sometimes lunate or lyre-shaped, smooth, pale olivaceous to tan-colored or buff, with reddish brown tips, becoming gray or whitish when dead. Small spines on flowering branchlets 2 mm. long. Vegetative leaves with 4 to 8 pairs of pinnae; rachis 7 to 12 cm. long, without interpinnal nectar glands but with a row of 3 or 4 glands at the base; pinnae 4.5 to 5.5 cm. long, the leaflets 14 to 19 pairs, uniformly brown when dry, linear-oblong, 8 to 10 mm. long, 2.8 mm. broad, those bearing apical bodies at length retuse or truncate; rachis of pinnae sometimes with a minute solitary terminal gland at the base of the uppermost pair of leaflets. Leaves of flowering branchlets with 1 to 5 pairs of pinnae; rachis bearing at its base a row of 3 glands. Flower spikes 32 to 36 mm. long, including the peduncle, the latter 11 to 13 mm. long, about equal in thickness to the axis of the spike. Interfloral pedicelled bracteoles with orbicular peltate laminae, these imbricated over the flowers before anthesis like the scales of a fish, after anthesis their margins everted and concealed by the mass of anthers. Flowers tubular-funnelform, obovoid, or broadly subcylindrical; calyx 1.2 to 1.3 mm. high, subentire or obtusely 4 or 5-lobed; corolla one-fourth to one-third longer than the calyx, acutely 5 or 6-lobed, the divisions sometimes irregularly cleft; stamens very numerous, the filaments flesh-colored, the anthers straw-colored; style filiform. Legumes small, 2-valved, at length dehiscent by ventral and dorsal sutures, glabrous, dark brown or blackish, compressed, nearly straight along the dorsal suture, curved along the ventral suture, tapering at the base and slightly retrocurved at the apex. Seeds ovoid or elliptical, somewhat compressed but not flattened; testa hard, smooth, dark brown.

Type in the U. S. National Herbarium, no. 399366, collected at Acapulco, State of Guerrero, Mexico, April 30, 1903, by E. W. Nelson (no. 7024), with flowers and fruit. Cotype in the same herbarium, no. 692158, collected in the same locality, in 1895, by Dr. Edward Palmer (no. 390a), without flowers and with a single legume.

16. **Acacia costaricensis** Schenck, Repert. Nov. Sp. Fedde **12**: 361. 1913.—Bot. Jahrb. Engler **50**: 465. 1914.

Type in the Berlin Herbarium, collected near Lepanto, Costa Rica, in January, 1857, by Dr. Carl Hoffmann (no. 275), without fruit. Specimens collected by C. Wright in Nicaragua (U. S. North Pacific Explor. Exped. 1853–56), cited by Schenck as conspecific, are in the Grisebach Herbarium at Göttingen, the Gray Herbarium, and the U. S. National Herbarium (no. 692165), the last with broad flat pods terminating in a sharp retrocurved point.

17. **Acacia penonomensis** sp. nov. Closely related to *Acacia costaricensis*, but with falcate pods, spikes of pale yellow flowers borne on very

slender puberulent peduncles, and relatively broader and shorter leaflets with minute marginal hairs. Spikes before anthesis covered with the pale flesh-colored, scalelike, imbricated, suborbicular limbs of the pedicelled interfloral bracteoles, after anthesis bright lemon yellow from the mass of stamens, 23 to 26 mm. long, 4 to 5 mm. thick, the axis not exceeding in thickness the slender peduncle, this straight and rigid, about 8 mm. long and 0.5 mm. thick, pale brownish, clothed with white puberulence, and bearing a 4-toothed basal involucel, this puberulent outside. Flowers crowded; calyx flesh-colored, broadly ovoid or ellipsoid, inflated, 1.25 mm. high, 1 mm. broad, minutely puberulent about the margin, obscurely 6-lobed or subentire; corolla pale yellow, puberulent, 6-lobed, exceeding the calyx by about one-fourth its length; filaments and anthers pale yellow; style filiform. Legume 2-valved, dehiscent by both dorsal and ventral sutures, curved, compressed, 4.5 cm. long, 1 cm. broad, tapering at the base into a stipe like neck, terminating at the apex in a point. Seeds about 12, in a single row, embedded in a sulphur-yellow pulpy aril, broadly ovoid, 5 mm. long, 4 mm. broad, somewhat compressed into a thick oblique ovoid disk, the testa hard, smooth, glossy dark brown. Large stipular spines reddish brown, becoming blackish, broadly **V**-shaped or deltoid, 2.6 to 3.2 cm. long, 9 to 11 mm. broad at the base, this inflated and usually compressed, the apex abruptly acuminate and terminating in a very slender, fine point. Spines of the flowering branchlets minute, subulate. Vegetative leaves not observed. Leaves of the flowering branches sometimes rudimentary, the perfect ones composed of 1 to 6 pairs of pinnae; rachis pubescent, 3 to 4.5 cm. long, without interpinnal glands, but with 1 to 3 contiguous pubescent porelike basal glands and usually a similar but smaller terminal gland on the pubescent rachises of the pinnae just beneath the last pair of leaflets, very much as in *A. Collinsii*. Leaflets oblong-obovate, fringed with short hairs.

Type in the Herbarium of the New York Botanical Garden; duplicate in U. S. National Herbarium, no. 677927, collected in the vicinity of Penonomé, Panama, February 23 to March 22, 1908, by R. S. Williams (no. 113).

GROUP IV. FOLLICULARES

Pericarp a follicle, dehiscing by a single suture; seeds in a single row. Leaf rachis with a beadlike nectar gland at the base of each pair of pinnae; nectar glands of the petiole 1 to several, or wanting.

Section 7. **Bursariae** Schenck

Large stipular spines of vegetative branches much flattened and very broad, their bases connate and pocket-like, often resembling an inverted bicorne chapeau. Flowers distinct, not closely crowded, forming a lax linear spike with a slender, often flexible rachis. Pods slender, falcate or curved, compressed, the seeds approximate, inclosed in a thin, whitish or brownish, feltlike aril.

18. **Acacia Hindsii** Benth. Lond. Journ. Bot. **1:** 504. 1842.

Type in the Kew Herbarium, collected on the shore of Manzanillo Bay, State of Colima, Mexico, 1836–39, by Dr. Richard B. Hinds, Surgeon of H. M. S. *Sulphur* (no. 248).

19. **Acacia bursaria** Schenck, Repert. Nov. Sp. Fedde **12:** 363. 1913. —Bot. Jahrb. Engler **50:** 485. 1914.

Type in the Berlin Herbarium, collected near San Felipe, Guatemala, February, 1878, by Bernouilli and Cario (no. 1129).

20. **Acacia sinaloensis** sp. nov. Closely related to *A. Hindsii* Benth. and *A. bursaria* Schenck, but distinguished by its lighter-colored, broadly **V**-shaped or **Y**-shaped spines, these alternate, regularly disposed at intervals of 3 or 4 cm. along the slender, straight, terete, glabrous, reddish brown branches; length of spines 30 to 40 mm., breadth along the suture formed by the connate flattened bases 12 to 14 mm.; extremities terete, tapering into a very sharp point; color of spines usually olivaceous or yellowish green, turning brownish or buff-colored when old and dead. Vegetative leaves fernlike, elliptical or oblong in outline; main rachis grooved above, sparsely pubescent (under the microscope), bearing a raised porelike gland at the base of each pair of pinnae; base of the rachis (petiole) with 1 to 3 similar glands; pinnae 12 to 18 pairs, linear, approximate, their rachises 30 to 34 mm. long, sparsely pubescent; leaflets 5.2 mm. long, 1.4 mm. broad, thin and membranaceous when young, at length subcoriaceous, many of them bearing caducous amber-colored apical bodies, those without the latter acuminate at the apex, the margins of the leaflets bearing very short fine hairs (under the microscope) from the base to the apex, the base very oblique, the midrib conspicuous beneath, the lateral nerves scarcely visible even with the microscope. Leaves of the small axillary branchlets smaller, with fewer pairs of pinnae, these composed of fewer, relatively broader, more rounded leaflets, their rachises provided at the base with a pair of subulate stipular spines, usually without a basal nectar gland, but with one of these at the base of each pair of pinnae. Flowers wanting, but apparently borne in a lax spike. Fruit a falcate or retrocurved follicle dehiscing along the ventral suture, 11 mm. broad near the middle, acuminate at the apex, tapering at the base; seeds 8 to 10, in a single row, embedded in a yellowish white, thin aril, crowded and compressed, oblong or clavate, 8 or 9 mm. long, 4 mm. broad, 2 mm. thick, tapering toward the base into a rounded point, the testa dark brown, hard and polished, with an oblanceolate area enclosed by a raised line on each side.

Type in the U. S. National Herbarium, no. 636818, collected in the vicinity of Villa Unión, State of Sinaloa, Mexico, growing about a pond, April 2, 1910, by Rose, Standley, and Russell (no. 13972).

Section 8. Leiocerates

Large stipular spines of vegetative branches resembling polished subterete spreading horns, somewhat compressed at the connate bases. Smaller spines of the very short axillary branchlets subulate. Leaf rachis pubescent, bearing a raised nectar gland at the base of each pair of pinnae but (in the type) none on the petiole. Pods of the same general form as in the preceding section but broader and thicker, the seeds enveloped in a thicker aril.

21. **Acacia tepicana** sp. nov. General outline of the bipinate leaves narrowly oblanceolate or oblong, the pinnae short and the leaflets closely crowded. Rachis 6 to 8 cm. long, reddish brown, pubescent, bearing about 14 pairs of pinnae, with a pubescent beadlike or truncate conoid gland at the base of each pair of pinnae, but none at the base of the petiole; pinnae 10 to 18 mm. long, the shortest ones near the base; leaflets 9 to 17 pairs, very small, 4.5 to 6 mm. long, 1.5 mm. broad, oblong, unequal and truncate at the base, acute or short-acuminate at the apex, subcoriaceous, the midrib and lateral nerves inconspicuous, the margins contiguous or overlapping and bearing minute short straight hairs (as seen under the microscope); lowest leaflets much smaller, sometimes rudimentary, bearing a long tapering amber-colored waxlike apical body. Large connate stipular spines broadly V-shaped, subterete, somewhat compressed and broadened at the base, 27 mm. long, 8 or 9 mm. broad at the base, brown, the surface smooth and hornlike. Small spines of the abbreviated rudimentary axillary branchlets subulate, reddish brown. Spikes borne on very short axillary branchlets; peduncles (only those of mature fruiting specimens observed) 8 mm. long, bearing a basal involucel; axis of spike not exceeding the peduncle in thickness. Flowers not observed; interfloral bracteoles short-pedicelled, with a circular disklike peltate limb 1.2 mm. in diameter. Pericarp coriaceous, glabrous, without a definite dorsal suture but sometimes splitting down the back, brown and glabrous outside, reddish and feltlike on the inner surface, compressed, retrocurved, 13 mm. broad in the middle, narrowed at the base into a stipelike neck, long-acuminate at the apex. Seeds 10 to 12, in a single row, ovoid, slightly compressed, about 5.2 mm. long, 4.2 mm. broad, and 4 mm. thick, approximate, embedded in a yellowish white aril having the taste of dried apples; testa olivaceous, hard, smooth and glossy, bearing a raised oval ridge on each side.

Type in the U. S. National Herbarium, no. 637234, collected in the vicinity of Acaponeta, Territory of Tepic, western Mexico, April 10, 1910, by Rose, Standley, and Russell (no. 14357).

GROUP V. HEBACANTHAE

Involucel borne at or above the middle of the peduncle. Large spines puberulent when young, never becoming smooth or polished. Interfloral pedicelled bracteoles not peltate, but with an ovate or fan-shaped limb with a hairy margin.

Section 9. Clavigerae

Flowers crowded in club-shaped, cylindrical, or oblong spikes, covered before anthesis with the imbricated ovoid limbs of the pedicelled bracteoles. Peduncles long, straight, slender, puberulent or hirtellous, borne upon axillary flowering branches, solitary or clustered. Large stipular spines straight or nearly so, widespreading, at first puberulent, except at the smooth glossy reddish point, sometimes glabrate in age, but the surface dull and never polished.

22. **Acacia Standleyi** sp. nov. Flower spikes club-shaped, at anthesis, thicker at the apex than at the base, 18 to 22 mm. long, 7 to 8 mm. thick, pubescent before anthesis; peduncles in clusters of 2 to 5, the longest 27 mm. long at anthesis, minutely pubescent below the involucel, the latter 4-toothed, pubescent outside, situated at or above the middle of the peduncle; axis of spike slightly thicker than the peduncle. Flowers with pale yellowish brown or buff, broadly tubular, obtusely lobed calyx and tan-colored, acutely 6-lobed corolla, the latter exceeding the calyx by one-half its length; stamens very numerous, yellow; style filiform. Large spines pubescent at first, with glabrous reddish points, at length dull gray or blackish, 3 to 3.5 cm. long, 6 to 8 mm. broad at the base, very widely divergent, the pair separated by a thickened ridge (the persistent base of the petiole) adnate to the branch. Vegetative leaves with about 25 pairs of pinnae; main rachis pubescent above, about 10 cm. long, with 1 to 3 conspicuous glands at the base and a gland just below each of the 2 or 3 terminal pairs of pinnae, these glands usually with a smooth, light brown, annular margin; pinnae about 2.5 cm. long, those of a pair sometimes not quite opposite; rachis of pinnae pubescent above; leaflets about 30 pairs, approximate, relatively thick and coriaceous, scarcely showing the venation even under the microscope, oblong-linear, 3.2 mm. long, 0.8 mm. broad, unequal at the base, rounded at the apex, sometimes mucronulate or tipped with an apical body, the margin at first bearing a fringe of minute hairs, at length glabrate. Leaves of the axillary flowering branches with 4 to 8 pairs of pinnae composed of 12 to 16 pairs of leaflets, these 2 mm. long, 0.6 mm. broad, when young fringed with hairs, many of them tipped with apical bodies; main rachis bearing a conspicuous annular nectar gland at the base of each pair of pinnae and usually one on the petiole, just below the lowest of these; stipular spines subulate, 4 mm. long.

Type in the U. S. National Herbarium, no. 637251, collected in the vicinity of Acaponeta, Territory of Tepic, western Mexico, April 11, 1910, by Rose, Standley, and Russell (no. 14374).

23. **Acacia hirtipes** sp. nov. Flower spikes oblong or cylindrical, 11 to 15 mm. long, 6 mm. thick, covered before anthesis by the tomentulose laminae of the bracteoles; peduncles densely hirtellous, in clusters of 2 or 3, 14 to 20 mm. long; involucel 4-toothed, hirtellous, situated above the middle of the peduncle; axis scarcely thicker than the peduncle. Flowers with reddish brown or tan-colored calyx resembling that of *A. Standleyi* but narrower at the base and pubescent about the shallowly lobed margin; corolla dark purple or blackish, exceeding the calyx by one-half or three-fourths its length, pubescent with whitish hairs around the 5- or 6-lobed margin; filaments reddish brown; anthers pale tan-

colored; interfloral bracteoles tomentose on the upper surface. Fruit not observed. Large stipular spines broadly V-shaped, cinereous, puberulent except at the points, 3 to 4.2 cm. long, 10 mm. broad at the cuneate base, the latter flattened but not adnate to the branch as in *A. Standleyi*. Spines of the flowering branches subulate, 3 to 6 mm. long, when young strigose except at the polished red tips. Vegetative leaves not observed. Leaves of the flowering branches with 5 to 12 pairs of pinnae composed of 9 to 18 pairs of leaflets, these 2.4 mm. long, 0.8 mm. broad, similar in shape to those of *A. Standleyi* but with a persistent marginal fringe of stiff short straight hairs; rachis persistently and densely hirtellous, clothed with minute stiff whitish hairs; nectar glands dark purplish, circular, bowl-shaped, with a thick annular magin, one in the smaller leaves of the short branchlets one borne at the base of each pair of pinnae and an additional one on the petiole; on the larger leaves of the longer branches similar glands borne at the base of each pair of pinnae of the upper half of the leaf, but none in the lower half except a solitary gland on the petiole.

Type in the U. S. National Herbarium, no. 694036, collected on the Río de las Cañas, Department of Santa Rosa, Guatemala, altitude 3000 feet, April, 1892, by Heyde and Lux (no. 3299, in part; mixed with specimens of *A. bursaria*) under the name of "*A. spadicigera*."

Acacia hirtipes is a shrub with densely cinereous-hirtellous young growth, closely related to *A. Standleyi* but easily distinguished by the dark purplish corolla, the more densely hirtellous indument of the peduncles and leaf rachis, and the persistent marginal hairs of the leaflets.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal, and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

AGRICULTURAL CHEMISTRY.—*Aroma of hops: A study of the volatile oil with relation to the geographical sources of the hops.* FRANK RABAK. Journal of Agricultural Research **2**: 115–159. May 25, 1914.

The paper discusses the aroma of hops grown in various parts of the United States and in Bohemia, the basis of comparison being the volatile oil. Factors which influence the aroma of hops, such as climatic conditions and soil, are discussed. Special attention is given to the esters which are the principal odor bearers of the oil. In order that a logical comparison of the various hops may be made, the volatile oils distilled from the several hops are carefully compared as regards their physical and chemical properties. This scheme of comparison is carried through four successive seasons to ascertain whether any constant similarities or differences exist in the oils, especially in the oils distilled from foreign and domestic hops.

Comparisons are made of the yields of volatile oil from the various hops; the physical properties, including color, odor, taste, specific gravity, refraction, and solubility; and the acid, ester, and saponification numbers of the oils. The oils are subsequently fractionated and the properties of the fractions compared. Tables and curves showing the differences in the oils are included.

A detailed chemical examination of a sample of the volatile oil of hops is given and the approximate composition indicated. Important differences in the oils are apparent, not only during any particular season but for several seasons. The curves show these constant differences in properties most forcibly. The curves of ester content show remarkable differences in the oils from the several geographical sources, the imported oils being consistently lower from year to year in esters to which the characteristic aroma is largely due. The geographical source of hops seems to be indicated by the ester content of the oils. A review of the chemical investigations of the aromatic constituents of hops by other investigators completes the paper. F. R.

GEOLOGY.—*Geology and geography of a portion of Lincoln County, Wyoming.* A. R. Schultz. U. S. Geological Survey Bulletin 543. Pp. 141, with maps, sections, and views. 1914.

Geological formations that outcrop in this area range in age from the Cambrian to the Quaternary. The beds are closely folded and in places overturned. The beds that strike in a north-south direction are exposed in parallel belts throughout the field. Three coal groups have been recognized, ranging in age from Cretaceous to Eocene, and one phosphate group of Carboniferous age.

Tht main disturbances giving rise to the structural features occurred near the close of the Cretaceous, although minor movements have taken place since the deposition of the Eocene beds. Besides the numerous parallel folds and synclines that trend in a north-south direction, the beds have been broken by two parallel thrust faults that lie from 6 to 15 miles apart in an east-west direction and have been traced for a distance of approximately 100 miles in the western part of Wyoming. Along these faults the Carboniferous and Cambrian beds on the west come in contact with beds of Colorado and Montana age on the east.

The economic deposits of greatest importance are the coals. They occur in the Frontier, Adaville, and Evanston formations and belong to beds that are of Colorado, Montana-Laramie, and Eocene age, respectively. The Frontier coal, a high-grade bituminous coal that does not slack on exposure to air, has a heat value of from 12,000 to 14,000 B.t.u. The Adaville and Evanston coals are subbituminous and break down readily on exposure to air. The heat value is considerably less than that of the Frontier coal and ranges from 10,000 to 12,000 B.t.u. The phosphate deposits occur throughout the area near the top of the Carboniferous beds. Gold placers have been worked along Snake River and its tributaries, but on account of the fineness of the gold the placer workings have not been very successful. It requires from 1,000 to 1,200 colors to make a cent value. The richest pay streaks in the gold-bearing sand and gravel lie near bedrock and run from 9 cents to $3.00 per cubic-yard, while some of the material is comparatively barren.

A. R. S.

GEOLOGY.—*Raritan, New Jersey, folio.* W. S. Bayley, R. D. Salisbury, and H. B. Kümmel. Geologic Atlas of the United States, No. 191; U. S. Geological Survey. Pp. 32, with sections and 5 maps. 1914.

The area treated is in the center of the Highlands of New Jersey and contains some of the most important magnetite mines of the State. The out-cropping hard rocks embrace pre-Cambrian, Cambrian, Ordovician, Silurian, Devonian, and Triassic sediments, pre-Cambrian and Triassic igneous rocks, and metamorphic pre-Cambrian rocks of undetermined origin. Above these are unconsolidated deposits of Quaternary age.

The pre-Cambrian rocks lie in a series of northeast trending ridges, between which are valleys underlain by Paleozoic beds. These ridges and the intervening valleys constitute the Highlands. The northwest corner of the quadrangle includes a small area of the Kittatinny Valley which borders the Highlands on the north. This is underlain by Cambrian and Ordovician rocks. On the south the Highlands are bordered by the Piedmont plateau which in this area is underlain by Triassic sedimentary formations and associated basalt flows and diabase sheets and dikes.

The Quaternary deposits include glacial material of the Jerseyan and Wisconsin stages, old and recent alluvium and deposits of the glacial Lake Passaic. The terminal moraine of the Wisconsin stage crosses the quadrangle in an east-west direction about six miles from its northside.

The principal economic resources of the quadrangle are magnetic and limonitic iron ores, building stone, crushed rock, and lime rock. Of less importance are clay, sand, gravel, peat, and roofing slate. The water resources are valuable as water supplies and for the development of power. The magnetite, which is by far the most valuable economic product, is regarded as of magmatic origin. The iron is believed to have been contributed by the same magma that formed also the granitoid gneisses and pegmatites that constitute the greater part of the pre-Cambrian rocks. Brief descriptions of the principal mines in the area illustrate the manner of occurrence of the ore. W. S. B.

PALEONTOLOGY.—*Cambrian Geology and Paleontology, II. No. 11.—New Lower Cambrian subfauna.* Charles D. Walcott. Smithsonian Miscellaneous Collections **57**[11]: 309–326, pls. 50–54. July 21, 1913.

In this paper is described a hitherto unrecognized Lower Cambrian subfauna. It occurs in the Mahto formation (upper portion of the

Lower Cambrian) in the Robson Peak district of the Canadian Rockies. The majority of the species making up the fauna are new and are here described. The new species are referable to the genera Mickwitzia, Lingulella, Obolella, Holmia?, Wanneria, Callavia, and Olenellus.

EDWIN KIRK.

PALEONTOLOGY.—*Cambrian Geology and Paleontology, II. No. 12.—Cambrian formations of the Robson Peak district, British Columbia and Alberta, Canada.* CHARLES D. WALCOTT. Smithsonian Miscellaneous Collections **57**[12]**:** 327–343, pls. 55–59, figs. 11, 12. July 24, 1913.

The stratigraphic and structural features of the Robson Peak district of the Canadian Rockies are described herein, particular attention being paid to the Cambrian formations and their contained fossils. The Cambrian section as shown in this area includes 12,200 feet of sediments, representing Lower, Middle, and Upper Cambrian. Beneath these beds lie 2,000+feet of Algonkian sandstones and siliceous shales. The section is capped by 3,000 feet of Ordovician.

Several changes are proposed in the geographic nomenclature of the region, and a number of new names are applied to mountains, rivers, and glaciers. Twelve new formation names are proposed for subdivisions of the stratigraphic series. Faunal lists of the different formations are given, and broad correlations are made with the Mount Bosworth Cambrian section. The paper is illustrated with splendid photographs of the Canadian Rockies.

EDWIN KIRK.

PALEONTOLOGY.—*Cambrian Geology and Paleontology, II. No. 13.—Dikelocephalus and other genera of the Dikelocephalinae.* CHARLES D. WALCOTT. Smithsonian Miscellaneous Collections **57**[13]**:** 345–412, pls. 60–70. April 4, 1914.

The trilobite genus Dikelocephalus which has been a catchall for numerous Upper Cambrian species, is in this paper thoroughly revised; foreign species are removed and referred to their proper genera; and three new genera referable to the subfamily Dikelocephalinae are established. Of the three genera originally referred by Beecher to the Dikelocephalinae only one, Dikelocephalus, is retained. In the subfamily as revised four additional genera are added, Conokephalina Brögger, and three new genera, Saukia, Osceolia, and Calvinella.

In order to show the stratigraphic relationships of the trilobites a provisional classification of the pre-Ordovician formations of the Upper

Mississippi Valley is given. This includes two new formation names. Eau Claire and Mt. Simon (Ulrich MSS., 1914). Numerous faunal lists of these formations and of other Upper Cambrian formations in various parts of the United States which carry Dikelocephalinae are given.

Several new species are described: three under Dikelocephalus, eight under Saukia, and two under Calvinella. *Dikelocephalus lodensis* Whitfield has been chosen as the genotype of Saukia; *Dikelocephalus osceola* Hall, of Osceolia; and *Dikelocephalus spiniger* Hall, of Calvinella. Another new genus, Hungaia, is also established (p. 351) with *Dikelocephalus magnificus* as the genotype. This genus is not subsequently defined and evidently is not referable to the Dikelocephalinae.

Edwin Kirk.

BACTERIOLOGY.—*The colon group of bacteria.* L. A. Rogers, William M. Clark, and Brooke J. Davis. Journal of Infectious Diseases **4**: 411–475. May, 1914.

A collection of cultures of the colon type isolated from milk was studied with special reference to the exact determination of the gases formed and the application of these determinations to the classification of the group. It was found that, when determined by exact methods after uniform growth conditions, the volume and relative proportions of the different gases were produced with great uniformity. This character divided the collection into two groups, one of which, characterized by a low volume of gas composed of nearly equal parts of hydrogen and carbon dioxide, corresponds to the *B. coli communis* and *B. coli communior* type. The remaining cultures produce much greater volume of gas and an increasing proportion of carbon dioxide. The increase in the volume of gas was produced almost entirely by increasing quantities of carbon dioxide, while the volume of hydrogen remained nearly constant. In many cultures the ratio of carbon dioxide to hydrogen was nearly or quite 2:1. The variations from the type, as well as the variation in duplicate determinations, were much greater in the latter group. The gas ratio was closely correlated with other physiological reactions, especially the fermentation of carbohydrates and alcohols. The fermentative ability was more pronounced in the high-ratio group, but some particular substances were fermented by a large number of the low-ratio group but by only a few of the high-ratio group. Two possible subdivisions, based on fermentative reactions, could be made in the low-ratio group. It was evident that the high-ratio group was made up of a number of types, but sufficient data for their classification were not available.

L. A. R.

MAMMALOGY.—*The white rhinoceros.* EDMUND HELLER. Smithsonian Miscellaneous Collections **61**[1]: 1–77, plates 1–29, text figs. 1–3, 2 maps. October, 1913.

The first portion of the present paper is devoted to the itinerary of the Smithsonian African Expedition, under the direction of Colonel Roosevelt, and a general description of the Lado Enclave, where the white rhinoceroses were secured, together with a short account of its chief floral features. The systematic part which follows covers 30 pages, in which are comprised: A discussion of the generic characters of the living and extinct forms of rhinoceroses and their probable derivation; dental peculiarities of the white rhinoceros; subspecific characters of the Nile race; and a description of its coloration, external form, size, geographical range, and habits, as well as a history of its discovery. In the following 10 pages Colonel Roosevelt's account of the shooting and field natural history of the species is quoted. Several pages are then devoted to a complete bibliography, followed by twenty pages of explanatory matter referring to the plates of skulls. The numerous illustrations consist of 8 plates showing the country, natives, and floral features; 5 views of white rhinoceroses in the flesh; 2 of live specimens taken on the shooting grounds; and 2 of mounted specimens in the National Museum. The 20 plates of skulls consist of 99 separate figures illustrating all the specimens collected by the expedition, besides specimens of related genera in the British Museum, U. S. National Museum and other institutions. Of the two maps one illustrates the distribution of the species throughout its whole African range, and the other the distribution of the Nile race in the Lado Enclave of the Upper Nile region.

The white rhinoceros, because of its remarkably elongate skull and the highly specialized structure of its cheek-teeth, is treated as a distinct generic type and the sole representative of the genus Ceratotherium. The Nile form, *Cottoni*, was originally described as a species, but a comparison of the large series of specimens now in the National Museum with the South African specimens preserved in European museums has shown it to be only a rather slight subspecies characterized chiefly by the somewhat flatter dorsal outline of its skull, this notwithstanding that the two forms are separated by 1000 miles of territory and have doubtless been thus separated for a great length of time.

Zoologists have usually considered the white rhinoceros as a close blood relative of the recently extinct woolly rhinoceros of northern Europe, but a comparative study of the skulls of the two shows them to be fundamentally different and to resemble one another only superficially, in the structure of the teeth. None of the known fossil forms of Eurasia and America are considered as generically identical with the white rhinoceros, which is regarded by the author as a form of African derivation.

E. H.

ENTOMOLOGY.—*Type species of the genera of ichneumon flies.* HENRY L. VIERECK. Bulletin of the U. S. National Museum, No. 83. Pp. 1–186. January 31, 1914.

In the present work the author has listed the genera of the superfamily Ichneumonoidea and has given the original reference for each genus, the number of species originally included, and the type of the genus, or, if the genus was based on more than one species without specifying a genotype, the reference to the work in which the type was first fixed. Genera based on one species only are indicated as monobasic; wherever two or more were found to have the same species as genotype the fact is indicated by the term isogenotypic. Many genera, when originally described, had no species included, in which case there is given the citation for the first species subsequently included; or, if more than one were simultaneously included, the number is given and the treatment is similar to that of the other genera.

In completing this work, it was found that certain generic names were being used in a sense different from that of the original describer and it thus became necessary to propose the following: Chorebidea for Chorebus of authors, not of Haliday; Deuteroxorides for Xorides of authors, not of Latreille; Diclosterocerus for Closterocerus Hartig, not of Westwood; Helconidea for Helcon of authors, not of Nees; Ischnopsidea for Ischnus of authors, not of Gravenhorst; Mesostenidea for Mesostenus of authors, not of Gravenhorst; Myiarthridea for Myiarthrus of authors, not of Foerster; Pimplidea for Pimpla of authors, not of Fabricius; Plectiscidea for Plectiscus of authors, not of Gravenhorst; Plesiophthalmidea for Plesiophthalmus Ashm., not of Foerster; Porizonidea for Porizon of authors, not Fallen; Zavipio for Vipio of authors, not of Latreille.

J. C. CRAWFORD.

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BIGELOW, H. B. *Medusae and Siphonophorae collected by the U. S. Fisheries steamer "Albatross" in the northwestern Pacific, 1906.* Proceedings of the U. S. National Museum **44**: 1–119, pls. 1–6. March 26, 1913.

COCKERELL, T. D. A. *A peripatus from Guatemala.* Proceedings of the Biological Society of Washington **26**: 87, 88. May 3, 1913. (Describes *Peripatus* (Epiperipatus) *Biolleyi Betheli*, var. nov.—W.R.M.)

CUSHMAN, J. A. *A monograph of the Foraminifera of the north Pacific Ocean: Part IV. Chilostomellidae, Globigerinidae, Nummulitidae.* Bulletin 71, U. S. National Museum. Pp. i–vi, 1–46, pls. 1–19. February 28, 1914. (Nearly all of the species treated are elaborately figured; none is described as new.—W.R.M.)

FISHER, W. K. *Four new genera and fifty-eight new species of starfishes from the Philippine Islands, Celebes, and the Moluccas.* Proceedings of the U. S. National Museum **43**: 599–648. February 5, 1913. (The four new genera are: Ctenopleura and Astromesites, of the family Astropectinidae; Perissogonaster and Astrothauma, of the family Goniasteridae.—W.R.M.)

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RATHBUN, MARY J. *New genera and species of American brachyrhynchous crabs.* Proceedings of the U. S. National Museum **47**: 117–129, pls. 1–10. May 20, 1914. (Describes three new genera of Goneplacidae, six new species of Grapsidae, and two new species of Ocypodidae.—M.J.R)

RICHARDSON, HARRIET. *The isopod genus* Ichthyoxenus *Herklots, with description of a new species, from Japan.* Proceedings of the U. S. National Museum **45**: 559–562, text figs. 1–6. June 4, 1913.

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Stejneger, L. *Results of the Yale-Peruvian expedition of 1911. Batrachians and reptiles.* Proceedings of the U. S. National Museum **45**: 541–547. June 4, 1913. (Includes descriptions of three new amphibians and two new reptiles from Peru.—W.R.M.).

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ENTOMOLOGY

Johnson, F. *The grape leafhopper in the Lake Erie valley.* Bulletin of the U.S. Department of Agriculture, No. 19. Pp. 1–47, pls. 1–3. January 24, 1914. (A professional paper dealing with the life-history and habits of this species. *Typhlocyba comes* Say, its parasites and predaceous enemies, natural checks, and artificial methods of control; includes also a bibliography.—J.C.C.)

Morgan, A. C., and Crumb, S. E. *The tobacco splitworm.* Bulletin of the U. S. Department of Agriculture, No. 59. Pp. 1–7. January 19, 1914. (A short account of the immature stages, life-history and food-habits of *Phthorimaea operculella* Zeller, with remedial measures.—J.C.C.)

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Mohler, J. R. *Cerebrospinal meningitis ("forage poisoning").* Bulletin of the U. S. Department of Agriculture, No. 65. Pp. 1–14. February 14, 1914.

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ANTHROPOLOGY

HENDERSON, J., and HARRINGTON, J. P. *Ethnozoology of the Tewa Indians.* Bureau of American Ethnology, Bulletin 56. Pp. i–x, 1–76. 1914.

HOLMES, W. H. *Remarks* [*on the relation of archeology to ethnology*]. Amer. Anthropologist, n.s., **15**: 566, 567. October–December, 1913 [pub. 1914].

MICHELSON T. *Notes on the social organization of the Fox Indians.* Amer. Anthropologist, n.s., **15**: 691–693. October–December, 1913 [pub. 1914].

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TECHNOLOGY

COBB, N. A. *Tests of the waste, tensile strength, and bleaching qualities of the different grades of cotton as standardized by the United States Government.* Bulletin of the U. S. Department of Agriculture, No. 62. Pp. 1–8. January 14, 1914.

DUVEL, J. W. T., and DUVAL, L. *The shrinkage of shelled corn while in cars in transit.* Bulletin of the U. S. Department of Agriculture, No. 48. Pp. 1–21. December 19, 1913.

NEWLIN, J. A. *Tests of wooden barrels.* Bulletin of the U. S. Department of Agriculture, No. 86. Pp. 1–12. March 14, 1914.

OKEY, C. W. *The wet lands of southern Louisiana and their drainage.* Bulletin of the U. S. Department of Agriculture, No. 71. Pp. 1–82. April 30, 1914.

PENNINGTON, MARGARET E., and others. *The Refrigeration of dressed poultry in transit.* Bulletin of the U. S. Department of Agriculture, No. 17. Pp. 1–35. November 5, 1913.

STUBENRAUCH, A. V., and MANN, C. W. *Factors governing the successful storage of California table grapes.* Bulletin of the U. S. Department of Agriculture, No. 35. Pp. 1–31. December 31, 1913.

STUBENRAUCH, A. V., and others. *Factors governing the successful shipment of oranges from Florida.* Bulletin of the U. S. Department of Agriculture, No. 63. Pp. 1–50. March 28, 1914.

TRULLINGER, R. W. *Water supply, plumbing, and sewage disposal for country homes.* Bulletin of the U. S. Department of Agriculture, No. 57. Pp. 1–46. February 21, 1914.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 285th meeting was held at the Cosmos Club, May 13, 1914.

INFORMAL COMMUNICATIONS

A barite deposit on Castle Island, Duncan Canal, Alaska: E. F. Burchard.

Andradite and gedrite from a contact metamorphic zone in the Washington-Duquesne camp, Arizona: F. C. Schrader.

A microscopic method of measuring the refractive indices of liquids: Fred. E. Wright (See this Journal **4**: 269–279. June 4, 1914.)

REGULAR PROGRAM

The oxidized zinc ores of Leadville, Colorado: G. F. Loughlin. No abstract. (This paper will form a chapter in a monograph on the Leadville district to be published by the U. S. Geological Survey.)

Some geodetic evidence of isostasy: William Bowie. The speaker gave a brief summary of the results of the investigations by the Coast and Geodetic Survey during the last few years dealing with the figure of the earth and with gravity reductions. He pointed out the great increase in the accuracy of the results due to the introduction of the theory of isostasy. By this means Hayford was able to determine the figure of the earth with greater precision than had been obtained previously.

Especial attention was called to an illustration in Hayford's second report on investigations concerning the figure of the earth in which are shown areas of excess and deficiency of mass, as indicated by the deflection anomalies. It was stated that a gravity station was placed in or near 13 of the 16 areas indicated and, in each case, the gravity results agreed with those of the deflections. The results of the recent gravity investigations prove conclusively that there is no definite relation between the character of the topography and the sign and size of the gravity anomalies if the reduction is made by the Hayford method. If the Bouguer or rigid method of reduction is used there is a decided relation between the topography and the size and sign of the anomalies.

The data at hand do not show whether regional or local distribution of compensation is nearer the truth. The reduction by both methods of the distribution has been made by the Coast and Geodetic Survey, but the results are negative.

A preliminary computation of the depth of compensation was made in the Survey, using gravity observations alone. The results were not entirely satisfactory, as the determination was weak. The speaker stated that the geodetic evidence shows definitely that large areas, such as that of the United States, are perfectly compensated on an average and that areas very much smaller than the United States are also in a nearly perfect state of isostasy. It will need further and extensive geodetic observations to determine the minimum area which may be completely, or in large part, in a state of isostasy.

Stratigraphy of the Montana group (Upper Cretaceous) in northwestern Montana and its relation to the Belly River beds and Judith River formation: EUGENE STEBINGER. The section of the Montana group, in northwestern Montana, as exposed on Two Medicine River between its mouth and Family post office, was found to differ considerably from the standard section of the Montana group for central Montana, which, as described by Stanton and Hatcher in 1903, in connection with their stratigraphic study of the Judith River formation, includes the Eagle, Claggett Judith River, and Bearpaw formations. The section on Two Medicine River was readily divided into four lithologic units, which from the base upwards are as follows: (1) Virgelle sandstone, a coarse gray to buff sandstone 220 feet thick, resting on Colorado shale; (2) Two Medicine formation, a rudely bedded mass of light colored clays and sandstones, chiefly fresh water in origin, 1950 feet thick; (3) Bearpaw shale, a dark marine clay shale, 500 feet thick; (4) Horsethief sandstone, a coarse gray to buff sandstone 360 feet thick. These four stratigraphic units were traced northward into the area in southern Alberta containing the Belly River beds as described by G. M. Dawson, of the Canadian Geological Survey. The Belly River beds were found to be equivalent to all of the strata included in the Virgelle sandstone and Two Medicine formation. On the other hand, by tracing the formations in the section on Two Medicine River eastward to central Montana, the Virgelle sandstone was found to be equivalent to the massive sandstone member forming the lower part of the Eagle sandstone, while the Bearpaw shale appeared to be the same at each locality. It thus became apparent that the marine shale of the Claggett formation thins out in going westward from the central part of the State, so that the Two Medicine formation is equivalent to all of the strata in central Montana included in the Judith River, Claggett, and the upper part of the Eagle formations. The Belly River beds of Dawson are therefore not identical and equivalent to the Judith River formation, as has been stated by Stanton and Hatcher, but are equivalent to all of the Eagle, Claggett, and Judith River formations combined.

A diagram of the lithologic units of the Montana group in this region was presented, outlining the sections described and also the section of the Montana group from the Black Hills region, the rocks which are mainly continental in origin being graphically indicated as distinct from those that are chiefly marine. The interfingering of the sheets of the continental sediments from the west with the marine sediments from the east during each of the major oscillations of the western shore line of the Montana sea, together with the inference that the important sandstones in the Montana group were laid down as near-shore or beach sands, and only during recessions of the sea, was pointed out on the diagram.

FRANK L. HESS, *Secretary.*

THE BOTANICAL SOCIETY OF WASHINGTON

The ninety-seventh regular meeting of the Botanical Society of Washington was held in the Assembly Hall of the Cosmos Club, Tuesday, May 5, 1914, at 8 P.M. Messrs. P. V. Cardon, G. P. Van Eseltine, and A. B. Clawson were elected to membership.

The scientific program was as follows:

PROF. CHAS. O. APPLEMAN, *The physiology of the rest period in the potato tuber* (with lantern). (To be published as a Maryland State Experiment Station Bulletin.)

DR. H. B. HUMPHREY, *A recently discovered loose smut of rye* (with lantern). (To be published in Phytopathology.)

MR. L. H. DEWEY, *The common names of plant fibers.* Confusion in the names of textile fibers of vegetable origin causes uncertainty, financial loss, and injury to the trade. The name "hemp" and its forms in other languages is the oldest name used to designate a plant fiber. This name is now used in many languages as a specific term to designate the true hemp, *Cannabis sativa*, to which in all instances it was first applied, and also as a generic term to designate all long fibers. This double use is confusing. The name sisal is also being used in a similar double sense.

The following suggestions are made regarding the choice of names of fibers: (1) Names in most general use are to be preferred, providing they are not misleading; (2) the same term should not be used to designate fibers from different kinds of plants; (3) one name should be used to designate the fiber from one kind of plant, irrespective of the country in which the plant is cultivated or the manner in which the fiber is prepared; (4) geographic names are objectionable in general terms; (5) names that may be adopted directly in all languages are desirable; (6) single words of not more than three syllables are best.

P. L. RICKER, *Corresponding Secretary.*

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. IV AUGUST 19, 1914 No. 14

PHYSICS.—*The axial chromatic aberration of the human eye.* P. G. NUTTING, Eastman Research Laboratory, Rochester, N. Y.

A bright object viewed directly by a normal human eye shows no perceptible colored fringes. From this it has been assumed by some that the eye is fairly well corrected chromatically—at least for the most luminous constituents of white light. On the other hand, if the same object be viewed through a filter transmitting only the extreme red and blue, it will appear with either a red or blue fringe, showing that for these extreme rays the eye is not corrected.

Helmholtz[1] passed monochromatic light through a small hole and found that when red light was used the hole appeared in best focus when viewed from a distance of about 8 feet. With blue illumination it appeared brightest at about $1\frac{1}{2}$ feet, and with extreme violet but a few inches (nur einige Zolle). With these rough determinations of Helmholtz the question appears to have rested.

With the aid of very simple apparatus it was found possible to obtain rather precise determinations of axial focal length. The test object used was the image of the slit of a monochromatic illuminator (*S*, fig. 1) formed by a movable lens *L* of about 20 cm. focal length. At a fixed distance (about 20 cm.) back of this was the observer's eye, *E*. In order to fix the accommodation

[1] Physiolog. Optik, 3rd edition, 1: 147. 1909.

there was placed immediately in front of the eye a plate of optical glass, *P*, reflecting the image of a suitable object at the desired distance.

Three eyes were tested at accommodations of 25 cm., 100 cm., and ∞; the remainder at ∞ only. The object serving to fix the accommodation was so chosen that the slit image appeared against a dark background, such as a distant tree trunk or a black printed letter, so that a barely perceptible amount of white light was mixed with that of the colored slit image. In making determinations at wave lengths 406 and 436 a mercury arc was used as source, at other wave lengths a Nernst lamp. A shift of the lens 1 cm. corresponded to 0.01 mm. shift in focal point at the retina, the relation between the two being roughly linear. The uncer-

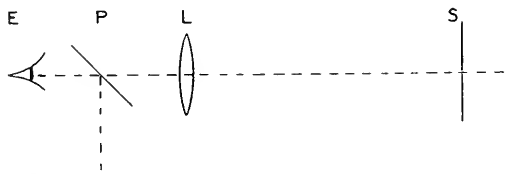

Fig. 1

tainty on a group of five settings was not over 2 mm.; results could be reproduced at different times to about 5 mm. on the scale.

All the subjects chosen had good normal vision. Two, C. H. B. and C. E. S., were women. Four, L. A. J., P. G. N., C. E. S., and M. B. H., were experienced in photometric observations; the others, practically without experience in such work. L. E. J. has marked natural ability and has had long experience in color work.

The results obtained are given in the following table and in figure 2. Data are given as relative focal differences, $\delta v/v$. From these, approximate distances in millimeters of focal points from the retina may be obtained by multiplying by 15.

All the eyes tested show more or less correction. For comparison, the axial error of an eye of pure water is given at the top of the figure. In the most luminous part of the spectrum, from 520 to

660, all eyes show less variation in focal length than an equivalent eye of pure water would have. In some eyes the correction in the central region would compare favorably with that of a good photographic or telescopic objective.

TABLE 1

ACCOMMODATION ∞

WAVE LENGTH	SUBJECTS L. A. J.	P. G. N.	L. E. J.	C. E. S.	C. H. B.	M. B. H.	J. D. H.
780	0.010	0.013	0.004	0.020	0.006	0.016	0.012
740	0.009	0.010	0.011	0.017	0.004	0.010	0.011
700	0.002	0.005	0.009	0.007	0.003	0.008	0.008
650	0.000	0.000	0.005	0.003	0.002	0.004	0.003
600	0.000	0.000	0.000	0.001	0.001	0.000	0.001
550	−0.003	0.000	−0.005	−0.001	−0.001	−0.004	−0.004
550	0.003	0.000	0.005	0.001	0.001	0.004	0.004
500	0.014	−0.006	0.012	0.005	0.005	0.014	0.011
465	0.025	0.020	0.022	0.024	0.012	0.022	0.024
436	0.036	0.039	0.033	0.031	0.022	0.031	0.032
406	0.051	0.064	0.050	0.042	0.038	0.043	0.052

WAVE LENGTH	L. A. J. ∞	L. A. J. 100	L. A. J. 25 cm.	P. G. N. ∞	P. G. N. 100	P. G. N. 25 cm.	J. D. H. ∞	J. D. H. 100	J. D. H. 25 cm.
780	0.010	0.011	0.014	0.013	0.014	0.020	0.012	0.011	0.016
740	0.009	0.009	0.010	0.010	0.012	0.016	0.011	0.012	0.018
700	0.002	0.003	0.003	0.005	0.004	0.009	0.008	0.008	0.011
650	0.000	0.000	0.001	0.000	0.001	0.004	0.003	0.005	0.007
600	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001
550	−0.003	−0.002	−0.004	0.000	0.002	−0.005	−0.004	−0.005	−0.005
500	0.014	0.011	0.019	−0.006	0.005	0.011	0.011	0.013	
465	0.025	0.023		0.020	0.012		0.024	0.022	
436	0.036	0.038		0.039	0.032		0.032	0.033	
406	0.051	0.049		0.064	0.054		0.052	0.054	

Several types of correction are shown that are new to lens optics. The high order central corrections of L. A. J. and P. G. N. are accompanied by decreased violet but normal red correction. L. E. J. shows no correction except in the extreme red and violet where the correction is normal. M. B. H. is slightly corrected except in the extreme regions. C. H. B. is fairly well corrected over a wide region from 480 to 780.

Tests were made for residual chromatic spherical aberration (departure from Gauss condition) by placing half of a half-tone screen over the test slit. The writer could detect no residual in his own eye in the region from 500 to 650. Beyond 700 in the red and beyond 480 in the blue it is noticeable, while at 406 in the violet it amounted to fully twenty times the normal diffusion. L. A. J. agreed with the writer, but L. E. J. could detect little loss of definition at 406.

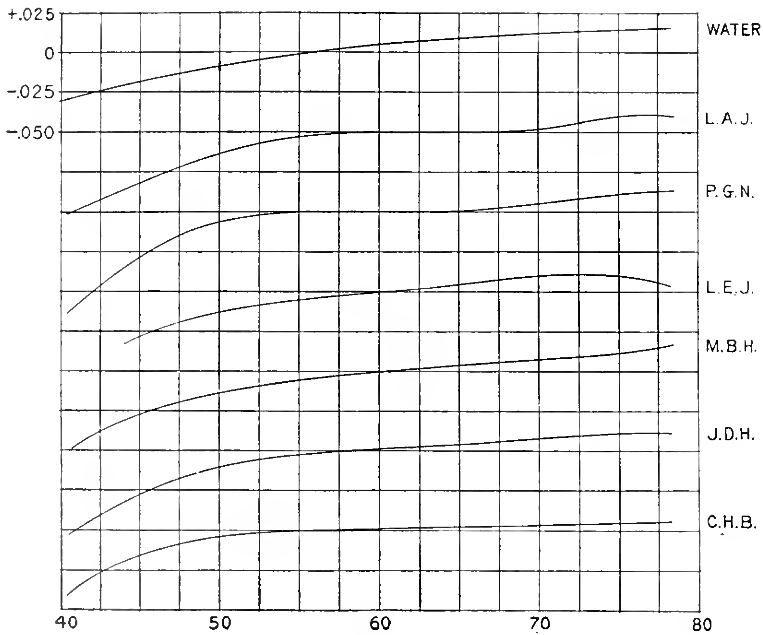

Fig. 2

I wish to record my indebtedness to Mr. Eastman and Dr. Mees for apparatus and to those of my assistants who served as subjects.

PHYSICS.—*The determination of the relative refringence of mineral grains under the petrographic microscope.* FRED. EUGENE WRIGHT, Geophysical Laboratory.

Two standard methods are in common use by microscopists for the determination of the relative refractivity of two adjacent mineral grains in the thin section, and also of a single grain and the liquid in which it is immersed; the first method is based on the phenomena produced by central illumination with a narrow pencil of incident rays, while in the second the phenomena obtained by oblique illumination are observed. Both methods are convenient and entirely satisfactory for ordinary purposes. Their accuracy is the same, differences of 0.001 in refractive indices being recognizable under favorable conditions. But in many instances, especially in the measurement of the refractive indices of fine grains immersed in refractive liquids, it is extremely difficult to detect the faint differences in light intensity which appear at the margins of the grains and by means of which the differences in refractivity are recognized. Under such conditions the eye of the observer is subjected to severe strain and tires quickly. Fortunately, however, it is possible, by modifying the conditions of observation slightly, to render the phenomena more easily visible and thus to relieve the eye strain to a large extent and at the same time to increase the accuracy of the determinations. These modifications involve both the sources of light and a new method of two-fold oblique illumination. They are not difficult to apply and may, therefore, be described briefly.

Sources of light. In place of the sodium flame ordinarily used as source of monochromatic light, the following light sources have been substituted: Mercury light, helium light, and either a calcium-flame or a molybdenum- or tin-spark. With this array of lights set up side by side on the dark room table, and in conjunction with a monochromatic illuminator or a dispersion prism or suitable ray filters (Wratten mercury-line filters), the following spectral line sources are available: $\lambda = 546.1$, 558 to 561 (average about 560), 577 and 579, (average 578) and $588\mu\mu$. With these lights it is not difficult to determine between which two of the four available lines (546, 560, 578, 588$\mu\mu$) the refractive indices of mineral and liquid coincide, the liquid having the higher refractive index for the shorter wave length, and the mineral the higher index for the longer wave length. Now the refractive index of solids increases about 0.001 for a decrease in wave length of 10 to 20$\mu\mu$, while for liquids the change is approximately twice as great. If, therefore, the refractive index of a mineral be accurately measured for any wave length between 546 and 588, its index for the wave length 589$\mu\mu$ (D line) can be estimated with an error not exceeding ± 0.001 and a liquid then prepared of exactly this index, whereupon the estimated refractive index of the mineral grain can be checked by immersion in the new liquid. By use of this arrangement a considerable amount of time has been saved in the routine measurement of the refractive indices of fine crystal grains. Occasionally the monochromatic illuminator (Hilger type with Nernst light filament and ground glass diffusing screen) has been found useful for ascertaining approximately the wave length for which the refractive index of the grain coincides with that of the enveloping liquid.

New method involving two-fold oblique illumination. Oblique illumination is obtained ordinarily by means of a sliding stop below the condenser of the microscope.[1] This stop is purposely not sharply imaged in the object field but appears as a shadow with a hazy edge which passes gradually into the brightly illuminated part of the field. The mineral grains are placed in this transition shadow edge between light and dark, and the illumination of their edges both in white and in monochromatic light is observed. Because of the prismatic refraction of the inclined edges of such grains the intensity of illumination of edges adjacent to the shadow is different from that of the opposite edges, when the refractive index of the grains is different from the refractive index of the liquid in which they are immersed. These differences become less distinct as the refractive index of the liquid approaches that of the mineral; and, if the refractive indices differ

[1] The principles of oblique illumination are discussed in detail in Am. J. Sci. (4) **35**: 63–82. 1913.

by only ± 0.001, the intensity differences in illumination are difficult to see, because of the relatively large amount of light in the field. To reduce the field illumination, and thus to increase the differences in relative intensity of illumination and to render them more clearly visible, a double stop device has been found useful.

This device consists essentially of two safety razor blades mounted in a horizontal position to a vertical connecting bar which in turn is attached to the side of the stage support of the microscope. These blades are so adjusted that as the lower blade swings into position below the condenser, the upper blade is brought to rest in the conjugate image plane above the condenser and between the objective and slide. The upper stop is so adjusted that its knife edge faces the knife edge of the image of the lower blade. In case these two edges just meet, the entire field of view appears very weakly illuminated and is almost dark. The path of the rays is indicated in figure 1. The effect of the refracting mineral grain is to disturb the path of the transmitted rays so that instead of focussing sharply in the image plane they are deflected (as indicated by the two rays with arrows in figure 1 and are thus able to enter

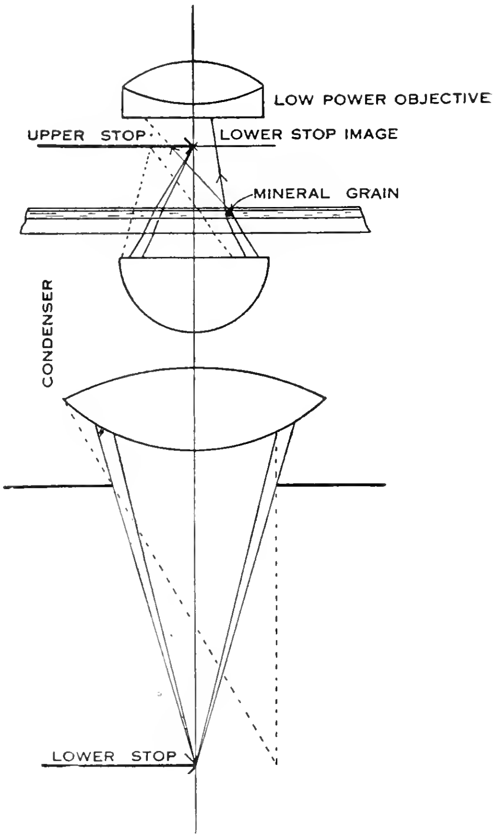

Fig. 1

the low power objective (E. F. 16 mm.) and finally to reach the eye of the observer. If a mineral grain immersed in a liquid of slightly different refractive index be examined under these conditions of illumination, its edges appear in part brighter, and in part darker than the field. The intensity of illumination of the field is so weak that the illumination of the edges is clearly marked even for differences in refractive index of only ± 0.001, and the eye suffers no appreciable strain in making the observation. If now the upper blade be moved away from the edge of the image, a small amount of direct light from the condenser enters the field, and the phenomena produced by oblique illumination from the lower stop are observed under reduced field illumination. As the upper blade recedes, the field illumination increases until finally the conditions of ordinary oblique illumination are reached. The phenomena observed under the first set of conditions are, moreover, the reverse of those produced on withdrawing the upper stop; the edges which appeared bright in the first case are dark in the second, and vice versa. This reversal, caused by the shift of the upper stop, is an additional factor which adds to the sensitiveness of the method. The movable upper stop not only increases the distinctness of the ordinary phenomena of oblique illumination by reducing the field illumination, but it also enables the observer to reverse the phenomena and to study the slight differences in illumination against a dark field for which the eye is more sensitive.

It is of interest to note that the principle on which the first part of the new method is based is that first used by Foucault for testing the chromatic and spherical aberrations of a telescope lens. The method was later used by Töpler for detecting small differences in the refractive index of a medium, especially inhomogeneity in optical glass. Töpler's method is still used for this purpose, and for testing the homogeneity of solutions especially with respect to concentration currents; it has also been employed by R. W. Wood to obtain direct photographs of sound waves.

CHEMISTRY.—*The determination of carbon in steels and irons by direct combustion in oxygen at high temperatures.* J. R. Cain and H. E. Cleaves, Bureau of Standards.

In determining carbon in steels by the method of direct combustion in oxygen it has been the practice at the Bureau of Standards to pulverize and reburn the oxides—repeatedly, if necessary. Although particles of metal are seldom found in the oxides, additional carbon is generally obtained by this method; in some samples as much as 0.02 per cent. With the idea that such carbon

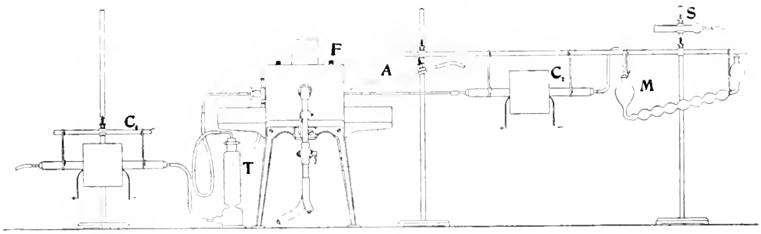

Fig. 1. Details of Apparatus

C_1 and C_2, porcelain tubes filled with copper oxide and wound with nichrome wire for heating; *T*, tower filled with stick KOH; *F*, gas furnace; *A*, tube for air cooling; *M*, Meyer bulb; *S*, soda lime guard tube.

was probably retained as difficultly oxidizable carbides, it was thought that alloy steels contining such metals as chromium, titanium, and tungsten, or high percentages of silicon, all capable of yielding carbides very resistant to oxidation, would be especially subject to this source of error. Additional weight was given to this view by results reported from laboratories specializing in the analysis of such alloys, and obtained by combustion at temperatures higher than those usually recommended.

As combustions are ordinarily effected, the mass of oxides is kept fused for only a very short time, if at all, after the metal has ceased to burn, inasmuch as the temperature usually maintained in the furnace is 950° to 1100°, whereas the melting points of the oxides obtained by us during combustion[1] were near to

[1] Determinations made at this Bureau indicate that the oxides, when melted in oxygen, gradually absorb that gas with rise in melting point. This matter will be discussed in the more extended paper to be published by us elsewhere.

1450°. It was therefore thought that more accurate results might be attained if, after combustion had ceased, the oxides were maintained in a state of fusion for some minutes. The present work was carried out in order to test these ideas, by burning Bureau of Standards analyzed steel and iron samples—particularly the alloy steel standards—at temperatures ordinarily employed but finishing at temperatures above the fusion point of the oxides. The gas furnace and other apparatus shown in figures 1 and 2 were employed. The combustion tube was of platinum, with provision for water and air cooling of the ends, as shown. When the flame from the blow-pipe impinged directly upon the platinum without a protecting tube the temperature attained was about 1520°, as indicated by a platinum, platinum-iridium thermoelement and millivoltmeter. In some of the work a protecting alundum tube was used around the platinum tube. This however, was found to reduce the temperature more than was desirable, largely because of reduced combustion space in the already too small combustion chamber of the furnace used. During combustion the steel was supported directly on the platinum boat; by careful regulation of the rate of admitting oxygen and of the temperature of the furnace the steel particles were coated superficially with oxide before there was any danger of serious injury to the platinum by alloying; as soon as this coating was formed the combustion could be finished at a moderate rate without danger to the boat. The use of the alundum generally recommended as a lining material for boats during combustion was found objectionable in these experiments, because when it was employed the entire contents of the boat could not be kept fused (the melting point of alundum being about 2000°) and there was also some indication that additional carbon, not oxidized by prolonged ignition in oxygen at 1500°, was eliminated from the alundum when in contact with fused iron oxide. Similar difficulties were encountered with other supporting materials that were tried. The catalyzer following the furnace was found absolutely necessary, since otherwise very irregular results, sometimes several hundredths per cent low, were obtained; tests with palladium chloride solution showed the presence of carbon monoxide in considerable quantity, when the catalyzer was omitted, and its absence when the catalyzer was used. The barium carbonate titration method,[2] recently described by one of us, was used for the determination of the carbon dioxide.

The routine followed in making a determination consisted in inserting into the combustion tube the boat containing the sample, and connecting up the Meyer tube containing barium hydroxide solution. While passing a slow current of oxygen the combustion

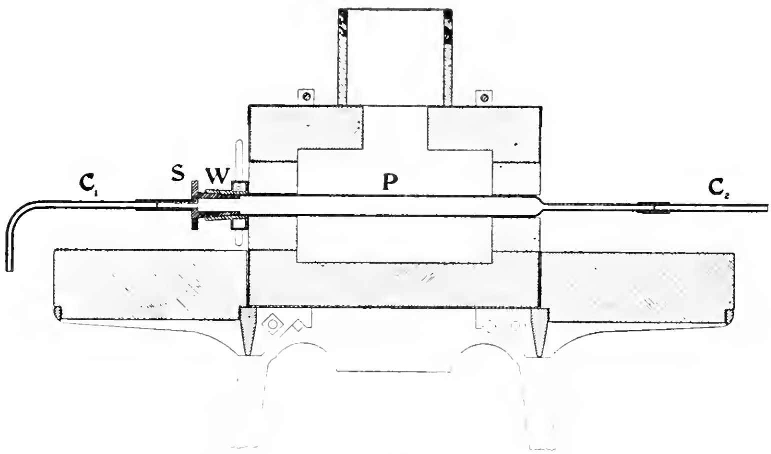

Fig. 2. Cross-section of Furnace

P, platinum tube; *W*, water cooled jacket of German silver; *S*, stopper, German silver; C_1, and C_2, copper tubes soldered to the platinum tube.

tube was brought to about 700° or 800° and kept at that temperature until the superficial oxidation of the particles was effected; this required a minute or two; then the temperature was raised to about 1000° and the combustion completed. As soon as absorption of oxygen had ceased the blow-pipe flame was turned on full, this stage of the combustion being continued twenty-five to thirty minutes to insure that the oxides had been kept fused a sufficiently long time. The Meyer tube was disconnected and the determination finished by filtering off and washing the precipi-

[2] J. R. Cain. B. S. Tech. Paper No. 33; also J. Ind. and Eng. Chem. June, 1914.

TABLE 1

RESULTS* OBTAINED BY COMBUSTION OF B. S. STANDARD STEELS AND IRONS AT HIGH TEMPERATURE

B. S. NO. AND DESCRIPTION OF SAMPLE	CERTIFICATE VALUE FOR CARBON, AVERAGE OF ALL METHODS	VALUES OBTAINED BY COMBUSTION AT HIGH TEMP.			DIFFERENCE
		Cain	Cleaves	Average: Cain and Cleaves	
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
		0.350			
Vanadium steel B.S. No. 24..		0.350		0.351	+0.003
	0.348†	0.354			
Chrome vanadium steel B.S.		0.381	0.379	0.380	+0.007
No. 30.....................	0.373	0.381			
		0.380	0.383	0.383	+0.011
Chrome-nickel steel B.S. No.	0.372	0.383	0.380		
32.........................			0.386		
			0.383		
	0.278	0.282			
		0.280			
Nickel steel B.S. No. 33......		0.289		0.285	+0.007
		0.285			
		0.288			
	0.599	0.612	0.610		
Chrome-tungsten steel B.S.		0.609	0.608		
No. 31.....................		0.609	0.608	0.609	+0.010
			0.608		
	0.805	0.800	0.804		
Bessemer steel‡ 0.8 B.S. No.		0.806	0.804	0.805	0.000
23.........................		0.805	0.809		
		0.805	0.805		
		0.371			
Bessemer steel 0.4 Renewal	0.363§	0.370		0.372	+0.009
B.S. No. 10b...............		0.374			
		0.374			
	2.726	2.74			
Pig Iron C 2d Renewal No. 5b		2.75		2.743	+0.017
		2.74			

* This is a partial list of results for the steels reported; the later publication will contain more data for these steels.

† Certificate value omitting the results by the colorimetric method, which is not considered applicable to this steel.

‡ This steel was used as a standard for checking up the apparatus, and usually one or two determinations a day were made with it; these numerous determinations, with very few exceptions, were of the kind shown in the table.

§ Results given on the certificate as the average by analysts making one combustion without reburning the oxides.

tated barium carbonate and titrating it against standard acid as described in the paper above cited. The oxides were usually found to be thoroughly fused and to have spread over the bottom of the boat; in some cases they even crept over the sides of the container. A second fusion of such oxides gave no further carbon dioxide to a freshly filled and clear barium hydroxide tube. Great care was taken at all stages of the work to eliminate extraneous carbon dioxide, so that the frequent blank determinations made by passing oxygn at the rate used in a combustion for twenty minutes to one-half hour gave no amounts of barium carbonate determinable by the method used.

The results of Table 1 show that some steels give higher results by the new method than by the old and that others yield only slightly higher figures, while with the iron the difference amounts to nearly 0.02 per cent. The alloy steels thus far tested do not seem to give higher results than are to be found among the plain carbon steels. Whether greater differences in general may be found with other products can be determined only after further work.

The more extended paper on this subject to be published by us elsewhere will contain results on the remaining standard analyzed steel samples of the Bureau of Standards, as well as the description of an electric furnace used for heating the porcelain and platinum combustion tubes used.

MINERALOGY.—*Preliminary note on searlesite, a new mineral.*[1]

ESPER S. LARSEN and W. B. HICKS, U. S. Geological Survey.

The mineral for which the name searlesite is proposed was found in samples from the deep well in Searles Lake, San Bernardino County, California. One sample, washed from the clay at a depth of 540 feet, consists almost entirely of spherulites which are made up largely of radiating fibers of searlesite with a considerable amount of sand and calcite. In another specimen the searlesite is associated with pirssonite, trona, halite, sand, etc.

[1] To appear in full in the American Journal of Science.

Searlesite is rather soft and is readily fusible. It is soluble in hydrochloric acid with gelatinization and appreciably soluble in water. The optical properties are:

α = 1.520 2 E very large
γ = 1.528 Maximum extinction angle large

After correction for insoluble minerals and for calcite the chemical analysis corresponds approximately to $Na_2O.B_2O_3.4SiO_2.2H_2O$.

BOTANY.—*The genus Arthrocnemum in North America.* PAUL C. STANDLEY, National Museum.[1]

Arthrocnemum is one of the smaller genera of the Chenopodiaceae, similar in general appearance to Salicornia, but distinguished by its glabrous seeds, with rather copious endosperm, and by having distinct perianths, which are not immersed in the joints of the flowering spikes but project from them rather conspicuously. In Salicornia the seeds are without endosperm and are covered with numerous short hairs, while the flowers are coalescent and immersed in the joints.

About eight species of Arthrocnemum are known, all natives of the coasts of the warmer parts of Europe, Asia, Africa, and Australia. No true representative of the genus has ever been reported as such from North America, although Moquin[2] referred *Salicornia ambigua* Michx. to it with doubt. That species, however, is a true Salicornia.

In 1898 Mr. S. B. Parish described a new Salicornia from southern California. His description alone would exclude the plant from the genus, for he describes the seed as "smooth." This character, however, would not seem remarkable to one who had studied Sereno Watson's treatment of Salicornia,[3] for that writer says, under *S. ambigua*, "*S. fruticosa* of the Old World differs in being erect, stouter and more branched, the seed larger and smooth." The European plant to which Watson referred is

[1] Published by permission of the Secretary of the Smithsonian Institution.
[2] Chenop. Enum. 112. 1840.
[3] Proc. Am. Acad. **9**: 123-125. 1874.

properly known as *Arthrocnemum glaucum* (Delile) Ung. Sternb.,[4] while the Linnaean *Salicornia fruticosa* is a true Salicornia, with pubescent seeds. These two plants have been greatly confused by Old World botanists.[5]

Salicornia subterminalis is undoubtedly a member of the genus Arthrocnemum. While closely related to *A. glaucum* of the Mediterranean region it appears distinct in its much narrower, more acute spikes, numerous slender, erect branches, and pale seeds. The form of the inflorescence, too, is peculiar. The flowering spikes usually do not terminate the branches, but themselves terminate in long sterile branches. The flowering joints may be found almost anywhere along the young branches; sometimes they are solitary, but more often there are 3 to 14 together. The plant of the Pacific Coast may, therefore, be known as below. The Mexican specimens come from a locality far distant from southern California. It is probable that, when the coastal regions of Sonora and Lower California have been more thoroughly explored, the plant will be found at intervening stations.

Arthrocnemum subterminale (Parish) Standley.

?*Arthrocnemum fruticosum californicum* Moq. in DC. Prodr. **13**[2]: 151. 1849.—Type collected in California by Nuttall ("*Salicornia californica* Nutt.! in herb."). The description is very brief but seems to indicate the present plant.

Salicornia ambigua S. Wats. Proc. Am. Acad. **9**: 125. 1874, in part; not Michx.—The Wilkes specimen listed below was doubtless referred here by Watson, who cites Wilkes among the collectors. The Wilkes Expedition, however, collected specimens of *S. ambigua*, also.

Salicornia subterminalis Parish, Erythea **6**: 87. 1898.—Type from San Jacinto Plains, California, *S. B. & W. F. Parish* 1520.

Specimens have been examined from the following localities:

California: San Francisco Bay, *Wilkes Expl. Exped.* 1204. Near Bakersfield, *Coville & Funston* 1234. Menifee, *Parish* 4463. San Jacinto Plains, *S. B. & W. F. Parish* 1520. Ballona marshes, near Mesmer, *Abrams* 2565. San Diego, *Wooton; K. Brandegee.* Vicinity of Monument 258, Pacific coast, *Mearns* 3930. Avalon, Santa Catalina Island, *Trask.*

Mexico: Topolobampo, Sinaloa, *Rose, Standley, & Russell* 13286.

[4] See Asch. & Graebn. Syn. Fl. Mitt. Eur. **5**: 190. 1913.

[5] See C. E. Moss. Some species of Salicornia, Journ. Bot. Brit. & For. **49**: 177–185. 1911.

BACTERIOLOGY.—*Bacterial precipitation of calcium carbonate.*
KARL F. KELLERMAN and N. R. SMITH, Bureau of Plant Industry.

In 1914 the late George H. Drew[1] called attention to the probable importance of bacteria in the formation of marine deposits of calcium carbonate. He isolated and designated as *Bacterium calcis* an organism which, cultivated in the laboratory, precipitated calcium carbonate from synthetic cultural media. At the suggestion of Dr. T. Wayland Vaughan, in charge of Coastal Plain Investigations, U. S. Geological Survey, we have undertaken a bacteriological study of samples of water and oolitic sand from the Great Salt Lake and from the Atlantic Ocean near the Bahamas and the Florida Keys. The samples of water and bottom mud which served as a basis for these experiments were obtained through the courtesy of Dr. Vaughan.

The progress of this study has been necessarily slow, since the elaboration of new technique is required in dealing with such unusual conditions. At the present time, however, it is believed that some important facts have been established. We have found it possible in the laboratory to form precipitates of calcium carbonate by three types of biological processes. These are briefly outlined below in the probable order of their importance.

1. The associative action of mixed cultures of bacteria, one species which forms traces of carbon dioxide and one which forms ammonia either by decomposing some proteid or by reducing nitrates to nitrites and to ammonia, gives rise to ammonium carbonate. This ammonium carbonate reacts with any calcium sulphate which may be in solution according to the formula:

$$CaSO_4 + (NH_4)_2\ CO_3 = CaCO_3 + (NH_4)_2SO_4$$

It is obvious that the carbon dioxide necessary for this reaction may be produced by plant or animal catabolism as well as by bacterial fermentation.

[1] Drew, George Harold. On the Precipitation of Calcium Carbonate in the Sea by Marine Bacteria, and on the Action of Denitrifying Bacteria in Tropical and Temperate Seas. Publ. No. 182, Carnegie Institution of Washington, p. 7–45. 1914.

2. Calcium carbonate may be precipitated from water laden with calcium bicarbonate by bacterial production of ammonia according to the formula:

$$Ca(HCO_3)_2 + 2NH_4OH = CaCO_3 + (NH_4)_2CO_3 + {}_2H_2O$$

3. Calcium carbonate may be precipitated as a result of the bacterial decomposition of calcium salts of organic acids such as calcium succinate, calcium acetate, or calcium malate. The denitrification of nitrates also takes place in these cultures and perhaps is essential to the formation of calcium carbonate. The formulae for this reaction have not yet been determined.

From our experimental work it seems probable that the precipitation of calcium carbonate described by Drew as occurring in solutions supplied with organic compounds of calcium is due to the calcium liberated from the decomposing molecule of the organic calcium salt. We have produced rather large crystals of calcium carbonate by the growth of certain bacteria in media which contained no calcium whatever except in the form of organic salts. In this connection it should be noted that denitrification of nitrate will not in all cases produce the ammonia necessary for some of the reactions referred to above. Where a culture medium remains alkaline during the production of nitrite further production and accumulation of ammonia is possible. Where the culture medium is faintly acid, however, in the first stage of the fermentation, the nitrite is produced, and with the production of even minute traces of ammonia a decomposition of the resulting ammonium nitrite takes place with the liberation of free nitrogen, according to the formula:

$$NH_4NO_2 = N_2 + 2H_2O$$

A study of Drew's original description of *Bacterium calcis*, as well as careful study and staining of similar organisms isolated from samples of water collected near the Florida Keys, shows beyond doubt that the proper genus for this organism is Pseudomonas. New data for identification are given in the following description:

Pseudomonas calcis (Drew) n. comb.

Bacterium calcis Drew, Carnegie Inst. Pub. No. 184, p. 26. 1914.

An actively motile organism, 1.1μ by 1.5 to 3μ, bearing a single flagellum (see Fig. 1). Sometimes forms long threads. Grows best in media containing three per cent. sodium chloride or in sea water containing pepton and nitrate, but is quickly killed by stronger solutions of sodium chloride. Grows weakly in three per cent. salt pepton broth, forming neither nitrites nor ammonia. Grows luxuriantly in three per cent. salt pepton broth containing two-tenths per cent. nitrate, forming nitrite in twenty-four hours, ammonia in forty-eight hours. In synthetic broth composed of sea water 1,000 grams, sodium phosphate 0.25 grams, potassium nitrate 2 grams, together with 5 grams of either calcium malate, calcium succinate, or calcium acetate, nitrites are formed in forty-eight hours to six days. Ammonia is formed in four days in the medium containing calcium malate. Only traces of ammonia, within the limits of experimental error, in media containing calcium succinate or calcium acetate. The addition of a small quantity of pepton to any of these media stimulates luxuriant growth and rapid production of both nitrite and ammonia.

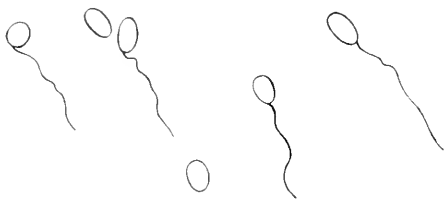

Fig. 1. *Pseudomonas calcis;* showing the terminal flagellum, stained by a modification of Williams' method. Drawn, greatly enlarged, from a photomicrograph.

ANTHROPOLOGY.—*Algonquian linguistic miscellany.* TRUMAN MICHELSON, Bureau of American Ethnology.

The Fox citations in this paper are either from Dr. Jones' Fox Texts (by page and line) or from the present writer's texts, unless the contrary is explicitly stated. The author's texts were collected in the current syllabary, being written out by various informants. The citations from these have been restored according to the phonetic scheme of Dr. Jones, though this is not to be considered as altogether satisfactory. The numerals within the brackets all refer to sections of the Algonquian sketch in Part 1 of the Handbook of American Indian Languages.

These notes are assembled here in the belief that they will be of value to future investigators of Algonquian languages and that a more accurate and complete linguistic classification of Algonquian tribes will be possible when more data of this nature are available.

PHONETIC CHANGES

1. *n* to *c*. In my Contributions to Algonquian Grammar[1] I have shown that in both Fox and Potawatomi *n* changes to *c* before an *i* which is either a new morphological element or the initial sound of such an element. I also raised the question as to whether this change might not occur in other dialects. That it likewise is found in Ojibwa is shown by *mīcin* GIVE (THOU) ME as contrasted with *kīgamīnin* I WILL GIVE THEE, both of which are quoted from Dr. Jones' unpublished texts. The last example also shows that the change does not occur before Ojibwa *i* when this corresponds to Fox *e* (Fox *kīmīnen*^{e}, M., I WILL GIVE THEE). From my Shawnee notes of 1911 it appears that the same or a like phenomenon occurs in that language. Thus *kalōsilō'* SPEAK TO ME (theoretically *kAnōcin*^{u} in Fox, supported by *kAnōc*^{i} TELL IT [an.] in Jones' Texts at 298.26; *-in*^{u} [31]; see my 'Contributions,' l. c.); *kitesi* YOU TOLD ME (theoretically Fox *ketec*^{i}, *ke—*^{i} [28]; stem *te*, *-c-* as above; supported by Fox *kīmīc*^{i} at J. 240.14 I WISH YOU WOULD GIVE ME, *kī—*^{i} [28] as contrasted with *kitele* I TOLD YOU (corresponds to Fox *ketene*, J. 110.5, 116.14). It is likely that in both cases the *s* is a mishearing for *c*; observe that in Shawnee *θ* corresponds to Fox *s*, e.g., *θōgi-* BIND = Fox *sōgi-*.

2. *s* to *c*. That *s* changes to *c* in Ojibwa under the same conditions as in Fox (*Am. Anthropologist*, l. c., p. 471) is clear from *wīniciyan* THOU WILT KILL ME as compared with *kiwīnisîn* I WILL KILL THEE, and *kānisadwā* THOU WHO DIDST KILL THEM. The citations are both from Jones, l. c. The change does not take place before Ojibwa *i* (*î*) when this corresponds to Fox *e*, which shows this last is the more original, for which see also the discussion of the change of *n* to *c*.

3. *my* to *m* in Ojibwa. In Jones' texts I find *nimācitä'ä'* I FEEL SAD AT HEART. Contrast this with Fox *ämyācitähätc*^{i} (in my unpublished texts) HE HAD DOLEFUL FEELINGS IN HIS HEART. The Ojibwa example may furthermore be used to illustrate the change of *n* to *c* in that language: See *American Anthropologist*, l. c., p. 471.

4. Interchange of Fox *ō* and *aw*. In paragraph 34 of the Algonquian sketch in the Handbook of American Indian Languages I pointed out

[1] Am. Anthropologist, N. S., XV, p. 470 ff.

that in the case of double objects the pronominal form of the third person object, singular or plural, animate or inanimate, is -*amō*- (-*amu*-) before consonants, -*amaw*- before vowels. On further investigation it appears that the interchange of *ō* and *aw* is not restricted to these cases but is universal in Fox. Examples showing this are *ä'pyätōyān*[i] (J. 322.7) I HAVE BROUGHT IT [*ä—yān*[i], 29; *'tō*, 21, 37], *kī'pyä'tawipw*[a] (M.) YOU WILL BRING IT TO ME [*kī—ipw*[a], 28), *ä'pyä'tawutc*[i] (M.) THEN IT WAS BROUGHT TO HIM [*ä—utc*[i], 41], *pyä'tawigwähig*[i] (M.) THEY MUST HAVE BROUGHT IT TO ME [-*igwähig*[i], see below p. 406]; *neneskinawāw*[a] (J. 68.14) I LOATHE HIM [*ne—āw*[a], 28], *äneskinōnān*[i] (M.) BECAUSE I HATE THEE [*ä—nān*[i], 29]; *ä'kanōnetc*[i] (J. 8.5) HE WAS ADDRESSED, [*ä—etc*[i], 41; -*n*-, 21, 37], *kanawin*[u] (J. 180.4) SPEAK [-*n*[u], 31]; *ä'a'ci'tōnāgw*[e] WHEN HE BUILT THEM (inan.) FOR YOU (J. 30.16) [*ä—nāgw*[e], 29; -*'tō*-, 21, 37], *äci'tawiyametcin*[i] (J. 32.6) THOSE (inan.) HE MADE FOR US [change OF stem-vowel, 33; the table in 33 does not give the termination -*iyametcin*[i] as it is not constructed in such a way as to take into consideration such rare combinations], *aci'tawiyä'kap*[a] (M.) THOU MIGHTEST MAKE THEM (inan.) FOR THEM (an.) [-*iyä'kap*[a], 30].

THE SUPPOSED FOX STEM *uwīwi*-

In section 16 of the Algonquian sketch in the Handbook of American Indian Languages, a Fox stem *uwīwi*- TO MARRY is assumed. This is wrong; we evidently have the type of incorporation discussed in the *Am. Anthropologist*, N. S., XV, p. 474 ff. as is shown by *uwīwan*[i] (J. 146.3, 216.3 etc.) HIS WIFE [*u—an*[i], 45], *nīw*[a] (J. 216.4) MY WIFE [*n—*[a], 45]. The word *uwīw*[a], cited in the sketch, is either a mistake for *uwīwan*[i], or more probably for *uwīwiw*[a] HE MARRIES. This last is reconstructed by myself but is supported in formation by *kīhuwīw*[i] I WOULD HAVE YOU TAKE HER TO WIFE, J. 82.2, etc. [*kī*-, 28; -*h*-, 8]; *wīhuwīhiw*[a] HE WANTS TO GET HIMSELF A WIFE, J. 320.14 does also [*wī—w*[a], 28; -*h*-, 8], though the second *h* of this is obscure. Incidently it may be remarked that *owīwan*[i] (J. 228.8; a variant of *uwīwan*[i]) is wrongly treated in section 8 of the same sketch. The first *w*, not the second, is the glide as is shown by *nīw*[a] MY WIFE: compare *nī'kān*[a] (J. 14.12, 26.17) MY FRIEND as contrasted with *uwī'kānan*[i] (J. 314.14, 15) HIS FRIEND; see section 45. The -*i*- of the supposed stem is of course simply the copula.

THE SUPPOSED FOX WORD *nepyätcānānāwAg^{i}*

A supposed Fox word *nepyätcānānāwAg^{i}* I HAVE COME TO TAKE THEM AWAY is cited in section 28 of the Algonquian sketch in the Handbook of American Indian Languages. The analysis there given makes *-ā-* occur in the wrong position; and there can be no doubt the word is a mistake for *nepyätcitcānānāwAg^{i}*, J. 50.22, in which *tcā* is an incorporated particle; see pp. 472, 473 of the American Anthropologist, N. S., vol. XV, and *pyä-* and *nā-* in section 16 of the sketch.

NOTE ON FOX *nīhutūgimāmipen^{a}*

In my 'Contributions' cited above, I assumed that *nīhutūgimāmipen^{a}* in Jones' texts at 8.6 (so, not 28.6) was an error for *kī-*. That this is not an error is shown by the following *kīyaw^{i}*. The correct analysis is: *nī—pen^{a}* [28]; *-h-*[8]; *-u-*[the possessive pronoun under discussion]; *-t-*[8, 45]; *-m-*(second one) [45]; *-i-*[20]. It is evident that *kī·u·tūgimāmipen^{a}* in Jones' texts at 8.3 is a variant of *kīutū'gimā'mipèn^{a}* in section 13 of the Algonquian sketch in the Handbook of American Indian Languages [*kī—ipen^{a}*, 28]. The first accordingly should be translated WE WOULD HAVE A CHIEF, NAMELY, THYSELF [see 46]; and the second THOU WILT BE CHIEF TO US. The very great similarity of the two words was the source of mistake.

INCORPORATION OF THE NOMINAL OBJECT

I have stated in my 'Contributions,' p. 473 that incorporation of the nominal subject or object does not occur in transitive verbs. From some recent work with Fox informants it appears that such incorporation can occur optionally after the first initial stem, or the element *-tci-* ('Contributions,' pp. 472, 473) if there is likewise another stem. A sentence written out by one informant, the phonetics of which I have restored according to Dr. Jones' scheme, stated to have been spoken by an old woman is as follows: *nepyätciketānesawâpAmāpen^{a}* WE (excl.) HAVE COME TO SEE YOUR DAUGHTER, the analysis of which is *ne—āpen^{a}* [28], *pyä-*[16], *-tci-* [see above], *ketānesa* [*ke—a*, 45], *wâpA-*[16], *-m-* [21,37]. It may be noted that the terminal vowel of *ketānes^{a}* YOUR DAUGHTER has beome full-sounding. Thus far I have not been able to confirm this type or incorporation by examples from either the texts of Dr. Jones or myself.

THE CONJUNCTIVE OF THE FOX INTERROGATIVE MODE

	I	we excl.	we incl.	thou	ye	he	they an.	it	they inan.
Intrans.	*-wānäni*	*-wāgäni*	*-wᴀgwäni*	*-wᴀnäni*	*-wägwäni*	*-gwäni*	*-gwähigi*	*-gwäni*	*-gwähini*
me	—	—	—	*-iwᴀnäni*	*-iwāgwäni*	*-igwäni*	*-igwähigi*		
us excl.	—	—	—	*-iwāgäni*	*-iwāgäni*	*-iyᴀmegwäni*	*-iyᴀmegwähigi*		
us incl.	—	—	—	—	—	*-nowᴀgwäni*	?		
thee	*-nowānäni*	*-nowāgäni*	—	—	—	*-nogwäni*	*-nogwähigi*		
you	?	*-nowāgäni*	—	—	—	*-nowāgwäni*	*-nowāgwähigi*		
him, them an.	*-āwᴀgäni*	*-āwᴀgetäni*	*-āwᴀgwäni*	*-āwᴀtäni*	*-āwägwäni*	*-āgwäni*	*-āgwähigi*		
it, them, inan.	*-ᴀmowānäni*	*-ᴀmowāgäni*	*-ᴀmowᴀgwäni*	*ᴀmowᴀnäni*	*-ᴀmowägwäni*	*-ᴀmogwäni*	*-ᴀmogwähigi*		

NOTES ON THE FOX INTERROGATIVE MODE

The Fox interrogative mode is discussed in section 32 of the Algonquian sketch in the Handbook of American Indian Languages. A table giving the terminations of the intransitive forms of the conjunctive will be found there. However, as I have already pointed out, transitive forms certainly exist, though not given in the table. Since then I have been able to construct a practically complete series by having Fox informants translate English sentences framed to bring out the desired points. The informants wrote the words in the current syllabary, the phonetics of which I subsequently restored according to Dr. Jones' scheme. This was done because transitive forms necessarily are of rare occurrence in texts containing myths or tales, owing to the nature of the sentences involved. However, the forms seem to be sufficiently confirmed by those I have found in the texts of both Dr. Jones and myself as to warrant publication, subject to future correction. The initial *ä-* or *wī-* is omitted in the table herewith.

Examples from the texts of both Dr. Jones and the writer illustrating the above follow.

Intransitive forms:

*wīhAnemime'tusänenīwi*wānän[i] (J. 380.12) AS LONG INTO THE FUTURE AS I SHALL LIVE [*hAnemi-*, 16; *me'tusänenīwi-* derived from the noun *me'tusäneniwa* MORTAL by the addition of the copula *-i-*, 20, and stripping the ending of animate nouns (-[a]) from the word; see Am. Anthropologist, N. S., XV, p. 475];

*wīhicawi*wāgän[i] (J. 364.20) WHAT WE (excl.) SHOULD DO [*-h-*, 8; *i-cawi-*, stem, 16];

*wīwäpipemutī*wAgwän[i] (J. 20.12) WHEN WE (incl.) SHALL BEGIN SHOOTING AT EACH OTHER [*wäpi-*, 16; *pemw-*, 16; *-tī-*, 38];

*pyā*wAnän[i] (M.) AT LAST THOU HAST COME [*pyä-*, 16; see also 11 at end];

*äcawicawi*wägwän[i] (M.) HOW YOU HAVE BEEN DOING [*cawi-*, 25; *cawi-*, 16];

äcawi gwän[i] (J. 342.15) WHAT HAS BECOME OF HIM (*cawi-*, 16];

*wīhutcipōnesegu*kwäg[i] (J. 364.16) HOW THERE SHOULD BE AN END OF THE KILLING OF THEM [*-h-*, 8; *utci-*, 16; *pō-* shortened from *pōni-*, 16: see 12; *ne-* KILL, initial stem; *-s-*, 21, 37 (not *nes-* as given in 16); *-e-*, 8; *-kwähig*[i] for *-gwähig*[i], 3; *-gu-*, 41);

*atä*gwän[i] (M.) IT MUST HAVE BEEN (here) [*-tä-*, 20]

Transitive forms:

*wīhicikᴀnōn*āwᴀgän[i] (M.) HOW I SHOULD THUS SPEAK TO HIM [*-h-*,8; *ici-*, 16; stem *kᴀn-* or *kᴀnō-*, 16, and above page—; *-n-*, 21, 37];

*wīwᴀtcāha*wᴀgwän[e] (J. 234.22, cf. 260.15) THAT WE CAN COOK FOR HIM [variant for *-āwᴀgwän[e]*, subjunctive; hence final *-[e]*, not *-[i]* as in table: see 32; *wᴀtcā-*, 16; *-h-*, 21, 37];

*äcim*iwāgän[i] (J. 280.11) WHATEVER YOU SHOULD TELL US [*cim-*, 16];

*wäten*āwᴀtän[i] (J. 300.10) FROM WHAT PLACE YOU GOT IT (an.) [*wäte*, evidently related to *wätci* as *pyäte* to *pyätci*: see 16 under *pyä-* and *utci-*, also 11; *-n-*, 21, 37];

*keke'känetᴀ*mōwᴀnän[i] (J. 288.5) YOU KNEW ABOUT ALL IT [*ke-*, 25; *ke'k-*, 16; *-äne-*, 18; *-t-*, 21, 37];

*wīnes*āwᴀtän[i] (M.) HOW YOU WILL KILL HIM [for analysis see above];

*äcike'känem*āwᴀtän[i] (M.) HOW YOU WILL THUS KNOW HIM [*-m-*,21,37; *ci* possibly for *ici:* see 12, 16];

*äcike'känetᴀ*mowᴀnän[i] (M.) HOW YOU WILL ACCORDINGLY KNOW IT;

*änänämi*wägwän[i] (J. 356.6) THAT YOU WILL ENTERTAIN OF ME IN YOUR THOUGHTS (*-m-*, 21, 37];

*wī'i'cimenwinawäh*āwägwän[i] (J. 366.6) HOW YOU SHALL PACIFY HIM [*ici-*, 16; *menwi-*, 16; *-h-*, 21, 37];

*änätᴀ*mowägwän[i] (M.) HOW YOU MAY SEE THEM (inan.) [stem *nä-*, wrongly given as *näw-* in 16: *w* is an instrumental, 21, 37; *-t-*, 21, 37];

*wīhinā'penᴀn*āgwän[i] (J. 278.6) HOW HE WOULD DO WITH THEM [-n- (next to last one), 21, 37];

*wī'i'cike'känetᴀ*mogwän[i] (M.) HOW HE WILL THUS KNOW IT;

*pyä'tawi*gwähig[i] (M.) THEY MUST HAVE BROUGHT IT TO ME [*pyä-*, 16; *'taw-* for *-'tō-*, 21, 37: see above, p. 403].

Furthermore it seems clear that there exists a participial of the interrogative mode as well as the conjunctive and subjunctive as shown by *wäwīgwän[a]* (J. 216.13) HE WHO HAPPENS TO MARRY [see the note on the supposed Fox stem *uwīwi-*; for the change in the vowel compare *wägwisit[a]* (J. 170.19) SHE WHO WAS MOTHER TO THE SONS, *wäwī'kānetītcig[i]* (J. 136.2) THEY WHO WERE FRIENDS TOGETHER, *wänāpämit[a]* (J. 138 TITLE) SHE WHO HAD A HUSBAND as contrasted with *ä'ugwisiwātc[i]* (M.) THEN THEY HAD A SON, *ähuwī'kānetīwātc[i]* (J. 150.12) THEY WERE FRIENDS TOGETHER, *unāpämin[u]* (J. 70.3) TAKE TO YOURSELF A HUSBAND: see 11, 33], *me'tusänenīwigwän[a]* (M.) WHO EVER SHALL LIVE AS MORTAL, *wīkaskimāgwän*[a] (J. 370.14) HE THAT MIGHT ENTICE HIM [*wī-* used as in the conjunctive; *kAski-*, 16; *-m-*, 21, 37], *āmikAskināwaswigwän*[a] HE WHO SHALL CONTRIVE TO OUTRUN ME (obtained in the translation of an English sentence), *mä'kwänetAmogwän*[a] (M.) HE WHO SHALL REMEMBER IT [change of stem-vowel, 33; *me'kw-*, 16; *-äne-*, 18; *-t-*, 21, 37], *wī'pwāwinahimAmātutAmogwän*[a] (M.) HE WHO SHALL NOT KNOW HOW TO WORSHIP THEM (inan.) [*wī-* and *pwāwi-* as in the conjunctive; *nahi-*, 16; *mA*, 25; *mātu-*, 16; *-t-*, 21, 37], *wī'ō'kumese'iwAgän*[a] (M.) WHOEVER WE (incl.) SHALL HAVE FOR OUR (incl.) GRANDMOTHER [for incorporations of this type, see Michelson, *Am. Anthropologist*, N. S., XV, p. 474 ff.; *ō-*, 45 at end; *-i-*, 20; *wī-* as above]. Evidently the endings of the interrogative participial bear a relation to those of the interrogative conjunctive similar to that which the terminations of the ordinary participial [33] do to those of the ordinary conjunctive [29], as is shown by the terminal [a] of the former as compared with the terminal [i] of the latter. The participial character of the forms under discussion is furthermore guaranteed by the occurrence of the characteristic change in the stem-vowel. Unfortunately it has not been possible thus far to obtain a complete series either from texts or by direct questions.

ECONOMICS.—*An objective standard of value derived from the principle of evolution,—I.* ALFRED J. LOTKA. Communicated by G. K. BURGESS.

Value primarily subjective and personal; definition. Any possessable quantity which has properties rendering it *desirable to an individual A* is said to have value *for that individual.* Value has thus primarily a subjective and personal connotation.

Elimination of the personal element. As members of one biological species all men resemble each other more or less closely in their tastes. Hence, a commodity which has value for one individual has, as a rule, a somewhat similar value for other individuals also. In a community in which a variety of goods are offered for sale, the price obtainable on the open market depends not upon the value set upon them by any one individual, but by a group of individuals, the potential purchasers. Value in such case, while still subjective, is no longer a purely personal matter.

Objective basis of subjective value. But we may go a step further. While value is primarily a subjective attribute attached to certain things by an individual, or by a group of individuals, we may naturally expect that it should have an objective basis, just as the subjective sensation "red," for example, has an objective basis in light of a wavelength of about 6.6 to 0.10^{-4} mm.

Indeed, this is not merely a matter of conjecture, but follows as an inevitable consequence of natural law. This is very clearly brought out in a passage in Spencer's *The Data of Ethics* (section 34), which at the same time exposes the nature of the objective basis of value. For, remembering that a thing "valued" is by our definition a thing *desired*, i.e., a thing whose possession gives pleasure or allays pain, we can apply directly to value the argument of Spencer with regard to pleasure and pain:

. . . . necessarily, throughout the animate world at large, pains are the correlatives of actions injurious to the organism, while pleasures are the correlatives of actions conducive to its welfare, since it is an inevitable deduction from the hypothesis of evolution, that races of sentient creatures could have come into existence under no other conditions.

If we substitute for the word Pleasure the equivalent phrase—a feeling which we seek to bring into consciousness and retain there, and if we substitute for the word Pain the equivalent phrase—a feeling which we seek to get out of consciousness and to keep out: we see at once that if the states of consciousness which a creature endeavors to maintain are the correlatives of injurious actions, and if the states of consciousness which it endeavors to expel are the correlatives of beneficial actions, it must quickly disappear through persistence in the injurious and avoidance of the beneficial. In other words, those races of beings only can have survived, in which, on the average, agreeable or desired feelings went along with activities conducive to the maintenance of life, while disagreeable and habitually avoided feelings went along with activities directly or indirectly destructive of life; and there must ever have been, other things equal, the most numerous and long-continued survivals among races in which these adjustments of feelings to actions were the best, tending ever to bring about perfect adjustment.[1]

[1] The same thought is expressed by Frederic Lyman Wells (Journ. Abnormal Psychology, October-November, 224, 1913): "Organisms tend, in the most multiform ways, to all sorts of activities that result in pleasure. These activities usually, but not necessarily, run parallel to those resulting in the objective advancement of the organism or its species; . . . . We do not clearly know the

We see, then, that, *as a general rule*, things (including actions) valued must be things beneficial to the individual and the race. The modification *as a general rule* is necessary, owing to the fact that the *perfect adjustment* of the individual to his environment has not yet been brought about.

These reflections give us the key to a quantitative and objective measure of value: Relative to a given community, let us call those the *true* or *objective* values $\mathbf{v}_1\ \mathbf{v}_2\ \ .\ \ .\ \ .$ of commodities $A_1\,A_2\ \ .\ \ .\ \ .$, the adoption of which by the community would make the adjustment of feelings to actions perfect, and would therefore, in Spencer's words, make "survivals most numerous." Let us see just what this implies.

Distribution of labor in several activities. In the mathematical development of the concept of objective value defined above, I will take for my basis a modification of the treatment applied by W. Stanley Jevons[2] to the discussion of the distribution of labor in the production of several commodities. Following, then, in the main, the line of argument given by Jevons, we consider a representative individual, who has the choice of distributing his energies as follows:

Let labor L_1 per unit of time be spent in the production of mass m_1 per unit of time of a commodity A_1, with a marginal productivity $\dfrac{dm_1}{dL_1} = p_1$, and with a concomitant production of fatigue f_1 per unit of time with a marginal productivity $\dfrac{df_1}{dL_1} = p'_1$. Similarly, let labor L_2 per unit of time be spent in the production of mass m_2 per unit of time of a commodity A_2, etc.

The individual considered, whom we suppose to reap the benefits of his activity by consuming the products thereof,[3] seeks to make the total pleasure of his activities a maximum. If $\omega_1 dm_1$

rôle of the hedonic factor in determining the reaction, but natural selection would, of course, tend to the survival of those organisms in which the hedonic and beneficial factors were best combined."

[2] W. S. Jevons, The Theory of Political Economy, 183. 1911.

[3] This supposition is tacitly implied, though not explicitly stated, in the development given by Jevons, *loc. cit.*

is the additional pleasure[4] derived from the consumption per unit of time of a small increment dm_i of the commodity A_i, and if $\omega'_i\, df_i$ is the additional pleasure (negative in this case, i.e., pain) derived from the concomitant production per unit of time of a small increment df_i of fatigue per unit of time incurred in the corresponding increment dL_i of labor per unit of time, then the total additional pleasure $d\,\Omega$ derived from the production and consumption per unit of time of the increments dm_1, dm_2 . . . . of commodities A_1, A_2 . . . is given by

$$\begin{aligned} d\,\Omega = {} & \omega_1\, dm_1 + \omega_2\, dm_2 + \dots \\ & + \omega'_1\, df_1 + \omega'_2\, df_2 + \dots \end{aligned} \tag{1}$$

Case 1. We shall consider first the simple case in which ω_1 is a function of m_1 only, ω_2 of m_2 only, etc.; i.e. the pleasure of production and consumption of any one commodity depends only on the amount of that particular commodity produced and consumed per unit of time, and is independent of the production and consumption of other commodities. In that case we can write[5]

$$\left.\begin{aligned} \omega_1 &= \frac{\partial\Omega}{\partial m_1} \qquad \omega_2 = \frac{\partial\Omega}{\partial m_2} \quad \dots\dots \\ \omega'_1 &= \frac{\partial\Omega}{\partial f_1} \qquad \omega'_2 = \frac{\partial\Omega}{\partial f_2} \quad \dots\dots \end{aligned}\right\} \tag{2}$$

and

$$\left.\begin{aligned} d\Omega = {} & \frac{\partial\Omega}{\partial m_1} p_1\, dL_1 + \frac{\partial\Omega}{\partial m_2} p_2\, dL_2 + \dots\dots \\ & + \frac{\partial\Omega}{\partial f_1} p'_1\, dL_1 + \frac{\partial\Omega}{\partial f_2} p'_1\, dL_2 + \dots\dots \end{aligned}\right\} \tag{3}$$

The condition for a maximum of the total pleasure Ω is evidently that the right hand member of (3) shall vanish for all arbitrary values of dL_1, dL_2 . . . . . , or

[4] ω_i is the marginal ophelimity of commodity A_i. (Pareto, Manuel d'Economie Politique, 556. 1909.)

[5] The function Ω defined by equations (2) and (3) measures total ophelimity. (Pareto, *loc. cit.*)

$$\frac{\partial\Omega}{\partial m_1} p_1 + \frac{\partial\Omega}{\partial f_1} p'_1 = \frac{\partial\Omega}{\partial m_2} p_2 + \frac{\partial\Omega}{\partial f_2} p'_2 = \quad . \quad . \quad . \quad . \quad = 0 \tag{4}$$

The unit of labor per unit of time has so far been left undefined. Condition (4) assumes a particularly simple form, if we agree to measure labor (per unit of time) by the degree of discomfort which it causes.[6] In that case

$$\frac{\partial\Omega}{\partial f_i} p'_i = \frac{\partial\Omega}{\partial f_i} \cdot \frac{df_i}{dL_i} = -1 \tag{5}$$

for all subscripts i, so that condition (4) here resolves itself into a set of equations

$$\left.\begin{aligned} &\frac{\partial\Omega}{\partial m_1} p_1 = \frac{\partial\Omega}{\partial m_1} p_2 = \quad . \quad . \quad . \quad . \\ = -&\frac{\partial\Omega}{\partial f_1} p'_1 = -\frac{\partial\Omega}{\partial f_2} p'_2 = \quad . \quad . \quad . \quad . \quad = 1 \end{aligned}\right\} \tag{6}$$

The ophelimities Ω_1, Ω_2 . . . are not capable of direct measurement. However, in the case of open competition (entire absence of monopolies), which is the only case to which Jevons' treatment and that here given applies, the ophelimities can be measured indirectly, since they are here proportional to the "values in exchange" v_1, v_2 . . . . of commodities A_1, A_2 . . . . , i.e.,

$$\frac{\partial\Omega}{\partial m_1} : \frac{\partial\Omega}{\partial m_2} : \quad . \quad . \quad . \quad :: v_1 : v_2 : \quad . \quad . \quad . \tag{7}$$

or

$$v_1 = k\frac{\partial\Omega}{\partial m_1} \qquad v_2 = k\frac{\partial\Omega}{\partial m_2} \qquad \text{etc.} \tag{8}$$

Introducing (8) into (6), we have

$$v_1 \; p_1 = v_2 \; p_2 = \; . \; . \; . \tag{9}$$

[6] In Jevons' treatment this assumption is implied in the words: (the) "amount of feeling dL_1, the increment of labor . . . . " *loc. cit.*, 185.

or, since the price P of a commodity is proportional to its "value in exchange,"[7]

$$P_1 p_1 = P_2 p_2 = \quad . \; . \; . \qquad (10)$$

Equations (6) and (9) or (10) are those derived by Jevons by a somewhat different process. This set of equations determines a certain definite distribution of labor when the values of ω, ω' and p and p' are given for each commodity and form of fatigue—and this is as far as Jevons carries the discussion of the problem.

For our present purposes the equations thus arrived at serve merely as a starting point on which to base our investigation. Jevons assumes certain characteristics ω, ω', p, p', of the representative individual as given, and determines the distribution of labor which follows from such a set of characteristics. We, discussing the case from the point of view of evolution, are interested in the effect produced by variations in these characteristics.

Let us examine, from this standpoint, the basic equations (3) and (4). These equations clearly bring out the fact that the distribution of labor in several pursuits depends, for a given type of individual, on two kinds of factors:

1. On the productivity of labor in different pursuits, or, as we may express it in closer harmony with our present point of view, on the productive "*efficiency*" of the representative individual in different kinds of labor. Thus, in particular, it is obvious that if, other things remaining equal, all the efficiencies p are increased, the total amount of commodities produced and thus rendered available for consumption will be increased. Normally this will bring with it a rise in the rate of increase of the community or race, i.e. a better adaptation of the race to its environment, or greater "*fitness.*"

2. On the other hand, given a certain set of values of the productivities or efficiencies p, the distribution of labor will depend on the values which the individual sets upon the several commodi-

[7] *Loc. cit.* pp. 184, 186, 187. In place of the prices $P_1 P_2$ . . Jevons introduces into equation (10) the quantities Q_1, Q_2 of the several commodities interchangeable on the market. These quantities Q are of course inversely proportional to the prices P.

ties, i.e., it will depend on the ω and ω'. There is evidently some particular set of ω, ω' which will give the best result, or the optimum adaptation, and any departure therefrom represents an "error in the judgment of values" on the part of the individual characterized by the "faulty" set of ω, ω'. Thus, for example, the drunkard sets an exaggerated value ω_a upon alcohol, and allows too great a proportion of his labor (earnings) to be spent upon this item. The lazy man has an exaggerated sense of the (negative) value of fatigue ω' in various pursuits, and does not accomplish as much as would be most advantageous for his welfare. On the other hand, there are over-energetic persons, who attach too small a (negative) value to fatigue, and who, disregarding the warnings of nature, continue to work when the benefits reaped are eclipsed by the physical injury incurred. And yet again there are ill-balanced enthusiasts, for whom the mere activity in certain pursuits has such attraction (ω' being in this case positive even for considerable values of f), that they have not the requisite time and energy left to provide adequately for the necessities of life. Our sense of fatigue is given us in order that we may strike the proper balance in these things, and evidently there is some set of ω, ω', which would give the best results, steering a median course between indolence on the one hand, and excessive, injurious application on the other.

To recapitulate, we note that the "fitness" of a species, i.e., its adaptation to existing conditions, depends, other things being equal, upon the manner in which it distributes its labor, its efforts, among its different activities. There is evidently, in general, some particular distribution which results in an optimum benefit, which represents an optimum adaptation. That optimum will be reached only when the "sense of value" of the individuals is perfect, or, as we may express it, when they value things (and actions) at their "*true*" or "objective" value. Conversely, we may turn the argument around, and draw from it the definition of the "true" or "objective" value of a commodity: We thus arrive at the following, which is a slightly modified statement of the definition provisionally laid down on p. 411:

Definition. Relative to a given species, those are the true or objective values v_1, v_2 . . . of commodities A_1 A_2 . . . , the adoption of which by the species would make the adjustment of feelings to actions perfect, or, in other words, would make the rate of increase of the species, under existing conditions, a maximum.

This definition now enables us to obtain directly a mathematical expression for the "objective values" of a set of commodities. For if, as before, the representative individual has the choice of distributing his energies in the production of commodities A_1, A_2 . . . , and if r is the rate of increase per head and per unit of time, of the species, the distribution of labor leading to a maximum rate of increase of the species is given by

$$\left\{\frac{\partial r}{\partial m_1}\frac{dm_1}{dL_1}+\frac{\partial r}{\partial f_1}\frac{df_1}{dL_1}\right\}dL_1+\left\{\frac{\partial r}{\partial m_2}\frac{dm_2}{dL_2}+\frac{\partial r}{\partial f_2}\frac{df_2}{dL_2}\right\}dL_2+\ .\ .\ .\ .\ =0 \quad (11)^{8}$$

for all arbitrary values of dL_1 dL_2 . . . .

But if we denote by

$$v_1=k\bar{\omega}_1=k\frac{\partial\bar{\Omega}}{\partial m_1},\ v_2=k\bar{\omega}_2=k\frac{\partial\bar{\Omega}}{\partial m_1},\ .\ .\ .\ . \quad (12)$$

the true values in exchange of commodities A_1, A_2 . . . , that is to say, those which would prevail if the individuals had a perfect sense of values; and if we similarly denote by

$$v'_1=k\bar{\omega}'_1=k\frac{\partial\bar{\Omega}}{\partial f_1},\ v''_2=k\bar{\omega}'_2=k\frac{\partial\bar{\Omega}}{\partial f_2},\ .\ .\ .\ . \quad (13)$$

the true values (in exchange) of fatigue f_1, f_2 . . . , then by our definition of "true value," the same distribution as defined by (11) must also be given by

$$\left\{\frac{\partial\bar{\Omega}}{\partial m_1}\frac{dm_1}{dL_1}+\frac{\partial\bar{\Omega}}{\partial f_1}\frac{df_1}{dL_1}\right\}dL_1+\left\{\frac{\partial\bar{\Omega}}{\partial m_2}\frac{dm_2}{dL_2}+\frac{\partial\bar{\Omega}}{\partial f_2}\frac{df_2}{dL_2}\right\}dL_2+\ .\ .\ .\ =d\bar{\Omega}=0 \quad (14)$$

for all arbitrary values of dL_1, dL_2, etc., equation (14) being simply a special case of equations (3) and (4).

[8] It is here assumed that $\frac{\partial r}{\partial m_1}$ is a function of m_1 only, $\frac{\partial r}{\partial m_2}$ a function of m_2 only, etc. The more general case where this is not the case will be considered later.

Now equations (11) and (14) are satisfied by the same values of $m_1, m_2, \ldots, f_1, f_2, \ldots$, provided that

$$\frac{\partial r}{\partial m_1} p_1 = \frac{\partial r}{\partial m_2} p_2 = \ldots = -\frac{\partial r}{\partial f_1} p'_1 = -\frac{\partial r}{\partial f_2} p'_2 = \ldots \quad (15)$$

$$\left.\begin{aligned} &= F(\bar{\Omega}) \frac{\partial \bar{\Omega}}{\partial m_1} p_1 = F(\bar{\Omega}) \frac{\partial \bar{\Omega}}{\partial m_2} p_2 = \ldots \\ &= -F(\bar{\Omega}) \frac{\partial \bar{\Omega}}{\partial f_1} p'_1 = -F(\bar{\Omega}) \frac{\partial \bar{\Omega}}{\partial f_2} p'_2 = \ldots \end{aligned}\right\} \quad (16)$$

where $F(\bar{\Omega})$ is an arbitrary function of $\bar{\Omega}$.

We may conveniently select for the function F the form

$$F(\bar{\Omega}) = \text{constant} = 1 \quad (17)$$

Then we have by (12), (13), (15), (16):

$$\mathbf{v}_1 : \mathbf{v}_2 : \ldots : \mathbf{v}'_1 \mathbf{v}'_2 : \ldots :: \frac{\partial r}{\partial m_1} : \frac{\partial r}{\partial m_2} : \ldots : \frac{\partial r}{\partial f_1} : \frac{\partial r}{\partial f_2} : \ldots \quad (18)$$

or

$$\mathbf{v}_1 = k' \frac{\partial r}{\partial m_1}, \ \mathbf{v}_2 = k' \frac{\partial r}{\partial m_2}, \ \ldots\ldots, \ \mathbf{v}'_1 = k' \frac{\partial r}{\partial f_1} \quad (19)$$

where k' is an arbitrary constant which appears wherever we are dealing with values in exchange, and the signification of which is that the choice of one commodity as standard of reference always remains arbitrary. In the present case it will be most convenient to fix the value of the constant k' arbitrarily by putting

$$k' = 1 \quad (20)$$

The value of the constant k which appears in equations (12) and (13) depends on the units employed in measuring marginal ophelimities. It will be simplest to measure these directly by the corresponding values in exchange, in which case we have

$$k = 1 \quad (21)$$

We have then for the "true" values in exchange and for the corresponding "ideal" ophelimities (i.e. those attached to the several commodities by an individual with a perfect sense of values) the simple relation

$$\mathrm{v}_j = \frac{\partial \bar{\Omega}}{\partial m_j} = \bar{\omega}_j = \frac{\partial r}{\partial m_j}, \quad \mathrm{v}'_J = \frac{\partial \bar{\Omega}}{\partial f_J} = \bar{\omega}'_J = \frac{\partial r}{\partial f_J} \tag{22}$$

for all values of j and J.

Thus our problem is solved for the special case here considered: We have found a mathematical expression for the numerical measure of the "true" or "objective" values of a set of commodities. The "true" value (per unit of mass) of a given commodity A_j, when the rate of consumption is m_j units of mass per head per unit of time, is the partial differential coefficient $\frac{\partial r}{\partial m_j}$ of the rate of increase r per head of the species, taken with regard to m_j.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOCHEMISTRY.—*The composition of crinoid skeletons.* F. W. Clarke and W. C. Wheeler. U. S. Geological Survey Professional Paper 90–D. Pp. 5. 1914.

This investigation relates to the formation of marine sediments and, therefore, of sedimentary rocks. A single group of existing organisms was studied, namely the crinoids, and their contribution to the sediments was established. The material was furnished by Mr. Austin H. Clark, of the U. S. National Museum, and consisted of 24 specimens representing 21 distinct genera, with a range of habitat from northern Japan to the shores of the Antarctic Continent. All of the crinoid skeletons consisted of calcium and magnesium carbonates, with minor impurities, and the proportion of $MgCO_3$ ranged from 7.28 to 12.69 per cent. The crinoids, therefore, contribute notable quantities of magnesia to the marine sediments. The proportion of magnesia, however, varied remarkably with temperature. The crinoids from high latitudes ran lowest in $MgCO_3$; those from warm regions ran highest; the variation being curiously regular. So far as the authors are aware, a regularity of this order, which they do not attempt to explain, has never been observed before.

Ten fossil crinoids, ranging from the Ordovician to the Eocene were also analyzed. These showed no regularities whatever, for they had evidently been much altered by leaching, and by the infiltration of foreign material. F. W. C.

GEOLOGY.—*Reconnaissance of the Grandfield district, Oklahoma.* M. J. Munn. U. S. Geological Survey Bulletin 547. Pp. 83, with maps, views and sections. 1914.

The Grandfield district embraces about 360 square miles in southern Oklahoma, including the southeastern part of Tillman County and the southwestern part of Cotton County, and is drained by Red River. The interstream areas are a smooth, slightly undulating, treeless prairie, into which the smaller streams have cut very slightly except near their mouths. The notable features of the topography are (1) the broad, smooth surfaces, (2) a few low, round, isolated hills adjacent to the divides, preserved by a capping of more resistant rocks, and (3) the many large "breaks" or washes similar in character to the well-known badlands of other portions of the West.

The lowest outcropping rocks in the Grandfield district are "Red Beds" of Permian age. There are relatively few data about the underlying rocks in this district, and these come from several deep oil and gas well records. The facts indicate that the upper portion of unexposed beds is of Permian age and that this series is underlain by older Carboniferous beds of the Pennsylvanian series.

In most of the Grandfield district the hard rocks are hidden beneath a surficial mantle of loose, unconsolidated material consisting of: (1) Dune sand, spread over a broad belt adjacent to Red River; (2) a dark or reddish sandy to clay soil, largely wind-blown, covering most of the smooth slopes of the interstream areas; and (3) a red clay-silt alluvium found in the broad, flat valleys of Deep Red Run and its tributaries. Beneath this thin veneer of Quaternary beds, exposed in many places in breaks and along the valley sides, lies a thin bed of coarse, hard quartz-lime conglomerate (here named the Grandfield conglomerate), very persistent and rarely exceeding five feet in thickness, which has been variously classified as of Quaternary or of late Tertiary age. It is underlain unconformably by "Red Beds" of Permian age which are correlated with the Wichita formation of northern Texas.

The most important structural feature recognized in the district is a low anticline that crosses it in a sinuous line trending generally east-southeast and west-northwest. Along the axis of this anticline lie a number of small elongated domes that are separated by low structural saddles. The rocks over the entire district generally dip eastward, and the dip is shown in the height of this anticline. The axis of this fold dips from an elevation of about 1,160 feet at the western side of the district to about 1,040 feet at its eastern edge, a distance of about 24 miles.

Another important structural feature of this district is a broad flat syncline or structural trough which lies north of and roughly parallel to the anticline. The axis of this fold pitches slightly toward the east, but is somewhat modified by one or two shallow basins.

In the location of oil pools from geologic examinations of the surface, structure is the one factor, of the several controlling the accumulation of oil, which can be determined. Other important factors are: (1) The thickness, number, and positions of beds which contain or have contained the organic material from which the oil and gas were derived; (2) the stratigraphic relation of beds carrying salt water to those in which the oil and gas originated; (3) the thickness, variability, and stratigraphic positions of porous lenses, or irregular beds of sand, that may serve as reservoirs; and (4) the structural changes through which these beds have passed since they were deposited. The effectiveness of the combination of these various factors in the production of oil pools in any given locality can be determined only by the drill, but drilling is to be undertaken only in localities at which the structure is favorable.

The old anticlinal theory based on the idea that oil and gas accumulations are due to differences in the specific gravity of gas, oil, and salt water, seems inadequate to explain the facts as observed. It is believed by the author that the accumulation of oil and gas in pools is due to the action of large bodies of water moving under both hydrostatic and capillary pressure. C. H. Wegemann.

GEOLOGY.—*Erosion and sedimentation in Chesapeake Bay around the mouth of Choptank River.* J. Fred. Hunter. U. S. Geological Survey Professional Paper 90–B. Pp. 7–15, with map and figure. May 23, 1914.

This work is a result of a comparison of a small portion of two separate topographic and hydrographic surveys of the Chesapeake Bay made by the United States Coast and Geodetic Survey, one in 1847–48, and a second, over a half century later, in 1900–01. A third supplementary topographic survey of a part of the area studied was made in 1910 by the author and C. C. Yates. It is demonstrated that very significant changes, both in the topography and in the hydrography of the region, have taken place, and quantitative data on the amount and rate of erosion and sedimentation in a representative area of the bay are presented.

The three islands at the mouth of Choptank River are being rapidly cut away and Sharps Island, whose north end has suffered a loss of 110 feet per year during the last ten years, will probably be entirely effaced before 1950. Practically all the erosion has been on the west and north sides of the islands; that is, on the shores which are most open to the attack of the southerly bay currents and the westerly winds and their waves.

In general, the cutting has been greatest along the shores having low scarps made up of the clays and marls of the Talbot formation, and least along those of the low-lying tidal marshes.

A study of the submarine changes shows rather extensive scouring along the eastern shore of the bay and less extensive, though equally intensive, shoaling at places within the river mouth. A further and more extensive study involving the entire bay and its tributary basins is suggested. J. F. H.

GEOLOGY.—*Dike rocks of the Apishapa quadrangle, Colorado.* WHITMAN CROSS. U. S. Geological Survey Professional Paper 90–C. Shorter contributions to general geology, 1914. C. Pp. 17–31, 4 plates. 1914.

The Apishapa quadrangle is situated on the plains south of Arkansas River, in Colorado, about twenty-four miles east of the mountain front. The geological map of this area in the Apishapa folio, by G. W. Stose, shows forty-three dikes which trend nearly west. These are a part of a great system of radial dikes, with associated sills, which surround the Spanish Peaks, an eruptive center situated twenty-five miles southwest of the border of the quadrangle.

The rocks of Apishapa quadrangle are all lamprophyric in character and are described under the names minette, augite minette, olivine-bearing augite vogesite, hornblende-augite vogesite, olivine-plagioclase basalt, and sodic diabase. The series to which they belong has a much greater range than this. Chemical analyses are given of four of the principal types, and photomicrographs illustrate the textures of three of the analyzed rocks.

These dike rocks are of types which are not commom in Colorado nor, indeed, in any part of the world. The full significance of their interesting characters can not be determined until the great series of dikes about the Spanish Peaks has been more thoroughly studied.

The analyzed rocks of the Apishapa quadrangle illustrate very forcibly the fact that magmas of the same chemical composition may produce rocks of notably different mineral composition under the influence of different conditions of consolidation. This is brought out by tables of analyses and norms. The vogesites (orthoclase rocks) are nearly identical chemically with rocks which have been called feldspar basalt, essexite, nephelite basanite, trachydolerite, etc. The incongruities of a purely mineralogical classification of such rocks are discussed. W. C.

GEOLOGY.—*Geology of the Standing Rock and Cheyenne River Indian reservation, North and South Dakota.* W. R. CALVERT, A. L. BEEKLY, W. H. BARNETT, AND MAX A. PISHEL. U. S. Geological Survey Bulletin 575. Pp. 49, with maps, sections, and illustrations. 1914.

Aside from the surficial deposits the geologic formations which outcrop in the Standing Rock and Cheyenne River Indian reservations are the Pierre shale and the Fox Hills, of Upper Cretaceous age, the Lance, probably of lower Tertiary age, and the Fort Union formation, definitely assigned to the last-named epoch. The Fox Hills rest conformably on the Pierre and no definite line can be drawn between the two formations. There is in most places, however, an abrupt lithologic change from the Fox Hills to the Lance formation, and locally the contact between the two is marked by a decided unconformity; but it is still an open question whether or not this unconformity represents a long-time break. The surficial deposits consist of scattered striated boulders and small patches of glacial gravel, of early Pleistocene age, and terrace gravel and alluvial valley filling, which were deposited later. The Cretaceous and Tertiary strata dip gently in a northwesterly direction at about 5 feet per mile. M. A. P.

PALEONTOLOGY.—*Cambrian Geology and Paleontology, III, No. 1.—The Cambrian faunas of Eastern Asia.* CHARLES D. WALCOTT. Smithsonian Miscellaneous Collections **64**[1]: 1–75, pls. 1–3. April 22, 1914.

This paper is essentially a resumé of the publications of the Carnegie Institution dealing with the Cambrian formations of Eastern Asia. In condensed and easily accessible form are placed the essential facts in regard to the stratigraphy and paleontology of the Cambrian in this area.

A historical review of the work on Cambrian geology in Eastern Asia is given. The account of the collections made by the Carnegie Expedition and by Professor Iddings is very full. Numerous sections, faunal lists, and correlation tables are furnished, and the various pre-Cambrian, Cambrian, and Ordovician formations are briefly described. Of special interest is the discussion as to the possible continental origin of the pre-Cambrian sediments, and of the relation of the Cambrian to the Ordovician. A general review of the Lower, Middle, and Upper Cambrian faunas is given, and broad correlations with extra-Asiatic faunas are made.

A new trilobite genus, Tsinania, is described, having as its genotype *Illaenurus canens* Walcott. EDWIN KIRK.

BOTANY.—*Classification of the genus Annona with descriptions of new and imperfectly known species.* W. E. SAFFORD. Contributions from the U. S. National Herbarium **18:** 1–68, pls. 1–41, text figs. 1–75. June 17, 1914.

This paper presents a synoptical view of the genus Annona by natural groups and sections, together with descriptions of two closely allied genera, Fusaea and Geanthemum, and critical notes upon Rollinia, Duguetia, and Raimondia.

Four groups of Annona are proposed: (1) the Guanabani, or soursops, including the sections Euannona, typified by *Annona muricata* L.; Psammogenia, typified by *A. salzmanni* A. DC.; Ulocarpus, typified by *A. purpurea* Moc. & Sessé; (2) the Pilaeflorae, or silky Annonas, including the sections Helogenia, typified by *Annona paludosa* Aubl.; Pilannona, typified by *A. sericea* Dunal; Gamopetalum, typified by *A. cornifolia* St. Hil.; (3) the Acutiflorae, or sharp-petaled Annonas, including Phelloxylon, typified by *Annona glabra* L.; Atractanthus, typified by *A. acutiflora* Mart.; (4) the Attae, the custard-apples, composed of the sections Chelonocarpus, typified by *Annona scleroderma* Safford; Atta, typified by *A. squamosa* L.; Ilama, typified by *A. diversifolia* Safford; and Saxigena, typified by *A. bullata* A. Rich.; (5) the Annonellae, or dwarf Annonas, including the sections Annonula, typified by *Annona cascarilloides* Wright, of Cuba; and Annonella, typified by *A. globiflora* Schlecht., of Mexico. In these sections the relationship between the species is shown in some cases by peculiarities of leaf structure, in others by the structure of the stamens or form of the flower, and in still others by peculiarities of the fruit and seed. Some of the sections are more sharply defined than others.

The following new species are described: *Annona jahni*, *A. lutescens*, *A. palmeri*, *A. crassivenia*, *A. sclerophylla*, *A. rosei*. Detailed figures are given of *A. montana* Macf., *A. sphaerocarpa* Splitg., *A. marcgravii* Mart., *A. salzmanni* A. DC., *A. purpurea* Moc. & Sessé, (including *A. manirote* H.B.K.) *A. involucrata* Baill., *A. paludosa* Aubl., *A. cornifolia* St. Hil., *A. nutans* R. E. Fries, *A. acutiflora* Mart., *A. longiflora* S. Wats., *A. macroprophyllata* Donn. Sm., *A. bullata* A. Rich., *A. cascarilloides* Wright, *A. globiflora* Schlect., and *A. bicolor* Urban, many of these having never before been figured.

Under the heading "Plants originally described under Annona but generically distinct" the author describes the genera Rollinia, Duguetia and Raimondia, already established, and proposes Fusaea and Geanthemum as new genera. Under Duguetia he points out the differences which separate this genus from Aberemoa of Aublet, which has been treated by R. E. Fries as a synonym, but which has pedicelled carpels more nearly like those of the genus Guatteria than like the crowded, angular, sessile carpels of Duguetia.

In the preparation of this paper the author has been fortunate in securing the loan of abundant material from the Berlin Herbarium and the De Candolle Herbarium, including several types of Humboldt, Bonpland and Kunth, and of Ruiz and Pavon. A critical study of these has shown that *Annona conica* Ruiz & Pavon is identical with *A. quinduensis* H.B.K., and that these plants must be placed in the recently established South American genus Raimondia, under the name *R. quinduensis*; and that *A. rhombipetala* Ruiz & Pavon is very closely allied if not identical with *A. longifolia* Aubl., which becomes the type of the new genus Fusaea. This plant was already set apart as a distinct section by Baillon, who placed it in the genus Duguetia, with which it has little real affinity. The present author therefore does not hesitate to raise Baillon's section Fusaea to generic rank. For similar reasons he establishes also the new genus Geanthemum (based upon R. E. Fries's section of that name) with two South American species and points out the close affinity of these to *Uvaria sessilis* Velloso, which Martius erroneously regarded as identical with *Duguetia bracteosa* Mart. W. E. S.

REFERENCES

Under this heading it is proposed to include, by author, title, and citation, references to all scientific papers published in or emanating from Washington. It is requested that authors coöperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

GEODESY

BOWIE, W., and AVERS, H. G. *Fourth general adjustment of the precise level net in the United States, and the resulting standard elevations.* Coast and Geodetic Survey Special Publication No. 18. Pp. 328, 4 plates, 1 map. 1914.

FARIS, R. L. *Results of magnetic observations made by Coast and Geodetic Survey, July 1, 1911–December 31, 1912.* Coast and Geodetic Survey Special Publication No. 15. Pp. 102. 1913.

MOURHESS, C. A. *Triangulation on coast of Texas, from Sabine Pass to Corpus Christi Bay.* Coast and Geodetic Survey Special Publication No. 17. Pp. 89, 1 plate, 18 maps. 1913.

SWICK, C. H. *Triangulation along west coast of Florida.* Coast and Geodetic Survey Special Publication No. 16. Pp. 147, 1 plate, 28 maps. 1913.

PALEONTOLOGY

BERRY, E. W. *A fossil flower from the Eocene.* Proceedings of the U. S. National Museum **45**: 261–263, pl. 21, text fig. 1. June 13, 1913. (Describes the new genus Combretanthites, with a single member, *C. eocenica*, sp. nov.—W. R. M.)

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SHUFELDT, R. W. *Extinct ostrich birds of the United States.* Aquila **20**: 411–422, pls. 1–5. 1913.

SHUFELDT, R. W. *Review of the fossil fauna of the desert region of Oregon, with a description of additional material collected there.* Bulletin of the American Museum of Natural History **32**: 123–178, pls. 9–43. July 9, 1913.

MAMMALOGY

GOLDMAN, E. A. *Descriptions of five new mammals from Panama.* Smithsonian Miscellaneous Collections **63**[5]: 1–7. March 14, 1914. (Describes one new species each of Chironectes, Felis, Lonchophylla, Lutra, and Aotus.—N. H.)

GOLDMAN, E. A. *A new bat of the genus Mimon from Mexico.* Proceedings of the Biological Society of Washington **27**: 75, 76. May 11, 1914. (Describes *Mimon cozumelae*, sp. nov., from Cozumel Island, Yucatan.—N. H.)

GOLDMAN, E. A—*The status of* Cebus imitator *Thomas.* Proceedings of the Biological Society of Washington **27**: 99. May 11, 1914. (Two forms of Cebus are recognized in Panama. The western form takes the name *Cebus capucinus imitator*.—N. H.)

Goldman, E. A. *The status of certain American species of Myotis.* Proceedings of the Biological Society of Washington **27**: 102. May 11, 1914. (*Myotis volans* H. Allen is recognized as a valid species, with *Myotis capitaneus* Nelson and Goldman as a synonym.—N. H.)

Hollister, N. *A review of the Philippine land mammals in the United States National Museum.* Proceedings of the U. S. National Museum **46**: 299–341, pls. 27–29. December 31, 1913. (Lists the 1,454 specimens of Philippine mammals in the U. S. National Museum collection, with critical notes, and describes eighteen new species from the archipelago.—N. H.)

Hollister, N. *A new name for the marmot of the Canadian Rockies.* Science, n. s., **39**: 251. February 13, 1914. (Proposes the name *Marmota oxytona*, to replace *M. sibila*, preoccupied.—N. H.)

Hollister, N. *Four new neotropical rodents.* Proceedings of the Biological Society of Washington **27**: 57–60. March 20, 1914. (Describes new forms of Proechimys, Myocastor, Lagostomus, and Hydrochoerus.—N. H.)

Hollister, N. *Four new mammals from tropical America.* Proceedings of the Biological Society of Washington **27**: 103–106. May 11, 1914. (Describes new forms of Philander, Nectomys, and Cebus.—N. H.)

Howell, A. H. *Ten new marmots from North America.* Proceedings of the Biological Society of Washington **27**: 13–18. February 2, 1914. (New subspecies of *Marmota monax*, *M. flaviventer*, and *N. caligata* are described.—N. H.)

Howell, A. H. *Notes on the skunks of Indiana, with a correction.* Proceedings of the Biological Society of Washington **27**: 100. May 11, 1914. (All records of *Mephitis mesomelas avia* from Indiana, except one from near the Illinois boundary, prove to refer to *M. mephitis putida*.—N. H.)

Jackson, H. H. T. *New moles of the genus Scalopus.* Proceedings of the Biological Society of Washington **27**: 19–22. February 2, 1914. (Describes a new species from Mexico, and four new subspecies from the United States.—N. H.)

Jackson, H. H. T. *New moles of the genus Scapanus.* Proceedings of the Biological Society of Washington **27**: 55, 56. March 20, 1914. (Describes two new subspecies: *Scapanus latimanus sericatus* and *S. latimanus grinnelli*, both from California.—N. H.)

Mearns, E. A. *Descriptions of three new raccoons from the Mexican boundary region.* Proceedings of the Biological Society of Washington **27**: 63–68. March 20, 1914. (*Procyon lotor fuscipes*, *P. lotor ochraceus*, and *P. lotor californicus* are described as new.—N. H.)

Mearns, E. A. *The earliest systematic name for the tuoza, or Georgia pocket gopher.* Proceedings of the Biological Society of Washington **27**: 102. May 11, 1914. (*Mus tuza* dates from Barton, 1806, not from Ord, 1815.—N. H.)

Miller, G. S., jr. *Notes on the bats of the genus Molossus.* Proceedings of the U. S. National Museum **46**: 85–92. August 23, 1913. (A synopsis of the forms of this genus, with descriptions of two new species, *Molossus fortis* and *M. debilis*.—N. H.)

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ORNITHOLOGY

Clark, A. H. *A new race of the mandarin duck from southern Japan.* Proceedings of the Biological Society of Washington **27**: 87. May 11, 1914. (Describes *Aix galericulata brunnescens*, subsp. nov.—C. W. R.)

Mearns, E. A. *Description of six new African birds.* Smithsonian Collections **61**[11]: 1–5. August 30, 1913. (Describes 6 new subspecies, 5 of them belonging to the genus Cisticola.—W. R. M.)

Oberholser, H. C. *Four new birds from Newfoundland.* Proceedings of the Biological Society of Washington **27**: 43–54. March 20, 1914. (New subspecies are described as *Dryobates pubescens microleucus*, *Bubo virginianus neochorus*, *Perisoreus canadensis sanfordi*, and *Pinicola enucleator eschatosus*.—C. W. R.)

Oberholser, H. C. *A monograph of the genus* Chordeiles *Swainson, type of a new family of goatsuckers.* Bulletin 86, U. S. National Museum. Pp. i–vii, 1–123, pls. 1–5. April 6, 1914.

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GEOPHYSICS.—*Note on mean density of fractured rocks.* GEORGE F. BECKER, Geological Survey.

In connection with the theory of isostasy changes in the mean density of rocks deserve study. CHARLES BABBAGE long since called attention to the effects of temperature in this regard. Another source of change in density is rupture; for since there is every reason to believe that the elasticity of volume for crystalline solids is perfect, fissures in rocks represent voids, and diminish density so long as they remain unfilled by secondary deposition.

It is a familiar fact that orogenic movements are accompanied by extensive and minute fissuring as well as by folding and distortion; and it is well known also that in many instances what at first sight resembles plastic folding or contortion turns out on close inspection to have resulted from the crushing of a bed or layer under confinement. Many years ago I came to the conclusion that the residual, unfissured fragments in the Coast Ranges of California do not average larger than a hen's egg. Such crushing must of course convert a vast amount of energy into heat, and in my opinion Mallet's theories on this subject have not received the attention they deserve. Thermal effects, however, will not be discussed here, but only mechanical ones.

A rude approximation to what happens when a brittle bed under confinement is bent may be imagined. The first step will be the formation of not more than four systems of fissures dividing the mass into polyhedral fragments tightly pressed together. As flexure proceeds fragments will grind against one another, edges and corners being comminuted. It would seem probable that the original fragments would thus be more or less rounded, the interspaces becoming packed with attrition products. In this condition the mass would somewhat resemble a pile of cannon balls in close order filled in say with buckshot. Now the interstitial space in closely piled spheres of the same radius is 0.2595 and if this space be filled with relatively very small spheres the voids would be reduced to the square of the fraction just stated or to between 6 and 7 per cent. If the buckshot were mingled with fine birdshot the voids would be still further reduced.

But the amount of voids can be found much more satisfactorily by experiment. If a tube of soft metal is filled with sulphur, run in in a liquid state, the pipe can be bent cold without collapsing, while, since sulphur is very brittle, the filling of the tube must be reduced to powder, with an accompanying diminution of density. At my request Mr. A. F. Melcher has made some trials by this method which will be described in the next note. The results show that the voids increase with the flexure up to a limit very nearly corresponding to the forecast which apparently represents a maximum reduction of density through rupture.

Imagine a tabular mass of rock exposing a plane surface at sea level as wide and as long as a mountain range and extending to a depth of 120 km. Suppose it either to be unfissured or that any fissures once intersecting it had been solidly filled with vein minerals. Then suppose that by lateral horizontal forces the mass be crushed as the Coast Ranges and other ranges have been. There would be a tendency to diminish the cross sectional area, but it may be imagined that the reduced width is compensated by increased horizontal length. The result of the formation of voids through fracture must be upheaval and, if the voids amount throughout to 5 per cent, the elevation produced by these alone will average 6 kms. or say 20,000 feet.

It is thus evident that the diminution of density due to crushing is of the order of magnitude requisite to account for the variations of topography in a sense compatible with isostasy. If too the forces to which crushing is due do not vary with depth and if the rocks are equally brittle, the compensation will also be uniformly distributed, except perhaps very close to the surface.

If a mountain range were to form as here suggested, infiltration would begin at once and the range would grow heavier unless erosion at least counterbalanced infiltration. A very ancient range might be peneplained without disturbance of isostatic equilibrium; if erosion were to proceed pari passu with infiltration, but that being vastly improbable either a positive or a negative anomaly might be induced.

Far be it from me to assert that the formation of voids explains orogeny; but it appears to be a vera causa giving results of the order of magnitude demanded and to be worthy of consideration in tectonic theory.

GEOPHYSICS.—*Note on the change of density of sulphur with rupture.*[1] A. F. MELCHER, Geological Survey. Communicated by GEORGE F. BECKER.

At the suggestion of Dr. G. F. Becker a few determinations have been made on the change, through rupture, of the density of sulphur. Six trial specimens were prepared, brass tubes of two different lengths and three different diameters being filled with sulphur. After the density of the samples had been determined, they were bent as nearly into the form of a complete circle as could conveniently be done and then the density was determined a second time. The second determination of density compared with the initial determination gave the change in density due to the rupture of the sulphur in bending.

The preparation and filling of the tubes with sulphur were not as easy as at first it would seem. Three of the tubes were 9 inches long with an internal diameter of 0.6 inches. The other three tubes were 12 inches long and of two different diameters, two of the tubes having an internal diameter of 0.4 inches and the remaining tube an internal diameter of about 0.5 inches. The tubes were first annealed to insure easy bending without

[1] Published with the permission of the Director of the U. S. Geological Survey.

breaking. In one end of the tube a closely fitting brass plug about 0.4 inches long was soldered. Through this plug and the tube a pin was soldered, in order that the plug might withstand the pressure of the sulphur under rupture.

The tube and plug were then weighed and placed in an electric furnace and nearly filled with powdered sulphur. After the sulphur had melted it was stirred to eliminate air bubbles. The circuit was then broken and the sulphur allowed to crystallize. In the center of the column of sulphur was found a depression due to the fact that the density of sulphur increases on solidifying and that it crystallizes first on the sides of the tube. By again melting the sulphur at the top or by adding more sulphur and melting it, this depression was largely, if not wholly, eliminated. Sometimes this process had to be repeated, working gradually towards the top of the tube.

TABLE 1

	I	II	III	IV	V	VI
Weight of sulphur, grams	62.0683	62.7628	64.8365	42.3654	44.8448	64.9445
Vol. of sulphur, cc. (Density = 1.9)	32.67	33.03	34.12	22.30	23.60	34.18
Decrease in weight due to bending	1.6311	1.6884	1.9286	1.2434	1.7017	1.9532
Temperatures centigrade	23.4°	23.4°	23.4°	27.3°	28.1°	27.3°
Density of water at above temperatures	0.99747+	0.99747+	0.99747+	0.99646	0.99624	0.99646
Volume increase	1.6352	1.6927	1.9335	1.2478	1.7081	1.9601
Vol. of sulphur after bending	34.3052	34.7227	36.0535	23.5478	25.3081	36.1401
Density after bending	1.809	1.807	1.798	1.799	1.772	1.797
Diminution in density ÷ initial density	0.048	0.049	0.054	0.053	0.067	0.054

After the sulphur column had been planed off the sample was again weighed, in order to get the weight of sulphur. Another closely fitting plug about 0.9 inches in length was then driven down in the open end of the tube against the surface of the sulphur and fastened by a pin and solder as in the previous case. It might be mentioned that some difficulty was encountered in soldering the plug and pin, due to the fact that sulphur melts at about 114°C. and solder at about 300°C. This difficulty was eliminated by using a large soldering iron and immersing the tube in water close up to the place of soldering.

The density was then determined by the loss of weight in water before and after bending the sample, with the following results:

The density of the sulphur, 1.9, was computed directly from the measurements of the tubes. This value is probably a little low as the diameter of the plug was taken for the diameter of the tube. However, a difference of 0.1 in density only gives a difference of about 0.002 in the diminution in density divided by the initial density. Other errors in the experiment may have arisen from wrinkles which sometimes form in the process of bending of the specimen, and to the plugs which may slightly protrude outside the tube unless the pin and plug are closely fitted and well soldered. The specimens were again weighed in air after the experiment, to see whether there was any change in weight due to leakage.

Specimens III and VI were bent a second time with a change in the percentage decrease of density from 5.4 to 5.65 and 5.4 to 5.47 respectively. The above data seem to indicate that as the deformation approaches a complete circle the change in the percentage decrease of density becomes less for equal increments of strain, as specimens III and VI were bent about the same amount, but VI was more nearly a complete circle than III before the second bending took place.

The percentage-decrease in density of specimen V is higher than the others. The high value of V is probably due to better mechanical construction and better filling of the tube than for the other specimens and is perhaps more significant since none of the tubes can have been absolutely free from air bubbles. This specimen was bent very nearly into the form of a complete circle and no wrinkles or protrusion of the plugs could be detected. Upon opening the tube the filling was found to be apparently complete throughout with no noticeable central void or depression.

The data obtained are not of the utmost precision, but are close enough to show that there is a decrease in density due to rupture and that the decrease in density approaches a value which is of the order of magnitude of 0.0673. This is the square of 0.2595 or of the interstitial space in closely piled spheres of equal radius. The approximation is apparently due to the rounding off of the edges and corners of the fragments formed at the inception of bending. Evidently different values depending upon the amount of the strain and the nature of the substance strained might be obtained, but the present experiments indicate that 6.73 per cent is the limiting value for sulphur subjected to shear under ordinary hydrostatic pressure. Were the bending to be carried further, or to be repeated, it seems possible that a diminution of interstitial space would result.

The author wishes to acknowledge his indebtedness to Mr. C. E. Van Orstrand for helpful suggestions made during the progress of the experiments.

PHYSICS.—*Combustion calorimetry and the heats of combustion of cane sugar, benzoic acid, and naphthalene.*[1] HOBART C. DICKINSON, Bureau of Standards.

The uniform standardization of combustion calorimeters of the Berthelot bomb type can best be accomplished by the combustion of substances having a known heat of combustion. A critical study of the stirred water calorimeter as used for bomb combustion shows that the sources of error are mainly of four kinds, viz., (1) temperature measurement, (2) evaporation, (3) lag effect, i.e., failure of some parts of the system to reach a steady condition with sufficient speed, and (4) uncertainties as to the boundaries of the calorimeter, i.e., as to what portions should be included in its heat capacity. It is shown that most of the errors may be avoided by the use of resistance thermometers and by the proper construction of the calorimeter and its jacket. The cooling corrections for a calorimeter designed in accordance with the conclusions reached can be made by a very simple procedure and with an accuracy corresponding to perhaps 1 part in 10,000 of the total amount of heat measured.

A method of electrical calibration was used, which enables the results of combustion observations to be expressed directly in calories almost independently of the electric units, or, if the heat capacity of the electric heating element used in the calibration

[1] The complete paper under the above title will be published in the Bulletin of the Bureau of Standards.

is known, to be used to check serious errors in either the calorimetric system or the electrical calibrating system.

Observations have been made with two different calorimeters built especially for the purpose and each calibrated by the above method several times independently. Both calibrations and combustions cover a period of more than three years during which time hundreds of observations have been made with different electrical equipment, and samples of material obtained from different sources and purified at different times and in different ways.

Determinations of the heat of combustion of napthalene gave 9622 ± 2 (20°) calories per gram weighed in air, with a maximum deviation from the mean of about 5 in 10,000 for groups of observations upon the same samples and about the same maximum deviation of different groups of observations from the mean of all, regardless of the sample.

Determinations of the heat of combustion of benzoic acid gave 6329 ± 1 (20°) calories per gram weighed in air, with a maximum deviation of about 1 in 1000 for the earlier experiments and 5 in 10,000 for the later ones. Observations taken on samples, some by no means pure, from different sources, show a maximum deviation of 15 in 10,000 and a mean deviation of 7 in 10,000.

Determinations of the heat of combustion of sucrose, fewer in number, gave 3949 ± 2 (20°) calories per gram weighed in air. The later observations show a maximum deviation of a little less than 1 in 1000 and a mean deviation of about 3 in 10,000, though the earlier ones show a maximum deviation of 15 in 10,000.

It appears that, of the three materials included in this investigation, benzoic acid is the most desirable as a combustion standard, as indicated by the agreement between the results of different observers. Napthalene has been found very reliable and convenient, although it requires care in handlirg, since a gram bricquet will lose more than 1 mgm per hour by sublimation. An accuracy of 3 parts in 10,000 is attainable. Sucrose seems not to be so well adapted for use as a combustion standard as is benzoic acid, because of its lower heat of combustion, its frequent failure to ignite, and the lower precision of the results obtained.

PHYSICAL CHEMISTRY—*The electrical resistance and critical ranges of pure iron.* G. K. BURGESS and I. N. KELLBERG, Bureau of Standards.

The exact location and description of the critical ranges A_2 and A_3 of pure iron, determined by heating and cooling curves, has recently been published by the Bureau of Standards.[1] Dr. Benedicks of Stockholm has since carried out dilatation measurements[2] which show that A_2 is accompanied by an expansion change, hitherto undetected. Messrs. Honda and Ogura,[3] following a number of other experimenters,[4] have plotted the magnetic and resistance-temperature curves for pure iron over the range 0° to 1000°C. Although their observations appear to give the general trend of the resistance-temperature curve of pure iron, they do not give an exact representation of the resistance changes taking place at A_2 and A_3, mainly for lack of sensitiveness.

In view of the importance of the subject and as providing a part of an adequate experimental basis for the elucidation of the question of the allotropy of iron, it was thought worth while to make as exact a determination of the resistance-temperature relation of pure iron as the experimental means at our command permitted, paying particular attention to the form of the curve over the A_2 and A_3 critical ranges.

The experiments here described were begun in the summer of 1912 and several preliminary methods of experimentation were tried out before satisfactory sensitiveness, accuracy, speed in manipulation, and closeness of observations to each other were obtained. In some of the earlier work the method was tried of bringing the heating bath or furnace to a definite tempera-

[1] G. K. Burgess and J. J. Crowe: Critical ranges A_2 and A_3 of pure iron, Bureau of Standards Scientific Paper No. 213. 1914. Also Bull. Am. Inst. Mining Engineers. October and December. 1913.

[2] Carl Benedicks: Experiments on allotropy of iron: behavior of ferro-magnetic mixtures; dilatation of pure iron. Jl. Iron and Steel Institute. May, 1914.

[3] K. Honda and Y. Ogura: Über die Beziehung zwischen den Änderungen der Magnetisierung und des elektrischen Widerstandes im Eisen, Stahl und Nickel bei hohen Temperaturen. Science Reports, University Sendai, **3**: 113. 1914.

[4] See Bureau of Standards Reprint No. 213, above cited.

ture and waiting for equilibrium to be established. It soon became evident that, although great sensitiveness and accuracy could be obtained, nevertheless it would take an infinite time to plot an entire resistance-temperature curve satisfactorily. The method adopted in the final series, and which satisfies all the above requirements, depends on the use of the cooling curve apparatus described in Bureau Reprint 213 (loc. cit.), together with a very sensitive, quickly manipulated and accurate Wheatstone bridge, by means of which the resistances of an iron wire and one of platinum wound on the same support and enclosed in vacuo in quartz glass may be exactly compared every few seconds by the intermediary of a drum-chronograph recording the times at which the resistances are measured. In other words, we have used an electrical resistance cooling curve outfit of the highest attainable accuracy and sensitiveness. The temperatures are

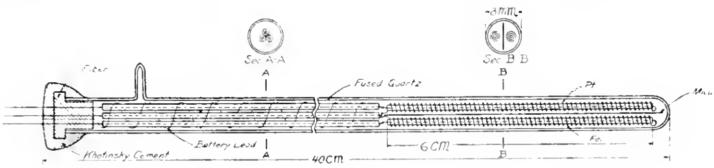

Fig. 1. Construction of platinum and iron thermometers.

given in terms of the resistance of the platinum wire which serves as a thermometer integrating the temperature of the iron wire exactly.

The construction of the combined platinum and iron thermometers is shown in figure 1. The platinum and iron wires of 0.2 mm. and 0.24 mm. diameter, respectively, are wound on thin walled, unglazed hard porcelain insulators 6 cm. in length and separated by a strip of mica. The thermometers are of the compensated three-lead type with one common lead and a common battery lead, all four leads being of platinum and provided with porcelain insulators. After winding the coils and before sealing off, the quartz containing tube was evacuated and, with the coils, heated to a bright red, thus partly annealing the wires and expelling gases. After sealing, the thermometers were again annealed to about 1000°C. in the electric furnace. Several platinum and iron thermometers were made in this way, the values of the resistances at 0°C. usually being about 1.5 ohms for the platinum and 1 ohm for the iron. The length of the thermometer was about one-tenth that of the specially wound platinum resistance furnace used in taking the resistance observations. The iron was from samples of the purest described in Reprint 213 (99.98 per cent iron). The design of the furnace and heating circuits were such that the rate of heating could be exactly controlled and the temperature of the iron was constant over its length at any instant. The Wheatstone bridge with which the best series was taken is one designed by E. F. Mueller of this Bureau, it being a modification of the one described in B. S. Reprint 124, in which are also described the methods of use of the resistance pyrometer. The precision of the resistance measurements was better than 0.00001 ohm and of the time 0.1 secs., or equivalent to 0.005°C. in temperature differences and to 1 in 1,000,000 of the iron resistance at 800°C. This is some 1000 times the precision of Honda and Ogura.

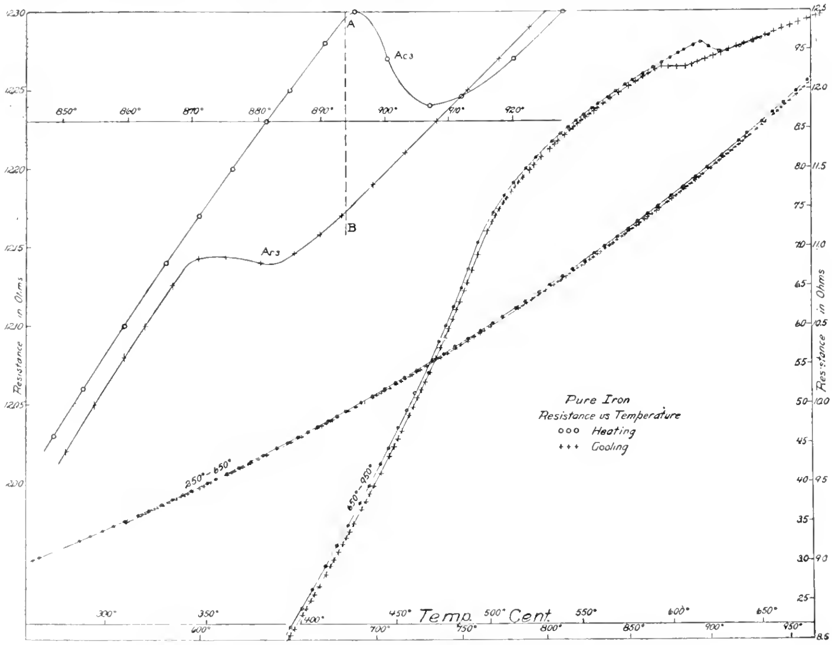

Fig. 2. Resistance vs. temperature curves of pure iron.

In all, six iron thermometers were used from three samples and all gave the same characteristics for pure iron. In figure 2 are shown the observations of the second heating and cooling curves taken with thermometer F-6, which are typical of the behavior of iron, and in figure 3 the temperature-coefficient of electrical resistance of pure iron, or more exactly the ratio of change of resistance of iron to that of platinum with temperature.[5]

[5] Tables are given in the complete paper to be published by the Bureau of Standards of the actual observations from which these curves are drawn.

In figure 2, the observations on heating are represented by circles and on cooling by crosses. The shift of the heating curve with respect to the cooling curve appears to be real as shown, since the iron returns exactly to the same resistance at 0°C. after heating. This non-coincidence of heating and cooling curves is probably caused by the different rates of heating and cooling, the former being about 0.10 deg. / sec. and the latter 0.06 deg. / sec. at 900°C.

It is seen from figures 2 and 3 that the resistance of iron increases from 0°C. without any anomalies—except possibly a minute one at 730°C., due to less than 0.01 per cent of carbon—

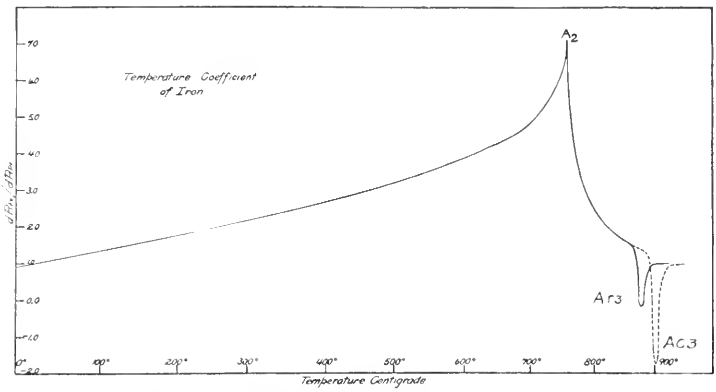

Fig. 3. Temperature coefficient of pure iron.

with a gradually increasing temperature coefficient to above 650° or until the neighborhood of A_2 is reached. As A_2 is approached the resistance rises rapidly, and at A_2 there is an inflexion in the resistance-temperature curve shown as a cusp at 757°C. in the temperature-coefficient curve. At Ac_3 the resistance of iron falls abruptly by some 0.005 of its value, which is recovered within a 25° interval, and above Ac_3 increases gradually again. On cooling the reverse phenomenon is observed at Ar_3, which is accompanied by a slight increase in resistance with falling temperature, preceded by an interval of relatively slight changes in resistance. These effects are shown best in the open scale plot in figure 2 of the A_3 region and in figure 3.

As closely as can be measured, the transformations Ac_3 and Ar_3 begin at the same temperature, 894°C. (see line AB of fig. 2); and as given by the resistance measurements, Ac_3 and Ar_3 each extend over the considerable temperature interval of 25°C.

These resistance measurements therefore show that A_2 is a strictly reversible transformation and that A_3 is a transformation taking place at a higher temperature on heating than on cooling. Evidently, the two types of transformation are fundamentally different.

The experiments here described are in agreement with the thermal observations previously recorded (see Reprint 213), although the position of maximum absorption or evolution of heat does not appear to coincide exactly with the temperatures at which the electrical resistance is changing most rapidly either at A_2 or A_3. The type of phenomenon is however the same as given by either method for A_2 and A_3 respectively.

Whether or not either or both of these critical ranges, A_2 and A_3, is to be considered an "allotropic point" will depend on the definition of allotropy, about which there does not yet appear to be agreement. The reversible thermal and electrical behavior at A_2 appears to be somewhat similar to that of a pure substance at its melting point, while at A_3 there is a progressive change with temperature of the electrical and thermal properties which are not reversible, the reaction taking place at a higher temperature on heating than on cooling. The A_3 change is certainly associated with recrystallization while no crystallographic change has as yet been found at A_2 which is also the temperature associated with the abrupt, reversible change of iron from the ferro-magnetic to the para-magnetic states.

GEOLOGY.—*A new dip chart.* FRED EUGENE WRIGHT, Geophysical Laboratory.

In both structural and mining geology the problem frequently arises to determine the direction, on a given vertical section, of the trace of a bed or plane of known dip and strike. This direction is the apparent dip of the stratum or vein as seen in the vertical section. This problem can be solved either by a purely graphical method of projection[1] or by use of the standard projection-equation

$$\tan C = \sin B \,.\tan A \qquad (1)$$

in which A is the true angular dip of the bed; B, the angle included between its line of strike and the vertical section; C, the desired angle of apparent dip as shown in the vertical section.

A chart for the graphical solution of this equation was first proposed by D. F. Hewett;[2] and more recently the same chart (with a few additional curves and on a reduced scale) has been published by H. Bancroft.[3] On this chart the abscissae are the azimuth angles B; the ordinates, the true angular dips, A; and the curves, the angles C. For the C-curves below 80° the

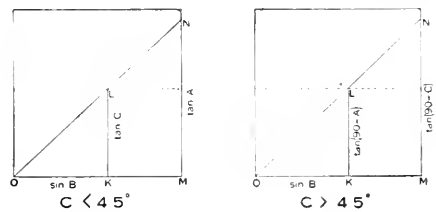

Fig. 1. Diagram to illustrate the relations underlying the construction of the dip-chart (fig. 2). The sides are considered to be of unit length. The sine values from 0 to 1 (angles from 0° to 90°) are plotted directly as abscissae; tangent values from 0 to 1 (angles from 0° to 45°), as ordinates. The third variable is represented by radial lines which pass through the origin and the tangent divisions on the unit ordinate.

interval is 5°; from 80° to 90° it is 2°. Under favorable conditions ($B > 20°$, $C < 60°$) the angle C can be read off directly with an error of about 0.5°; for dips greater than 60° the error may exceed 1°. This degree of accuracy is sufficient for most purposes.

It is possible, however, to obtain more accurate results (correct to 0.1° under favorable conditions) by use of a diagram (fig. 2) similar to that which was described sometime ago by the writer in a paper on "Graphical Methods in Microscopical Petro-

[1] Economic Geology, **9**: 55. 1914.
[2] Economic Geology, **7**: 190. 1912.
[3] Bull. Am. Inst. Mg. Eng., p. 1769. July. 1914.

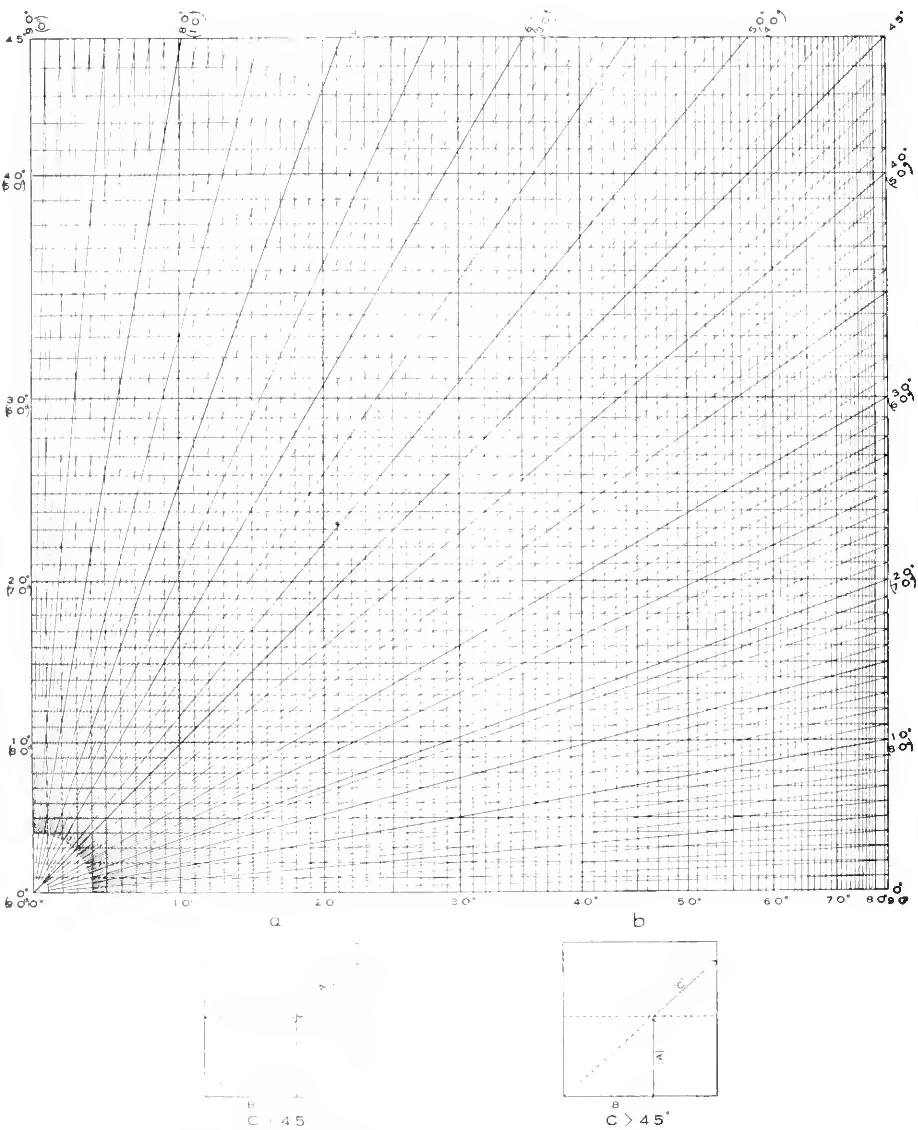

Fig. 2. Dip-chart. Graphical solution of the equation $\tan C = \sin B \tan A$, in which A = true dip of bed, B = angle between line of strike of bed and vertical section, C = inclination, from the horizontal, of trace of bed on vertical section (apparent dip of bed in vertical section). For values of $C < 45°$ use diagram a; for $C > 45°$ use diagram b. In these diagrams the arrows indicate the proper lines to follow in solving the equation for given values of A and B.

graphy."[4] In this paper the general principles underlying the construction of graphical plots for the solution of equations are discussed in some detail; of these principles the most important are: (1) Uniformity in relative accuracy over the entire plot, and comparable to that which obtains in nature (distortion as slight as possible); (2) the use of straight lines rather than curves, wherever possible. In the present instance such uniformity is best obtained by plotting the sine and tangent functions directly rather than the angles themselves. The diagram is then a straight line diagram throughout and the distortion present corresponds to that of the equation itself.[5] In the new chart all variables are represented in 1° intervals. The relations underlying the construction of this chart are shown in figures 1a and 1b in which the sides of the square (MO) are equal to unity. The triangles KOL and MON are similar and the proportion obtains

$$KL : KO = MN : MO = MN.$$

In figure 1a we have by construction

$$KO = \sin B, \ KL = \tan C, \text{ and } MN = \tan A.$$

On substituting these values in the above proportion we obtain equation (1) above. Similarly in figure 1b ($C < 45°$, $\tan C < 1$) we get on substitution

$$\tan (90 - A) : \sin B = \tan (90 - C)$$

an equation identical with (1).

Compared with the Hewett chart the present chart has the advantage of greater precision but it is, in one respect, apparently less satisfactory, namely, that when the angle $C < 45°$,

[4] Am. J. Sci. (4), **36**: 509–539. Plate VIII. 1913.

[5] From the standpoint of the graphical representation of an equation, we may consider the above equation to be an expression of direct relations between the functions themselves rather than between the variables under the functions. Fundamentally, of course, the equation expresses relations between the variables, and the increments are so taken. The procedure here adopted amounts practically to the representation of each function by a scale so chosen that the resulting curves are straight lines. The same principle underlies the construction of the slide rule and other calculating devices; also the use of logarithmic paper.

diagram a (fig. 2) must be used, while for $C > 45°$ diagram b (fig. 2) must be employed, and also the angles indicated in parenthesis (complements of the first). This change results from the fact that the tangent values range from zero to infinity, whereas the chart extends only to unity and reciprocal values have to be taken for values above unity. Thus for the first case ($C < 45°$, $\tan C < 1$) the equation employed is

$$\frac{\tan C}{\sin B} = \frac{\tan A}{1} \quad \text{or} \quad \tan C = \sin B . \tan A$$

while in the second case ($C > 45°$, $\tan C > 1$) the equation is transformed to read

$$\frac{\frac{1}{\tan C}}{1} = \frac{\frac{1}{\tan A}}{\sin B} \quad \text{or} \quad \frac{\tan (90 - C)}{1} = \frac{\tan (90 - A)}{\sin B}$$

The subtraction indicated in the last equation is accomplished by reading the numbers in parenthesis on the chart.

Two examples will suffice to indicate the method of using the chart:

(1) Find the apparent dip of a stratum, striking N 43.3° E and dipping 22.2°SE, on a vertical N-S section. In this case $B = 43.3°$, $A = 22.2°$. C, which is always less than A, is accordingly $< 45°$ and diagram a (fig. 2) is the correct one to use. From the chart we read off directly $C = 15.6.°$

(2) A vein striking N 23° W and dipping 63° NE is crosscut on a vertical E-W section. Find the inclination, from the horizontal, of the its trace on this section. In this instance $B = 67°$, $A = 63°$; from the chart we find by use of diagram b (fig. 2) $C = 61°$.

The chart has been found satisfactory and of great value in the graphical solution of transformation equations for projection work in optical crystallography. It is here presented in the hope that it may prove of equal service in the solution of the problem to find, on a given vertical section, the apparent dip of a bed or vein.

GEOLOGY.—*Post-Cretaceous history of the mountains of central western Wyoming.*[1] ELIOT BLACKWELDER, University of Wisconsin.

The field includes the Teton, Gros Ventre and Wind River Ranges with their environs. A continuous plain of aggradation about the close of the Cretaceous period was deformed by folding and overthrusting. Orogenic activity then ceased and the corrugated surface was sculptured into hills, mountains, and plains. The Wasatch and later Eocene and Oligocene continental deposits were then strewn by rivers and allied agencies upon the denuded outcrops of weak strata rather than in structural basins. Meanwhile, especially late in this sedimentary epoch, explosive volcanic eruptions added thick deposits of ash and breccia.

At a later time, probably in the Miocene, very gentle folding and normal faulting terminated the sedimentation and left new relief features, such as the great scarp of the Tetons, which were not accordant with those made at the close of the Cretaceous.

The subsequent erosion of the district produced a peneplain on even the hardest rocks. This plain was probably the characteristic feature of the Pliocene, but it is now represented only by high-level remnants in the Wind River and perhaps other ranges.

During the Quaternary, wide-spread elevatory movements without notable warping or faulting but perhaps with climatic changes induced the dissection of the peneplain by streams, wind and glaciers—in the order of their quantitative importance. The land forms, thus left, were controlled by the structure and relative resistance of the rocks below. Thus, while broad plains were excavated in the Tertiary clays, only narrow canyons were carved in the Pre-Cambrian gneiss.

Four distinct cycles of erosion later than the peneplain are distinguished and with them are associated three stages of Alpine glaciation. The oldest glacial deposits are the most widespread but have lost nearly all traces of glacial topography. The two

[1] Published by permission of the Director, U. S. Geological Survey. (To be printed in full in the Journal of Geology.)

younger sets of moraines are similar to each other, in forms and relations, but show important differences in the effects of subsequent erosion and weathering. The probable relations of the glacial stages to the erosional cycles are discussed. The activity of the wind in sculpture and deposition has been important. Interesting phenomena of gravity work, in the form of land-slides, earth-flows, and talus-glaciers receive brief mention.

TECHNOLOGY.—*The veritos firing rings.* A. V. BLEININGER and G. H. BROWN,[1] Bureau of Standards. Communicated by S. W. STRATTON.

In the pottery and other clay industries the heat effect due to the increasing kiln temperature is frequently determined from the shrinkage of unburned clay rings, of uniform composition and size, which are placed in different parts of the kiln. The shrinkage is measured by means of a simple calipering device which permits the reading of small differences in diameter. The object of the present work was the correlation of the arbitrary shrinkage number of the gauge with temperature as measured by means of standardized thermo-couples, so that the devices might be coördinated with pyrometer practice.

The work consisted in firing a number of these rings under conditions of constant temperature increase per unit time. Four firings were made with increases in temperature of 50, 25, 16.66 and 12.5°C. per hour. At frequent intervals rings were withdrawn from the kiln and their diameters measured after cooling. The temperatures at which equal contraction takes place are higher the more rapid the firing. The differences diminish as the temperature rises. The shrinkages for the two lower firing rates tend to coincide as the heat absorption becomes constant. Porosity determinations were made in connection with the shrinkage measurements; these resulted in curves practically parallel to the linear contraction. The firing rings were found to answer the purposes for which they are intended satisfactorily. A new series of rings, intended for lower temperatures, was found to be unsatisfactory, owing to irregularities in shrinkage.

[1] To appear as Technologic Paper No. 40 of the Bureau of Standards.

ECONOMICS.—*An objective standard of value derived from the principle of evolution,—II.* ALFRED J. LOTKA. Communicated by G. K. BURGESS.[1]

The question naturally arises, whether it is in any way possible to obtain a numerical estimate of the order of magnitude of the quantity $\frac{\partial r}{\partial m}$, and thus to establish a connection between our theoretical considerations and practical, concrete economic data.

The most obvious way to seek an answer to this question would, of course, be actually to determine $\frac{\partial r}{\partial m}$ for at least one commodity. Unfortunately the difficulties in the way of carrying out this plan are equally obvious. We are therefore forced to have recourse to indirect methods. This is not without its compensations. For, quite apart from its bearing upon the theory of value, the physical quantity $\frac{\partial r}{\partial m}$ is of considerable interest, and, since we can entertain but little hope of effecting its direct measurement in the near future, the discovery of any method, however rough, for gauging indirectly at least its order of magnitude, represents a distinct gain.

The basis for such an indirect determination is furnished us by the fact that, by definition, an individual with a perfect sense of values would gauge all commodities at their "true" values—or, as expressed by equations (12), (13), (18), (19)

$$\frac{\partial r}{\partial m_j} = \mathbf{v}_j \tag{23}$$

Had we such an individual at our disposal, we could, by simply questioning him, obtain through (22) a measure of the "true" values in exchange of all commodities, and thus, all but for a constant factor, a measure of $\frac{\partial r}{\partial m}$ for all commodities.

In actual fact we cannot do this, but we *can* question an actual representative individual, or, what amounts to the same thing, we can ascertain the prices of goods upon the actual market, and

[1] Part I of this paper appeared in the August issue of this Journal, pp. 409–418.

thus determine, not the "true" or "objective" values in exchange $\mathbf{v}$, but the subjective values in exchange

$$v_j = \mathbf{v}_j + \epsilon = \frac{\partial r}{\partial m_j} + \epsilon \tag{24}$$

where ϵ may be regarded as a measure of the "error" of the sense of values of the representative individual in determining the value (per unit mass) of the commodity A_j.

If we now make the assumption that ϵ is as a rule a small quantity, so that for purposes of rough estimation we may neglect it, and write

$$\frac{\partial r}{\partial m_j} = \mathbf{v}_j = v_j \tag{25}$$

our problem is solved, all but for the determination of a constant factor; the uncertainty which thus remains is due to the fact that our representative individual is able to indicate only the ratio $v_j : v_J$ and hence $\frac{\partial r}{\partial m_j} : \frac{\partial r}{\partial m_J}$ for any two commodities A_j and A_J, but is unable to give us any information regarding the absolute value of $\frac{\partial r}{\partial m}$ for any commodity.

We can, however, remove also this last remaining uncertainty: From (22) we see that in the objective system a commodity has unit value per unit quantity if

$$\frac{\partial r}{\partial q} = 1 \tag{26}$$

On the other hand, according to our agreement regarding the measurement of labor per unit of time (see page 413 and equation 5), we see that the unit of labor per unit of time has unit negative value, since by (5) and (22)

$$\frac{\partial \bar{\Omega}}{\partial L} = \frac{\partial r}{\partial L} = -1 = \mathbf{v}_L \tag{27}$$

This completely determines the unit of value if the unit of labor per unit of time is given, or vice versa. We are at liberty to fix one of these units arbitrarily—but then the other is fixed, in the objective system.

Let us, then, arbitrarily fix the unit rate of labor (per unit of time) at one (average) man-day (as actually practised at the present time) per man per day. The value of this, in objective units of value, is in the system here discussed –1; this means that doing one such unit of labor per day represents a loss of one unit of value per day. If the wages received just compensate for this loss (as would be the case with entirely open competition and absence of all monopoly—one of our fundamental assumptions), then the value of the average daily wage received (under actually existing conditions) would be + 1 objective unit of value. But the average daily wage actually received under existing conditions is, in dollars, + 2 units, say. Hence one objective unit of value, as defined above, is (to the degree of approximation attainable by our rough method of estimation) equal to 2 dollars, or 1 dollar is equal to 0.5 objective units of value.

Now if the rate of doing labor is measured in objective units, we have

$$\frac{\partial r}{\partial L} = -1 \tag{27}$$

If, on the other hand, it is measured in dollars per day, then, since 2 dollars per day is equal to 1 objective unit per day, we shall have

$$\frac{\partial r}{\partial L} = -0.5 \tag{28}$$

Let us consider by the aid of a numerical example what this means. With the same assumptions as before, and an average daily wage of 2 dollars per day for one man-day per day of labor, let us suppose that the rate of labor were increased until it corresponded to a fair wage of 2.01 dollars per day; that is to say, we are supposing that the rate of doing labor is increased by 0.005 objective units of value.

Then we should have

$$dr = \frac{\partial r}{\partial L}\, dL = -1 \times 0.005 = -0.005 \tag{29}$$

This means that the direct effect of such increase in the rate of doing labor, considered alone and apart from any accompanying or compensating influences (such as the additional wages received or their equivalent in product acquired) would be to decrease the natural rate of increase per head of the species (i.e., the excess of births over deaths) by 0.005. Thus, if before the change in the rate of doing labor, the rate of increase per head of the species had been 0.01, after the change it would be 0.005.

This result may at first sight appear greatly at variance with observed facts. In construing it, however, and making comparisons with actual observations, we have to bear in mind a number of points.

In the first place it has been assumed above that the dollar is a definite and stable unit of value. If this condition is not satisfied (and in practice it is not) then evidently large changes in the average daily wage may take place without necessarily any change at all in the average rate of doing labor, and hence without necessarily any change in the natural rate of increase r. In other words, equations (27), (28), (29) apply of course only if a constant and consistent unit of value is employed.

Furthermore, we have proceeded on the assumption that there is absolutely open competition, no sort of monopoly, in the community under consideration, so that every person either consumes directly the products of his own labor, or receives a "fair" wage, i.e., the exact equivalent of the pains of his labor. The effect of monopolies would in general be to lower wages, since the employer is thereby placed in a position to dictate terms. This implies that the estimate of $\frac{\partial r}{\partial L}$ obtained above would be too great (in absolute amount—it is of course a negative quantity). A similar effect would result from the influence of capital, which we have left out of account.

Again, our assumption above, that ϵ is a small quantity requires a little more careful examination than we have so far given it. This assumption is probably justified for most of the common commodities of life, viewed generally. But if we single out some one commodity, we have no guarantee that *it* may not, through some circumstance peculiar to its case, form an exception, and have a large error ϵ. Now this will not seriously affect our argument, provided only that such peculiar exception does not occur in the case of the one commodity which enters as a standard into our system—namely labor. Now it is quite possible that labor does constitute such an exceptional case: the sense of fatigue is given us to warn us of possible harm which may be incurred if labor is persisted in after it has become irksome beyond a certain point. It is well known that in many other instances nature provides for emergencies by allowing a large "factor of safety," and we may well expect that such a factor should enter as a correction in equation (27): The individual will not wait until that equation is satisfied, but will cease to labor as soon as

$$S \times \frac{\partial r}{\partial L} = -1 \tag{30}$$

where S is a factor of safety, and, as such, greater than unity. The neglect of this factor of safety in our estimate of $\frac{\partial r}{\partial L}$ above would produce an error in the same direction as the neglect of the effect of monopolies and capital. The corrections to be applied would therefore all work in the same direction and tend to bring the value of $\frac{\partial r}{\partial L}$ thus obtained into seemingly better harmony with the expectations which we are naturally led to entertain on the basis of observation.

Lastly, we have made the assumption that $\omega_1 = \omega_1(m_1)$, i.e., the marginal ophelimity of commodity A_1 depends only on the quantity of A_1 consumed per unit of time, and is independent of the rate of consumption of other commodities. This assumption is not strictly true in any case, and may be quite far from the truth in some cases. This assumption does not, however, materially affect our arguments and conclusions, and was made here only for the sake of simplicity. The consideration of the more general case, in which this assumption is discarded, is passed over here, and will be found at the end of this paper.

There are certain apparent objections which naturally present themselves upon a first consideration of the measure of value here proposed. The first of these relates to the question of currency. The common standard of currency in most civilized countries is gold. Now it may be urged that to measure the value of an ounce of gold by its $\frac{\partial r}{\partial m}$ would be absurd. It is true that a certain limited quantity of gold is in use in the industries, where a definite $\frac{\partial r}{\partial m}$ may properly be assigned to it. But the great bulk of gold circulates as currency, and such gold would be absolutely useless to a person isolated from commerce. It will rightly be urged that here $\frac{\partial r}{\partial m}$ is practically zero, yet the gold has a very definite and high value in exchange.

The fact is that currency is a "value" in a class by itself: it is strictly speaking not a value at all, but merely a certificate of ownership in values not specified in kind. The theory of currency therefore must be developed along special lines. There is no need to enter here into this aspect of our subject, as it is dealt with satisfactorily in the standard works on economics and currency, as for instance, in Irving Fisher's *The Purchasing Power of Money*.

Another set of values to which it may appear at first sight as if the standard of measurement here developed could not be applied is that of certain luxuries, such as gold ornaments, diamonds, and jewelry generally. The possession of these obviously can exert little or no *direct* influence upon the owner in such a way as to cause an increase (or decrease) in r. But it must be understood that in forming the differential coefficient $\frac{\partial r}{\partial m}$ not only the *direct* but also the indirect effects must be taken into account. And the indirect effect of luxuries in economics may be of the highest importance: The desire for their possession acts as an incentive to further effort to those who have already attained the bare necessities of life—often the very persons who by their superior ability are particularly qualified to render valuable services to the community by their activities. Such luxuries may be likened to the spices added to food: they have not themselves any appreciable food-value; nevertheless they fulfill an important function in stimulating the appetite. And though the prime motive of the man who labors in order to secure for himself luxuries, while others are in actual want of necessities, may not be altruistic, nevertheless, in all but exceptional cases his activity will on the whole contribute to the total assets of the community, whereas, as an idle non-producer he would still consume values without producing any—in other words, much as the "idle rich" may resent the statement, he would in point of fact be living at the expense of the community, just like his despised brother in the poorhouse.

This must not be taken to imply that the taste for luxuries is absolutely essential in an ideally constituted community: If all men were willing, after they have satisfied all their own wants, to continue laboring from purely philanthropic motives for the good of others, the useful function of luxuries, such as indicated above, would be eliminated. Just in the same way an individual with a thoroughly healthy and well-regulated appetite has no need of spices in his food, or of other stimulants. But in the existing order of things, which principally concerns the economist, luxuries do exert the beneficial influence indicated above, and therefore have a value, which is properly gauged, like that of any other commodity, by the differential coefficient $\frac{\partial r}{\partial L}$, formed with due regard to all the circumstances bearing upon the case.

Somewhat similar is the answer with which the writer would forestall certain other objections which will no doubt be raised by some against the application of the standard of value here proposed: These persons will point out, perhaps with some feeling, that some of the greatest values of all, ethical and esthetic values, utterly fail to be justly gauged by their quantitative effect upon the rate of growth of the species.

To this it is answered that *ethical* values, at any rate, have in the great majority of cases a very obviously beneficial effect upon the growth of the species. There is of course such a thing as misplaced charity, and "favoring the survival of the unfit"—things which have been made the subject of considerable discussion of late; but such modes of action, which from the point of view here developed must be considered to have a low or even a negative value, will be admitted to be undesirable also from the point of view of ethics.

Somewhat similar remarks apply in the case of esthetic values. There can be little doubt that our esthetic instinct fulfills some useful function, though it may not always be very apparent how. In many cases artistic feeling and expression is closely bound up with the manifestation of the mating instinct, and thus with the propagation and increase of the species. In other cases art is associated with the devotional phase of religion, an adjunct, and no doubt an effective auxiliary, to its ethical phase. That art in such connection as this serves a "useful" purpose, i.e., tends to increase r, and has therefore, according to our system, a positive value, needs no further demonstration, after what has been said above with regard to ethical values.

"But," perhaps some will say, "Art and Ethical Conduct have a value quite apart from any benefits which they bring to the community." With these there can be no arguing—they are merely expressing a personal conviction, voicing their own subjective sense of values. That this subjective sense of values is more or less at variance with the "true" or objective values of things is admitted; were this not so, the whole of the present investigation would be unnecessary. And if any person finds it utterly impossible to harmonize on some particular point his subjective sense of values with a proposed system of objective values, it is at least equally probable, *a priori*, that his sense of values is at fault, as that the proposed system of objective values is defective.

Again, some may urge that it is absurd to measure the benefit of any given thing to the species by its influence upon the "mere" number of individuals. To the consideration of those who would condemn this point of view as crassly material, we would respectfully submit the fact that the number of "souls" is of necessity equal to the number of "bodies" in a community, and that if such a despicable thing as mere bread is necessary to increase and sustain the number of bodies of the community, it is quite equally essential to the increase (if not the sustenance) of the number of souls of that community.

Again, it may be objected, that in judging of the value of a given thing we cannot be guided by its influence on the mere *number* of individuals to which it contributes, but it is at least as important to take into account any effect which it may have upon the *quality* or *character* of such individuals.

This is not disputed, but we have here specifically restricted our attentions to the consideration of one given type or species, the character of which is supposed to be given as one of the fundamental data of our problem. In this case, the *character* of the species being constant, the value of a given object or circumstance to the species must necessarily find expression entirely in its effect on the number of individuals. Value is an essentially *relative* concept, and as such *must* be defined *relatively* to some *one particular type*. To speak of the value of a pound of butter, or a bale of hay, or a dozen worms, is meaningless: to complete the statement we must speak of the value of a pound of butter to man, for example, of a bale of hay to a horse, or of a dozen worms to a starling. Hence in measuring the value of a given thing to a stated type of organism, we must consider this type as a given and fixed standard of reference, and then it follows, as indicated above, that the value of a given thing finds expression entirely in its effect upon the number of individuals.

Extension of the concept of value by a generalization of the equation for the distribution of labor in different pursuits. In the preceding paragraphs we have dealt explicitly with the value of "material" commodities, which we have supposed to be measured, as regards quantity, in units of mass; and with the value of labor, which we have found it most convenient to suppose measured by the "fatigue" or discomfort incurred in such labor. Implicitly we have repeatedly had occasion to refer to other "things" or circumstances which may possess the attribute of value. It is desirable to give some consideration to the exact treatment of this phase of our subject.

Quite generally labor L (or its equivalent, such as certain amounts of "money" or "currency") may be spent, not only in the production of masses $m_1, m_2 \ldots$ per unit of time of various material commodities A_1, A_2, but also in maintaining certain parameters $X_1, X_2 \ldots$ at certain values $x_1, x_2 \ldots$ Thus, every civilized community spends a certain amount of labor and money on sanitary measures, the function of which is to keep the parameters X_i, X_j . . . , say the death rates from diseases S_i, S_j, at certain values x_i, x_j . . . Equation (3) for the distribution of labor in different pursuits is in point of fact incomplete in that it takes account only of labor spent in the production of material commodities measurable in units of mass. To complete it we must add to the right hand member a number of terms of the form

$$+ \left\{ \frac{\partial\Omega}{\partial x_i} p_i + \frac{\partial\Omega}{\partial f_i} p'_i \right\} = dL_i \tag{31}$$

Equation (3) thus amplified by (31) is now in a form which covers in general all activities of a given species. For this reason it is of value in the treatment of the general theory of the struggle for survival, or in other words, the "evolution" in a system comprising a number of different species of organisms. It is not proposed to enter here into detail as regards this phase of the subject.

Case II. Lastly it remains for us to consider the general case, when ω_i is not a function of m_i alone, as we assumed above, but when

$$\omega_1 = \omega_1 (m_1, m_2 \ldots), \; \omega_2 = \omega_2 (m_1, m_2 \ldots), \tag{32}$$

In other words, we now regard the marginal ophelimity of commodity A_i as depending not only on the rate of consumption of A_i, but also on that of the remaining commodities. In this case the total pleasure derived from the production and consumption of the increments dm_1, dm_2 . . . of commodities A_1, A_2 . . . in general depends, not only on m_1, m_2 . . . , but also on the "path," i.e. on the order in which the several commodities are produced and consumed.

We can here still write

$$d\,\Omega = (\omega_1 p_1 + \omega'_1 p'_1)\; dL_1 + \ldots$$

but we cannot simply put, as before,

$$\omega_i = \frac{\partial\Omega}{\partial m_i}$$

In fact, the value of the partial differential coefficient $\frac{\partial\,\Omega}{\partial m_i}$ is in this case indeterminate, unless the "path" of the change is defined. On the other hand, as soon as the path is defined, say by the condition that certain parameters P are to be kept constant in forming the partial derivative $\frac{\partial \Omega}{\partial m_1}$, which latter we may accordingly write $\left(\frac{\partial \Omega}{\partial m_1}\right)_P$, then the value of

$$\omega_i = \left(\frac{\partial \Omega}{\partial m_i}\right)_P$$

becomes definite, and we have a definite value for

$$d\Omega = \left(\frac{\partial \Omega}{\partial m_1}\right)_P p_1\, dL_1 + \quad . \quad . \quad .$$

With a path thus prescribed we can apply exactly the same reasoning as before, and we shall have a precisely analogous set of equations, with only this difference, that everywhere for $\frac{\partial \Omega}{\partial m_i}, \frac{\partial \Omega}{\partial f_i}$ we must write $\left(\frac{\partial \Omega}{\partial m_i}\right)_P, \left(\frac{\partial \Omega}{\partial f_i}\right)_P$, and similarly, for $\frac{\partial r}{\partial m_i}, \frac{\partial r}{\partial f_i}$ we must write $\left(\frac{\partial r}{\partial m_i}\right)_P, \left(\frac{\partial r}{\partial f_i}\right)_P$

Thus, for a given prescribed path (order) or production and consumption we obtain a perfectly definite set of "true" or objective values: Both subjective and objective values are in this case dependent on the "path" of production and consumption.

Finally, it may be remarked that in general, among the various possible paths there is one which makes the rate of increase r of the species an absolute maximum.[2] In a specially restricted sense we might speak of the objective values corresponding to this path as the "true" values of the several commodities produced and consumed. But the more general interpretation previously indicated will probably be found more serviceable for the purposes for which the development here given has been worked out—that is to say, for the treatment of certain problems in the theory of evolution, as indicated by the writer elsewhere.[3]

[2] Compare Pareto, Manuel d'economie politique, 1909, 547.

[3] Jl. Washington Acad. Sci., **2**: 2. 49. 66. 1912; Ann. Naturphil. 1911, 59; Phys. Review, 1912, 235; Am. Jl. Sci., **24**: 199. 375. 1907.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

CHEMISTRY.—*Radioactivity of mineral waters.* R. B. Dole. U. S. Geological Survey, Mineral Resources of the United States, 1913, Part II. Pages 433–440. 1914.

The radioactivities of several well-known spring waters in Europe and in the United States are given with a brief discussion casting some doubt on the therapeutic value of natural radioactive waters. A select bibliography is appended. R. B.

GEOLOGY.—*Geology and ground waters of Florida.* George C. Matson and Samuel Sanford. U. S. Geological Survey Water-Supply Paper No. 319. Pp. 445, with maps, sections, and views. (Prepared in coöperation between the U. S. Geological Survey and the Florida Geological Survey, under the direction of Thomas Wayland Vaughan.)

Through a region of low relief the topography of Florida is sufficiently diversified to be interesting. The important topographic features are consequent, superimposed, and extended rivers; lakes occupying basins due to irregularities of deposition or to solution of limestones; a shore line with forms determined by both constructive and destructive agencies. Among the most important and interesting of the shore features are the living and fossil coral reefs bordering the southern end of the Floridian peninsula, and the numerous bars, capes, and sounds produced by wave action along the shore. Pleistocene terraces are extensively developed and occupy a very large percentage of the surface in the state.

Florida contains the most complete section of upper Tertiary deposits in the eastern part of the United States. Exposures of these formations are limited and consequently can be traced only short distances. This has probably led to the introduction of a number of names for deposits which upon further study can be placed in a single formation. An example of this is the Vicksburg group, consisting of limestones of lower Oligocene age, which is divided into three formations identical in lithologic character but having slightly different geographic distributions. The upper Oligocene contains sands, clays, fuller's earth, marls, and limestones. It is known as the Apalachicola group and comprises several formations that may eventually be reduced in number.

The Miocene is well represented in western and central Florida by fossiliferous marl, and along the east coast by siliceous limestone. The Pliocene beds are of varying types, from the marine Caloosahatchie marl to the nonmarine vertebrate-bearing beds of the Alachua clay. Limestones including oolites and reef rock, partly coraliferous, of Pleistocene age, underlie most of the southern part of the state. Other Pleistocene beds comprise shell marl, coquina, and siliceous sand.

The underground waters of Florida constitute a most important natural resource. The waters are generally hard from the abundance of limy material in the containing beds and in places are decidedly saline, but they are used as sources of supply for domestic and manufacturing purposes in many cities and villages. The conditions determining the occurrence of flowing wells, the distribution of flowing well areas, and the artesian prospects in each county are discussed in detail.

G. C. M.

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Under this heading it is proposed to include, by author, title, and citation, references to all scientific papers published in or emanating from Washington. It is requested that authors coöperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

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JOURNAL

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Vol. IV OCTOBER 4, 1914 No. 16

ASTRONOMY.—*Condensation of the tables of the azimuth of celestial bodies.* G. W. Littlehales, Hydrographic Office.

If finding the azimuth be viewed as a terrestrial measurement in connection with which the observed celestial body is considered to be projected vertically downward on the surface of the earth—that is to say, if the azimuth-angle be regarded as the angle whose apex is formed at the geographical position of the observer between his meridian and the great-circle arc passing through his geographical position and the geographical position of the observed celestial body, then it will become commonplace to regard any value of the azimuth as applying not only to the position of the particular celestial body observed but as applying besides to all geographical positions of which the great-circle passing through the geographical position of the observer and the geographical position of the observed celestial body is the locus; and, since every great-circle of the earth, except the equator itself, crosses the equator, there is always a point on the equator whose azimuth or true bearing from the observer is the same as the azimuth of the observed celestial body. The fact that this relation exists gives rise to the suggestion that the tables of the azimuths of celestial bodies at present in use, giving values for each latitude of the observer throughout a wide range of declination of the observed body, could be reduced in volume to the extent of omitting all except what relates to 0° of declination, provided only that convenient means be supplied for finding the difference of longitude or hour-angle between the meridian

TRUE BEARING OR AZIMUTH

LATITUDE

Hour Angle ° ′	0° ° ′	1° ° ′	2° ° ′	3° ° ′	4° ° ′	5° ° ′	6° ° ′	7° ° ′	8° ° ′	9° ° ′	10° ° ′	11° ° ′	12° ° ′	13° ° ′	14° ° ′	15° ° ′	Hour Angle h. m.
90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 90	VI 00
87 30	90 00	90 03	90 05	90 08	90 10	90 13	90 16	90 18	90 21	90 23	90 26	90 29	90 31	90 34	90 36	90 39	50
85 00	90 00	90 05	90 10	90 16	90 21	90 26	90 31	90 37	90 42	90 47	90 52	90 57	91 03	91 08	91 13	91 18	40
82 30	90 00	90 08	90 16	90 24	90 32	90 39	90 47	90 55	91 03	91 11	91 19	91 26	91 34	91 42	91 49	91 57	30
80 00	90 00	90 11	90 21	90 32	90 42	90 53	91 03	91 14	91 24	91 35	91 45	91 56	92 06	92 16	92 27	92 37	20
77 30	90 00	90 14	90 27	90 40	90 53	91 06	91 20	91 33	91 46	91 59	92 12	92 25	92 39	92 52	93 04	93 17	10
75 00	90 00	90 16	90 32	90 48	91 04	91 20	91 36	91 52	92 08	92 24	92 40	92 56	93 11	93 27	93 43	93 58	V 00
72 30	90 00	90 19	90 38	90 57	91 16	91 34	91 53	92 12	92 31	92 49	93 08	93 27	93 45	94 03	94 22	94 40	50
70 00	90 00	90 22	90 44	91 05	91 27	91 49	92 11	92 32	92 54	93 16	93 37	93 58	94 20	94 41	95 02	95 23	40
67 30	90 00	90 25	90 49	91 15	91 39	92 04	92 29	92 54	93 18	93 42	94 07	94 31	94 55	95 20	95 43	96 07	30
65 00	90 00	90 28	90 56	91 24	91 52	92 20	92 47	93 15	93 43	94 10	94 38	95 05	95 32	95 59	96 26	96 53	20
62 30	90 00	90 31	91 03	91 34	92 05	92 35	93 07	93 38	94 09	94 39	95 10	95 40	96 11	96 41	97 11	97 40	10
60 00	90 00	90 35	91 09	91 44	92 18	92 53	93 27	94 02	94 36	95 10	95 44	96 17	96 51	97 24	97 57	98 30	IV 00
57 30	90 00	90 38	91 16	91 55	92 33	93 11	93 49	94 26	95 04	95 42	96 19	96 56	97 33	98 09	98 46	99 22	50
55 00	90 00	90 42	91 24	92 06	92 48	93 30	94 11	94 53	95 34	96 15	96 56	97 37	98 17	98 57	99 37	100 16	40
52 30	90 00	90 46	91 32	92 18	93 04	93 50	94 35	95 21	96 06	96 51	97 36	98 20	99 04	99 48	100 31	101 14	30
50 00	90 00	90 50	91 41	92 31	93 21	94 11	95 01	95 50	96 40	97 29	98 17	99 06	99 54	100 41	101 29	102 15	20
47 30	90 00	90 55	91 50	92 45	93 40	94 34	95 28	96 23	97 16	98 09	99 03	99 55	100 47	101 39	102 30	103 21	10
45 00	90 00	91 00	92 00	93 00	93 59	94 59	95 58	96 57	97 55	98 53	99 51	100 48	101 45	102 41	103 36	104 31	III 00
42 30	90 00	91 05	92 11	93 16	94 21	95 26	96 30	97 35	98 38	99 41	100 44	101 46	102 47	103 47	104 47	105 46	50
40 00	90 00	91 11	92 23	93 34	94 45	95 56	97 06	98 16	99 25	100 34	101 42	102 49	103 55	105 01	106 05	107 09	40
37 30	90 00	91 18	92 36	93 54	95 12	96 29	97 45	99 01	100 17	101 31	102 45	103 58	105 10	106 21	107 30	108 38	30
35 00	90 00	91 26	92 51	94 16	95 41	97 06	98 29	99 52	101 15	102 36	103 56	105 15	106 32	107 49	109 04	110 17	20
32 30	90 00	91 34	93 08	94 42	96 15	97 48	99 19	100 50	102 20	103 48	105 15	106 40	108 04	109 27	110 48	112 07	10
30 00	90 00	91 44	93 28	95 11	96 53	98 35	100 16	101 55	103 33	105 10	106 45	108 17	109 48	111 17	112 44	114 09	II 00
27 30	90 00	91 55	93 50	95 44	97 38	99 30	101 21	103 11	104 58	106 44	108 27	110 08	111 46	113 22	114 56	116 26	50
25 00	90 00	92 09	94 16	96 24	98 30	100 35	102 38	104 39	106 37	108 33	110 25	112 15	114 02	115 45	117 25	119 02	40
22 30	90 00	92 25	94 49	97 11	99 32	101 52	104 09	106 24	108 34	110 42	112 44	114 44	116 39	118 30	120 17	122 00	30
20 00	90 00	92 45	95 29	98 12	100 52	103 27	106 01	108 32	110 55	113 16	115 30	117 40	119 44	121 43	123 37	125 25	20
17 30	90 00	93 10	96 19	99 25	102 28	105 27	108 21	111 08	113 49	116 23	118 51	121 11	123 24	125 30	127 30	129 23	10
15 00	90 00	93 44	97 25	101 02	104 35	108 00	111 19	114 28	117 26	120 17	122 57	125 27	127 48	130 01	132 05	134 00	I 00
12 30	90 00	94 30	98 57	103 17	107 29	111 27	115 13	118 49	122 08	125 13	128 04	130 43	133 10	135 25	137 30	139 25	50
10 00	90 00	95 39	101 12	106 32	111 35	116 18	120 40	124 39	128 17	131 35	134 34	137 16	139 42	141 55	143 55	145 44	40
7 30	90 00	97 33	104 51	111 42	117 56	123 30	128 27	132 48	136 35	139 55	142 50	145 24	147 39	149 40	151 27	153 02	30
5 00	90 00	101 15	111 45	120 53	128 33	134 53	140 05	144 20	147 51	150 47	153 16	155 22	157 10	158 45	160 07	161 19	20
2 30	90 00	111 48	128 38	140 10	147 58	153 23	157 20	160 17	162 35	164 24	165 53	167 07	168 08	169 01	169 46	170 26	10

LATITUDE

Hour Angle ° ′	15° ° ′	16° ° ′	17° ° ′	18° ° ′	19° ° ′	20° ° ′	21° ° ′	22° ° ′	23° ° ′	24° ° ′	25° ° ′	26° ° ′	27° ° ′	28° ° ′	29° ° ′	30° ° ′	Hour Angle h. m.
90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	VI 00
87 30	90 39	90 41	90 44	90 47	90 49	90 51	90 54	90 56	90 59	91 01	91 03	91 06	91 08	91 10	91 13	91 15	50
85 00	91 18	91 23	91 28	91 33	91 38	91 43	91 48	91 53	91 57	92 02	92 07	92 12	92 16	92 21	92 26	92 30	40
82 30	91 57	92 05	92 12	92 20	92 27	92 35	92 42	92 49	92 57	93 04	93 11	93 18	93 25	93 32	93 39	93 46	30
80 00	92 37	92 47	92 57	93 07	93 17	93 27	93 47	93 47	93 56	94 06	94 16	94 25	94 35	94 44	94 53	95 02	20
77 30	93 17	93 30	93 42	93 55	94 08	94 20	94 32	94 45	94 57	95 09	95 21	95 33	95 45	95 57	96 08	96 19	10
75 00	93 58	94 13	94 29	94 44	94 59	95 14	95 29	95 44	95 59	96 13	96 28	96 42	96 56	97 10	97 24	97 38	V 00
72 30	94 40	94 58	95 16	95 34	95 51	96 09	96 27	96 44	97 01	97 18	97 35	97 52	98 08	98 25	98 42	98 58	50
70 00	95 23	95 44	96 05	96 25	96 46	97 06	97 26	97 46	98 06	98 25	98 45	99 04	99 23	99 42	100 00	100 19	40
67 30	96 07	96 31	96 54	97 18	97 41	98 04	98 27	98 49	99 11	99 34	99 56	100 18	100 39	101 00	101 21	101 42	30
65 00	96 53	97 19	97 46	98 12	98 38	99 04	99 29	99 55	100 20	100 44	101 09	101 33	101 57	102 21	102 45	103 07	20
62 30	97 40	98 10	98 39	99 09	99 37	100 06	100 34	101 02	101 30	101 57	102 25	102 51	103 18	103 44	104 10	104 35	10
60 00	98 30	99 02	99 35	100 07	100 39	101 10	101 41	102 12	102 43	103 13	103 43	104 12	104 41	105 10	105 38	106 06	IV 00
57 30	99 22	99 58	100 33	101 08	101 43	102 18	102 52	103 25	103 59	104 32	105 04	105 36	106 08	106 39	107 10	107 40	50
55 00	100 16	100 55	101 34	102 13	102 50	103 28	104 05	104 42	105 18	105 54	106 29	107 04	107 38	108 12	108 45	109 18	40
52 30	101 14	101 57	102 39	103 20	104 02	104 42	105 22	106 02	106 41	107 20	107 58	108 36	109 13	109 49	110 24	110 59	30
50 00	102 15	103 01	103 47	104 32	105 17	106 01	106 44	107 27	108 09	108 51	109 31	110 12	110 51	111 30	112 08	112 46	20
47 30	103 21	104 11	105 00	105 49	106 37	107 24	108 11	108 57	109 42	110 26	111 10	111 53	112 35	113 17	113 57	114 37	10
45 00	104 31	105 25	106 18	107 10	108 02	108 53	109 43	110 32	111 21	112 08	112 55	113 40	114 25	115 09	115 52	116 34	III 00
42 30	105 46	106 45	107 42	108 38	109 34	110 28	111 22	112 14	113 06	113 56	114 46	115 34	116 21	117 08	117 53	118 37	50
40 00	107 09	108 11	109 13	110 13	111 12	112 11	113 08	114 03	114 58	115 52	116 44	117 35	118 25	119 14	120 01	120 47	40
37 30	108 38	109 46	110 51	111 56	113 00	114 01	115 02	116 01	116 59	117 56	118 51	119 44	120 37	121 27	122 17	123 05	30
35 00	110 17	111 30	112 40	113 49	114 56	116 02	117 06	118 09	119 10	120 09	121 07	122 03	122 37	123 50	124 42	125 32	20
32 30	112 07	113 24	114 39	115 53	117 04	118 14	119 21	120 28	121 31	122 33	123 34	124 32	125 29	126 23	127 16	128 08	10
30 00	114 09	115 31	116 51	118 09	119 25	120 39	121 50	122 59	124 05	125 10	126 12	127 13	128 11	129 07	130 01	130 54	II 00
27 30	116 26	117 54	119 19	120 42	122 01	123 18	124 33	125 44	126 54	128 00	129 04	130 06	131 05	132 03	132 58	133 51	50
25 00	119 02	120 35	122 05	123 32	124 55	126 16	127 33	128 47	129 58	131 06	132 11	133 14	134 14	135 12	136 07	137 00	40
22 30	122 00	123 38	125 13	126 43	128 10	129 33	130 52	132 08	133 20	134 29	135 35	136 37	137 37	138 35	139 29	140 22	30
20 00	125 25	127 08	128 47	130 20	131 49	133 13	134 33	135 49	137 02	138 11	139 16	140 18	141 17	142 13	143 06	143 57	20
17 30	129 23	131 10	132 50	134 25	135 55	137 20	138 39	139 55	141 06	142 13	143 17	144 16	145 13	146 07	146 58	147 46	10
15 00	134 00	135 49	137 30	139 04	140 33	141 55	143 12	144 26	145 33	146 38	147 38	148 34	149 27	150 17	151 04	151 49	I 00
12 30	139 25	141 11	142 50	144 21	145 45	147 03	148 15	149 23	150 26	151 24	152 19	153 10	153 58	154 43	155 26	156 05	50
10 00	145 14	147 23	148 54	150 17	151 34	152 44	153 48	154 48	155 43	156 34	157 21	158 05	158 46	159 25	160 01	160 34	40
7 30	153 02	154 28	155 45	156 55	157 59	158 57	159 50	160 38	161 22	162 04	163 42	163 17	163 50	164 19	164 50	165 15	30
5 00	161 19	162 23	163 20	164 11	164 57	165 39	166 17	166 51	167 23	167 52	168 18	168 43	169 05	169 27	169 46	170 05	20
2 30	170 26	171 00	171 30	171 57	172 22	172 44	173 03	173 21	173 38	173 52	174 06	174 19	174 31	174 41	174 51	175 01	10

TRUE BEARING OR AZIMUTH

LATITUDE

Hour Angle °	'	30° ° '	31° ° '	32° ° '	33° ° '	34° ° '	35° ° '	36° ° '	37° ° '	38° ° '	39° ° '	40° ° '	41° ° '	42° ° '	43° ° '	44° ° '	45° ° '	Hour Angle h.	m.
90	00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	VI	00
87	30	91 15	91 17	91 20	91 22	91 24	91 26	91 28	91 30	91 32	91 34	91 36	91 38	91 40	91 42	91 44	91 46		50
85	00	92 30	92 35	92 39	92 44	92 48	92 52	92 57	93 01	93 05	93 09	93 13	93 17	93 21	93 25	93 29	93 32		40
82	30	93 46	93 53	93 59	94 06	94 13	94 19	94 25	94 32	94 38	94 44	94 50	94 56	95 02	95 08	95 14	95 19		30
80	00	95 02	95 11	95 20	95 29	95 38	95 47	95 55	96 03	96 12	96 20	96 28	96 36	96 44	96 51	96 59	97 06		20
77	30	96 19	96 31	96 42	96 53	97 04	97 15	97 25	97 36	97 46	97 57	98 07	98 17	98 26	98 36	98 45	98 55		10
75	00	97 38	97 51	98 05	98 18	98 31	98 44	98 57	99 10	99 22	99 34	99 46	99 58	100 10	100 21	100 33	100 44	V	00
72	30	98 58	99 14	99 29	99 45	100 00	100 16	100 30	100 45	100 59	101 13	101 27	101 41	101 55	102 08	102 21	102 34		50
70	00	100 19	100 37	100 55	101 13	101 30	101 48	102 05	102 21	102 38	102 54	103 10	103 26	103 41	103 56	104 11	104 26		40
67	30	101 42	102 02	102 23	102 43	103 02	103 22	103 41	104 00	104 18	104 37	104 55	105 12	105 30	105 46	106 03	106 20		30
65	00	103 07	103 30	103 53	104 15	104 37	104 58	105 20	105 41	106 01	106 21	106 41	107 01	107 20	107 39	107 57	108 15		20
62	30	104 35	105 01	105 25	105 50	106 14	106 37	107 01	107 24	107 46	108 08	108 30	108 51	109 12	109 33	109 53	110 13		10
60	00	106 06	106 34	107 01	107 27	107 53	108 19	108 45	109 10	109 34	109 58	110 22	110 45	111 07	111 29	111 51	112 12	IV	00
57	30	107 40	108 10	108 39	109 08	109 36	110 04	110 32	110 59	111 25	111 51	112 16	112 41	113 05	113 29	113 52	114 15		50
55	00	109 18	109 50	110 21	110 53	111 23	111 53	112 22	112 51	113 19	113 47	114 14	114 40	115 06	115 32	115 56	116 20		40
52	30	110 59	111 34	112 08	112 41	113 13	113 45	114 17	114 47	115 17	115 47	116 15	116 43	117 11	117 37	118 04	118 29		30
50	00	112 46	113 22	113 58	114 34	115 08	115 42	116 15	116 48	117 19	117 50	118 21	118 50	119 19	119 47	120 14	120 41		20
47	30	114 37	115 16	116 54	116 31	117 08	117 44	118 18	118 53	119 26	119 58	120 30	121 01	121 31	122 00	122 29	122 56		10
45	00	116 34	117 15	117 55	118 34	119 13	119 50	120 27	121 02	121 37	122 11	122 44	123 16	123 47	124 18	124 47	125 16	III	00
42	30	118 37	119 20	120 03	120 44	121 23	122 03	122 41	123 18	123 54	124 29	125 03	125 36	126 08	126 40	127 10	127 39		50
40	00	120 47	121 32	122 16	122 59	123 41	124 21	125 01	125 39	126 16	126 52	127 27	128 01	128 34	129 06	129 37	130 07		40
37	30	123 05	123 52	124 38	125 22	126 05	126 47	127 27	128 06	128 45	129 21	129 57	130 32	131 05	131 38	132 09	132 40		30
35	00	125 32	126 20	127 07	127 53	128 37	129 20	130 01	130 41	131 19	131 57	132 33	133 08	133 42	134 15	134 46	135 17		20
32	30	128 08	128 57	129 45	130 32	131 17	132 00	132 42	133 22	134 01	134 39	135 15	135 51	136 24	136 57	137 29	137 59		10
30	00	130 54	131 44	132 33	133 20	134 05	134 49	135 31	136 11	136 50	137 28	138 04	138 39	139 13	139 45	140 16	140 46	II	00
27	30	133 51	134 42	135 31	136 18	137 03	137 46	138 28	139 08	139 47	140 24	141 00	141 34	142 07	142 39	143 09	143 39		50
25	00	137 00	137 50	138 39	139 26	140 10	140 53	141 34	142 14	142 52	143 28	144 03	144 36	145 08	145 38	146 08	146 36		40
22	30	140 22	141 12	141 59	142 45	143 29	144 10	144 50	145 28	146 04	146 39	147 12	147 44	148 14	148 44	149 12	149 38		30
20	00	143 57	144 45	145 31	146 15	146 56	147 36	148 14	148 50	149 25	149 57	150 29	150 59	151 27	151 55	152 21	152 46		20
17	30	147 46	148 32	149 15	149 56	150 35	151 12	151 47	152 21	152 53	153 23	153 52	154 20	154 46	155 11	155 35	155 58		10
15	00	151 49	152 31	153 11	153 48	154 24	154 58	155 30	156 00	156 29	156 56	157 22	157 47	158 11	158 33	158 54	159 15	I	00
12	30	156 05	156 43	157 18	157 51	158 22	158 52	159 20	159 47	160 12	160 36	160 58	161 20	161 40	162 00	162 18	162 36		50
10	00	160 34	161 06	161 36	162 04	162 30	162 55	163 18	163 40	164 01	164 21	164 40	164 57	165 14	165 30	165 45	166 00		40
7	30	165 15	165 40	166 03	166 25	166 45	167 04	167 23	167 40	167 56	168 11	168 26	168 39	168 52	169 04	169 16	169 27		30
5	00	170 05	170 22	170 38	170 52	171 06	171 20	171 32	171 44	171 55	172 05	172 15	172 24	172 33	172 41	172 49	172 57		20
2	30	175 01	175 09	175 17	175 25	175 32	175 39	175 45	175 51	175 57	176 02	176 07	176 12	176 16	176 20	176 24	176 28		10

LATITUDE

Hour Angle	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°	57°	58°	59°	60°	61°	Hour Angle h. m.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	VI 00
87 30	91 48	91 50	91 52	91 53	91 55	91 57	91 58	92 00	92 01	92 03	92 04	92 06	92 07	92 09	92 10	92 11	50
85 00	93 36	93 40	93 43	93 47	93 50	93 53	93 57	94 00	94 03	94 06	94 09	94 12	94 15	94 17	94 20	94 23	40
82 30	95 25	95 30	95 35	95 40	95 46	95 50	95 55	96 00	96 05	96 09	96 14	96 18	96 22	96 26	96 30	96 34	30
80 00	97 14	97 21	97 28	97 35	97 42	97 48	97 55	98 01	98 07	98 13	98 19	98 25	98 30	98 36	98 41	98 46	20
77 30	99 04	99 13	99 21	99 30	99 38	99 47	99 55	100 02	100 10	100 18	100 25	100 32	100 39	100 46	100 52	100 58	10
75 00	100 55	101 05	101 16	101 26	101 36	101 46	101 55	102 05	102 14	102 23	102 31	102 40	102 48	102 56	103 04	103 11	V 00
72 30	102 47	102 59	103 11	103 23	103 35	103 46	103 57	104 08	104 19	104 29	104 39	104 49	104 58	105 07	105 16	105 25	50
70 00	104 40	104 54	105 08	105 22	105 35	105 47	106 00	106 13	106 24	106 36	106 47	106 59	107 09	107 20	107 30	107 39	40
67 30	106 36	106 51	107 07	107 22	107 36	107 51	108 05	108 18	108 32	108 45	108 57	109 09	109 21	109 33	109 44	109 55	30
65 00	108 33	108 50	109 07	109 23	109 39	109 55	110 11	110 26	110 40	110 54	111 08	111 22	111 35	111 47	111 59	112 11	20
62 30	110 32	110 51	111 09	111 27	111 44	112 02	112 18	112 34	112 50	113 06	113 21	113 35	113 49	114 03	114 16	114 29	10
60 00	112 33	112 53	113 13	113 33	113 52	114 10	114 28	114 45	115 02	115 19	115 35	115 50	116 05	116 20	116 34	116 48	IV 00
57 30	114 37	114 59	115 20	115 41	116 01	116 20	116 39	116 58	117 16	117 33	117 51	118 07	118 23	118 38	118 53	119 08	50
55 00	116 44	117 07	117 29	117 51	118 13	118 33	118 53	119 13	119 32	119 50	120 08	120 25	120 42	120 58	121 14	121 29	40
52 30	118 54	119 18	119 42	120 05	120 27	120 49	121 10	121 30	121 50	122 09	122 28	122 46	123 03	123 20	123 36	123 52	30
50 00	121 07	121 32	121 47	122 21	122 44	123 07	123 28	123 50	124 10	124 30	124 49	125 08	125 26	125 44	126 00	126 17	20
47 30	123 23	123 50	124 15	124 40	125 04	125 27	125 50	126 12	126 33	126 54	127 13	127 33	127 51	128 09	128 26	128 43	10
45 00	125 44	126 11	126 37	127 03	127 27	127 51	128 14	128 37	128 58	129 19	129 40	129 59	130 18	130 36	130 54	131 10	III 00
42 30	128 08	128 36	129 03	129 29	129 54	130 18	130 42	131 04	131 27	131 48	132 08	132 28	132 47	133 05	133 23	133 40	50
40 00	130 36	131 04	131 32	131 58	132 24	132 48	133 12	133 35	133 57	134 19	134 39	134 59	135 18	135 37	135 54	136 11	40
37 30	133 09	133 38	134 05	134 32	134 57	135 22	135 46	136 09	136 31	136 52	137 13	137 33	137 52	138 10	138 28	138 44	30
35 00	135 46	136 15	136 42	137 09	137 34	137 59	138 23	138 45	139 07	139 29	139 49	140 08	140 27	140 45	141 03	141 19	20
32 30	138 28	138 57	139 24	139 50	140 15	140 39	141 03	141 25	141 47	142 08	142 28	142 47	143 05	143 23	143 40	143 56	10
30 00	141 15	141 43	142 09	142 35	143 00	143 24	143 46	144 08	144 29	144 49	145 09	145 27	145 45	146 02	146 19	146 34	II 00
27 30	144 06	144 34	144 59	145 24	145 48	146 11	146 33	146 54	147 14	147 34	147 53	148 10	148 27	148 44	148 59	149 14	50
25 00	147 03	147 29	147 54	148 17	148 40	149 02	149 23	149 43	150 02	150 21	150 39	150 55	151 12	151 27	151 42	151 56	40
22 30	150 04	150 28	150 52	151 14	151 36	151 57	152 16	152 35	152 53	153 11	153 27	153 43	153 58	154 13	154 25	154 39	30
20 00	153 10	153 33	153 54	154 15	154 35	154 54	155 13	155 30	155 47	156 03	156 18	156 32	156 46	157 00	157 12	157 24	20
17 30	156 20	156 41	157 01	157 20	157 38	157 55	158 12	158 27	158 42	158 57	159 11	159 24	159 36	159 48	160 00	160 11	10
15 00	159 34	159 53	160 10	160 27	160 43	160 58	161 13	161 27	161 41	161 53	162 05	162 17	162 28	162 38	162 49	162 58	I 00
12 30	162 52	163 08	163 23	163 38	163 52	164 05	164 17	164 29	164 41	164 51	165 02	165 12	165 21	165 30	165 38	165 47	50
10 00	166 14	166 27	166 39	166 51	167 02	167 13	167 23	167 33	167 43	167 51	168 00	168 08	168 15	168 23	168 29	168 36	40
7 30	169 38	169 48	169 57	170 06	170 15	170 23	170 31	170 38	170 45	170 52	170 59	171 05	171 11	171 16	171 21	171 26	30
5 00	173 04	173 10	173 17	173 23	173 29	173 35	173 40	173 45	173 50	173 54	173 58	174 03	174 07	174 10	174 14	174 17	20
2 30	176 32	176 35	176 38	176 41	176 44	176 47	176 50	176 52	176 55	176 57	176 59	177 01	177 03	177 05	177 07	177 09	10

of the observer and the meridian of the point of intersection with the equator of the great-circle arc passing through the geographical position of the observer and the geographical position of the observed celestial body. With this difference of hour-angle together with the latitude of the observer, the abridged azimuth tables, or the column of 0° of declination of the present solar azimuth tables, may be entered in the usual columns of time and latitude, and the required azimuth will thus be found.

The present great-circle sailing charts issued by the Hydrographic Office are constructed upon the gonomonic projection, and hence afford the means of accomplishing this purpose. The procedure is simple. It consists of plotting the latitude of the observer on any selected meridian and the observed celestial body in a latitude equal to the declination on a meridian whose difference of longitude from the meridian selected to represent the meridian of the observer is equal to the hour-angle of the observed celestial body, and, having drawn a straight line through the two positions thus plotted, noting the difference of longitude between the intersection with the equator of the straight line so drawn and the meridian selected to represent the meridian of the observer. If the geographical position of the observed body lies on the opposite side of the equator from the position of the observer and beyond the limits of the chart, plot the latter point as if it were on the same side of the equator and note on the equator the longitudes of both points; then join these four points diagonally by straight lines, and the longitude of the intersection of the diagonal lines will give the longitude of the required intersection with equator of the great-circle arc joining the geographical positions of the observer and the observed celestial body.

When either the latitude of the observer or the declination of the observed celestial body is higher than 60°, there will be instances arising in which even the most ample of these charts will not suffice to extend, to its intersection with the equator, the required great-circle arc passing through the geographical position of the observer and the geographical position of the observed celestial body. In such cases resort may be made to a gnomonic chart, known as Godfray's great-circle sailing chart, in which the geographical pole has been chosen as the point of tangency of the plane of projection. In this, however, since the parallels of latitude are represented by a series of concentric circumferences whose radii are equal to $r \times$ cotangent latitude, where r is any convenient linear magnitude and represents the radius of the earth, the equator can not be represented because the cotangent of 0° of latitude is an infinity; and hence the intersection of the straight line representing the great-circle arc passing through the geographical position of the observer and the geographical position of the observed celestial body must be sought on some parallel of latitude near the equator, such as the parallel of 20° of latitude which is made the boundary circle in Godfray's chart. The required azimuth is then found in the column of azimuths tabulated for that declination in the solar azimuth tables which is equal to the latitude of parallel upon which the intersection is found, which, in the case of intersections determined on the boundary circle of Godfray's chart, would be the column of azimuths for 20° of declination.

The condensed tables as here presented may be arranged to stand complete at one opening of a book of fair size; and hence, in addition to being free of the usual interpolations for declination, are rid of the disadvantage of turning from page to page in interpolating for latitude.

MATHEMATICS.—*Equations containing only one unknown constant to represent the parabola, the rectangular hyperbola, and certain exponential curves.* H. E. MERWIN, Geophysical Laboratory.

By completing the following expression $\dfrac{x_2 - x}{y_2 - y} = \dfrac{x_2 - x_1}{y_2 - y_1}$ . . . . . for three points in rectangular coördinates, equations can be formed for the parabola, the rectangular hyperbola, and certain exponential curves, each equation containing only one unknown constant. In each case after solving for the unknown constant, C, any point on the curve can be located by substituting its known coördinate, x_3 or y_3, for x or y of the equation. The curves, represented by the equation, do not pass through the origin.

Equations I and Ia represent the same rectangular hyperbola.[1] If a definite value of x is given, equation I should be used, otherwise Ia.

$$\frac{x_2-x}{y_2-y}=\frac{x_2-x_1}{y_2-y_1}+C\,(x-x_1)\ldots\ldots\ldots\ldots\ldots\text{I}$$

$$\frac{y_2-y}{x_2-x}=\frac{y_2-y_1}{x_2-x_1}+C\,(y-y_1)\ldots\ldots\ldots\ldots\ldots\text{Ia}$$

II and III are parabolas[2] with principal axes parallel to the x- and y-axes respectively.

$$\frac{x_2-x}{y_2-y}=\frac{x_2-x_1}{y_2-y_1}+C\,(y-y_1)\ldots\ldots\ldots\ldots\ldots\text{II}$$

$$\frac{y_2-y}{x_2-x}=\frac{y_2-y_1}{x_2-x_1}+C\,(x-x_1)\ldots\ldots\ldots\ldots\ldots\text{III}$$

Exponential forms[3] are as follows:

$$\frac{x_2-x}{y_2-y}=\frac{x_2-x_1}{y_2-y_1}\,C^{x-x_1}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{IV}$$

$$\frac{y_2-y}{x_2-x}=\frac{y_2-y_1}{x_2-x_1}\,C^{y-y_1}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{V}$$

Equivalent to IV is

$$\frac{y_2-y}{x_2-x}=\frac{y_2-y_1}{x_2-x_1}\,C^{x-x_1}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{IVa}$$

Equivalent to V is

$$\frac{x_2-x}{y_2-y}=\frac{x_2-x_1}{y_2-y_1}\,C^{y-y_1}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{Va}$$

[1] On expansion equation I becomes $A+Bx-Cxy+Dy=0$, where $A=y_2\left(\frac{x_2-x_1}{y_2-y_1}-Cx_1\right)-x_2$, $B=1+Cy_2$, $D=Cx_1-\frac{x_2-x_1}{y_2-y_1}$.

[2] By expansion II becomes $A+By-x+Cy^2=0$, where $A=x_2-y_2\left(\frac{x_2-x_1}{y_2-y_1}+Cy_1\right)$, $B=\frac{x_2-x_1}{y_2-y_1}-C\,(y_2-y_1)$.

[3] IV may be written $A+x+B\,(D-y)\,C^{x-x_1}=0$, where $A=-x_2$ $B=\frac{x_2-x_1}{y_2-y_1}$, $D=y_2$. Or it may be written in the form $y=\frac{a}{Cx}+\frac{x}{Cx}+d$.

Proper choice should be made between IV and IVa or between V and Va so that the logarithm of C will be positive. The exponential curves contain a flexure. On one side of the minimum (or maximum) they extend out indefinitely from both axes; on the other side they reflex and tend to become parallel to one axis. The end without the flexure is intermediate in curvature between a parabola and a rectangular hyperbola. Fig. 1 shows the character of thse curves. They can be made to pass through any three given points of which at least two must be on the non-reflex portion.

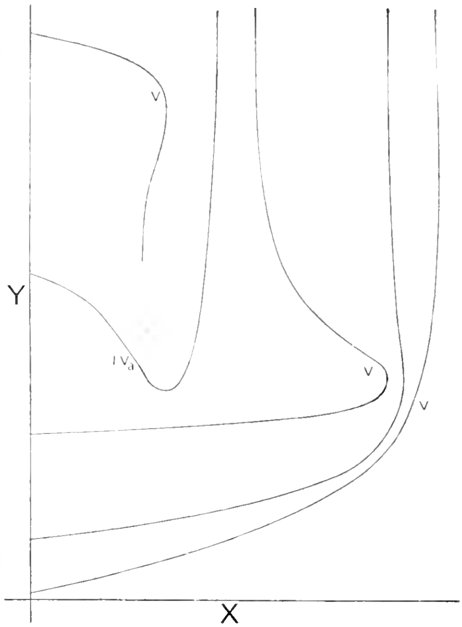


Fig. 1.

PHYSICS.—*The testing of potentiometers.* Frank Wenner and Ernest Weibel, Bureau of Standards.[1]

For precise measurements with a potentiometer the errors in the adjustment of the resistance sections or coils in the apparatus must be known. These errors can be determined by measurements of the resistances of the various sections but, without some systematic method of applying corrections, they are not easily allowed for in the use of the potentiometer.

We have found that it is convenient to express the relation between the known electromotive force, the unknown electromotive force, the readings and the corrections by the formula

$$E = f\,[(e_1 + a_1) + (e_2 + a_2) + \text{etc.}]\,(1 + b + c + d) \qquad (1)$$

[1] Presented at the Washington, 1914, meeting of the American Physical Society.

where

E is the value of the unknown electromotive force

f is the range readings

e_1 is the reading of the highest dial

e_2 is the reading of the next highest dial, etc.

$c = \dfrac{s - 2}{s}$ where s is the value of the known electromotive force

and s is the reading of the known electromotive force dial or dials, and b, d, a_1 and a_2, etc., are small corrections due to errors in the adjustment of the various resistance sections.

The correction a_1 depends only on the reading e_1, a_2 depends only on the reading e_2, etc., b depends only upon the reading s, and d depends only upon f. A table can therefore be constructed for each dial giving the corrections corresponding to each of its possible readings.

Let R_e be the resistance in the potentiometer between the E-terminals and R_s that between the S-terminals. Then if the total current is independent of the settings of the various switches or plugs,

$$\mathrm{E} = S\,R_e/R_s = f[(e_1 + a_1) + (e_2 + a_2) + \text{etc.}]\ (1 + b + c + d) \quad (2)$$

Thus if R_e/R_s is determined for the various readings of f, of e and of s the corrections b, d, a_1, a_2, etc., can be determined.

In order to reduce the time required for making the measurements and to obtain the data in such form that the corrections can be more easily calculated, a special piece of apparatus was constructed and has been in use during the past two years. This apparatus which we shall call a *ratio-set* has been found to furnish a rapid and direct means for calibrating all types of potentiometers which have so far been submitted to the Bureau of Standards for test. It is equivalent to 211,110 resistance sections of 0.01 ohm each, connected in series and so arranged that a branch connection (either to battery or galvanometer) can be made between any two adjacent sections. Or it is equivalent to a slide wire on which contact can be made at 211,110 points. The apparatus is made of 100 resistance sections, 20 of each of the following denominations; 100 ohm, 10 ohm, 1 ohm, 0.1 ohm, and 0.01 ohm. Five dial switches serve to shift resistance sections from one side to the other of the branch connection, or to cut out sections on one side and insert corresponding sections into the other side.

In use the ratio-set is connected in parallel with the potentiometer to be tested in such a way as to form two arms of a bridge, while the potentiometer forms the other two arms. This arrangement constitutes a Matthiessen and Hockin bridge. The ratio-set is adjusted so that a balance of the bridge is obtained for each setting of the dials of the potentiometer for which corrections are desired. The corresponding readings of the ratio-set (when connected for known errors in its resistance sections) give data from which the corrections b, e, a_1, a_2, etc., of equation (1) can be calculated. Certain adjustments are made such that the corrections are obtained almost directly from readings of the potentiometer and ratio-set.

PHYSICS.—*Adjustments of the Thomson bridge in the measurement of very low resistances.* F. WENNER and E. WEIBEL,[1] Bureau of Standards.

The purpose of this paper is to describe two new procedures for carrying out those adjustments which make the correction terms of the Thomson bridge equation negligibly small.

Both procedures require the use of a variable double ratio-set (so adjusted that, for any reading of the dial switches, the lack of equality of the two ratios, α/β, (fig. 1) is so small that no appreciable error is introduced on this account) and variable low resistance to be used in the connections, x_1 and x_2, between the terminals of the ratio-set and the potential terminals of the four-terminal conductors under comparison.

(1) With the test current supplied through the terminals b and b', the bridge is balanced by an adjustment of the dial-switches of the double ratio-set.

(2) With the test current supplied through the terminals n and o, the bridge is balanced by an adjustment of the variable low resistance forming a part of x_1.

[1] Paper to be published in the Bulletin of the Bureau of Standards.

(3) With the test current supplied through the terminals n' and o', the bridge is balanced by an adjustment of the variable low resistance forming a part of x_2.

(4) With the test current supplied through the terminals b and b', the bridge is balanced by an adjustment of the dial-switches of the double ratio-set.

In the other procedure the test current is supplied through the terminals b and b' only, but means are provided for connecting the terminals n and o, and n' and o' by conductors of low resistance. The adjustments are made in 4 steps, of which (1) and (4) are the same as given above. In (2) the terminals n and o are

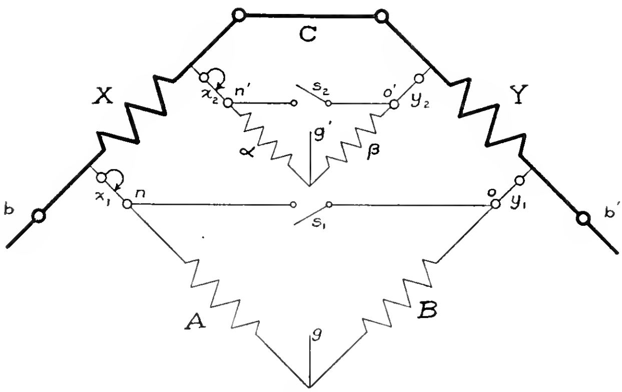


Fig. 1.

connected, while the bridge is balanced by an adjustment of x_1, and in (3) the terminals n' and o' are connected while the bridge is balanced by an adjustment of x_2.

Either procedure gives very accurately

$$x = ay/b \tag{1}$$

where x and y are the resistances of the four-terminal conductors under comparison; and A and B are the resistances between n and g, and g and o, when the final adjustment is made.

Both procedures differ from those previously used mainly in that they do not require changing over to a simple bridge by opening the low resistance connection between the resistances under comparison. Where the resistances under comparison and the resistance of the connection between them are very low, it is more or less impracticable to change over to a simple bridge during the adjustments. In such cases these procedures have been found more satisfactory.

MINERALOGY.—*Melilite and other minerals from Gunnison County, Colorado.* ESPER S. LARSEN and J. FRED HUNTER,[1] Geological Survey.

INTRODUCTION

The minerals described in this paper were collected by the authors during the summers of 1912–13 in the course of the geologic mapping of the Uncompahgre quadrangle, Colorado, under the direction of Whitman Cross. All but the anatase are from a small complex of peculiar igneous rocks near Iron Hill on the east bank of Cebolla Creek opposite the Cebolla Hot Springs, and a few miles southeast of Powderhorn post office, Gunnison County, Colorado.[2]

The rocks mapped in this area are, in the order of their age, a coarse-grained rock made up largely of melilite for which the name Uncompahgrite is proposed, a pyroxenite which locally carries segregated bodies of titaniferous iron ore, a rock related to ijolite, soda syenite, cancrinite syenite, and nepheline gabbro (or essexite).

The anatase was found in veinlets along joint planes in a dioritic dike which cuts the pre-Cambrian rocks in the gully about half a mile northeast of the Lot Mine, a few miles east of north of the mouth of Powderhorn Creek and Powderhorn post office, and only a few miles north of the Iron Hill area.

MELILITE

Occurrence and association. Several bodies of rock made up chiefly of melilite and for which the name Uncompahgrite is

[1] Published with the permission of the Director of the United States Geological Survey.

[2] All locations are given with reference to the United States Geological Survey topographic map of the Uncompahgre quadrangle.

proposed were found in the drainage of Beaver Creek, in all, covering an area a little less than a square mile. The largest of these is between the forks of Beaver Creek; others are south of the main Beaver Creek. The rock of these bodies is about two-thirds or more melilite with considerable pyroxene, magnetite, perofskite, and apatite, and in places biotite, calcite, and other minerals. It varies greatly in texture but is commonly coarse, and cleavage pieces of melilite a foot across are not uncommon. The finest grained rock is hypidiomorphic granular with crystals averaging 1 mm. across. In the coarser rock the luster of the giant melilite individuals is mottled by large included crystals of the other constituents. The melilite is anhedral so far as observed.

Physical properties. The mineral has a rather perfect basal cleavage, which is better developed in some specimens than in others. Its hardness is about 5. The specific gravity of the analyzed specimen is 2.98.

Optical properties. The pyroxene and ore are somewhat irregularly distributed in the large melilite crystals so that considerable sized fragments of melilite can be obtained nearly free from inclusions. The melilite is nearly colorless, to gray, and has a noticeably greasy luster. Splinters are clear and transparent but carry scattered, minute inclusions of opacite—probably magnetite. The gray color and lack of transparency of rather thick masses are due to these inclusions. In thin sections the melilite is colorless, and contains large crystals up to several centimeters across of pyroxene, apatite, calcite, magnetite, and perofskite in addition to the minute inclusions of opacite which are commonly collected in irregular areas or streaks. In the finer-grained rocks, sections of melilite with the maximum birefringence show a well-developed cleavage (001). Powdered fragments of the mineral commonly lie on the basal cleavage and hence are normal to the optic axis. The mineral is uniaxial and negative. The indices of refraction were measured on two polished plates from the analyzed specimen and also on polished plates from two other specimens from different outcrops. The following values were found: Coarse, analyzed material. $\omega_{Na} = 1.6319$ and

1.6326, av. 1.6323; ϵ_{Na} = 1.6254 and 1.6259, av. 1.6257; $\omega_{Na} - \epsilon_{Na}$ = 0.0066; $(\omega - \epsilon)$ measured = 0.007. In medium-grained material from another locality, ω_{Na} = 1.6327 and 1.6336, av. 1.6331; ϵ_{Na} = 1.6270 and 1.6273, av. 1.6271; $(\omega_{Na} - \epsilon_{Na})$ = 0.0060. In fine-grained material from a third locality, ω_{Na} = 1.6327; ϵ_{Na} = 1.6258; $\omega_{Na} - \epsilon_{Na}$ = 0.0069. Repeated measurements on a single plate checked to within 0.0002 so that the differences shown above are due to an actual difference in the values for different fragments.

In the greater part of the thin sections examined the melilite shows normal grayish interference colors almost identical with those of the associated apatite. In a few it shows abnormal blue colors and has a birefringence considerably lower than that of the associated apatite.

Resemblances. In the hand specimen the melilite closely resembles nephelite and, indeed, it is not always possible to distinguish between the melilite of some of the melilite rocks and the nepheline of some of the associated ijolites without the aid of a microscope. It is also difficult to distinguish the melilite rocks from some of the associated apatite-rich rocks, and chemical tests are necessary in some cases as the two minerals are similar both megascopically and microscopically. The apatite is whiter than the melilite and in thin sections it lacks cleavage and is commonly clearer than the melilite; otherwise its optical properties, when in granular aggregates, are almost identical with those of melilite.

Chemical properties. Material for the chemical analysis was carefully picked by hand from one of the coarse-grained specimens collected from an outcrop about 100 yards northeast of the point at which the mapped road up the south fork of Beaver Creek crosses that creek and about a mile above the mouth of North Beaver Creek. A careful microscopic examination of the sample showed the presence of a small amount of calcite and apatite, still less of pyroxene, and a very little opacite as small inclusions in the melilite. The mineral gelatinizes readily when treated with weak acids.

The following analysis (1) was made by W. T. Schaller in the laboratory of the United States Geological Survey. Analysis (2), which is of melilite from Capo di Bove, Italy, is given for comparison.

TABLE 1

Analyses and Ratios of Melilite

	1	1a	Ratios		2
SiO_2	42.07	44.13	732	710	41.09
Al_2O_3	10.30	10.80	106	103	10.93
Fe_2O_3	0.50				3.40
TiO_2	0.20				
FeO	2.18	2.04	28		
MnO	0.16	0.16	2		
MgO	4.15	4.35	108	787	5.87
CaO[1]	35.41	34.63	618		34.78
Na_2O	3.24	3.40	55		3.40
K_2O	tr.	tr			0.68
P_2O_5	0.82				
CO_2	0.90				
H_2O	0.47	0.49			0.24
	100.40	100.00			100.39

1. Melilite from Beaver Creek, Gunnison County, Colorado. W. T. Schaller, analyst.

1a. Analysis computed free from apatite, calcite, magnetite, and perofskite.

2. Melilite from Capo di Bove, Italy. Bodlaender, analyst.

[1] BaO and SrO were not determined. The melilite rock contains 0.28% BaO and 0.35% SrO and this is believed to be in the melilite.

Alteration. Two types of alteration of the melilite have been recognized, and both are believed to be due to contact metamorphism. In the more common type the melilite is altered to a very fine aggregate of garnet, diopside, and vesuvianite, with some calcite, zeolites, and several undetermined minerals. It appears to be a recrystallization of the melilite, probably without important additions or subtractions of chemical constituents. In the less common type the melilite is altered to a fibrous aggregate of a new mineral—cebollite, described in the following paper. The alteration begins along the cleavages and seams in the melilite, spreads out, and finally replaces all of that mineral. Melilite has been found in all stages of this alteration, which is no doubt due to the action of water solutions, probably hot solutions from the intruding pyroxenite magma.

PEROFSKITE

The relatively rare mineral, perofskite, is an abundant constituent of the melilite rock, the pyroxenite, and the ijolite. It is one of the chief constituents of the magmatic segregations of "iron ore" which are abundant in the pyroxenite. These segregations are made up of about equal amounts of magnetite and perofskite with varying amounts of apatite and biotite. So far as observed there is no ilmenite present. Singlewald[3] and Brunton[4] have not distinguished this type of iron ore from the more common ilmenite-magnetite ore.

In the melilite rock the perofskite, which is commonly in grains or octahedral crystals, forms several per cent of the rock, and locally is next to melilite in abundance. The larger crystals are several millimeters across.

The perofskite is iron black in color and has a sub-metallic luster approaching adamantine. In appearance it differs from magnetite, chiefly in luster, and the two minerals are difficult to distinguish megascopically except by the lack of magnetism in the perofskite. It is even more difficult to distinguish from some of the titaniferous garnet.

In thin sections the perofskite is weakly birefracting and shows a complex of polysynthetic twin lamellae resembling the grating of microcline or less often the albite and pericline twins of plagioclase. It is translucent and, in transmitted light, is Saccardos umber[5] in color and is perceptibly pleochroic with the absorption

[3] Singlewald, J. T., The iron ore deposits of the Cebolla District, Gunnison County, Colorado: Econ. Geol., **7**: 560. 1912.

[4] Brunton, S., Some notes on titaniferous magnetite. Econ. Geol., **8**: 677. 1913. Iron stained plagioclase is mentioned as a constituent of the iron ore from the Cebollite District. We have found no plagioclase in the ore but some of the perofskite shows polysynthetic twinning somewhat resembling that of plagioclase and might have been mistaken for an iron stained plagioclase.

[5] Color 17″ k of Ridgway's "Color standards and nomenclature," 1912, Washington, D. C.

$Z > X$. Its index of refraction is 2.34 and its birefringence, about 0.002. In thin sections it is distinguished from the garnet, which is also common in the rocks, by its slightly different color and especially by its weak birefringence and twinning, which is uniformly present except in a few of the very small crystals.

TITANIFEROUS ANDRADITE

Black andradite garnet is present in most of the igneous rocks of the Iron Hill area but is especially abundant in the rock related to ijolite and locally is an important constituent of the soda syenite. Specimens of a soda syenite collected from near the contact with the pyroxenite on the southeast slope of the knob 9500′ + north of North Beaver Creek are made up of microperthite and somewhat less garnet which is interstitial to the feldspar. The garnets are commonly about a millimeter across, are anhedral, black, and of submetallic luster. In thin sections they are dark reddish brown and are not very different from some of the perofskite for which they were at first mistaken. Their index of refraction was measured by the imbedding method and found to be 1.907 ± 0.005.

An approximate analysis of the garnets was made by W. T. Schaller of the Geological Survey with the following results:

TABLE 2

APPROXIMATE ANALYSIS OF TITANIFEROUS ANDRADITE

SiO_2	34.30	
Al_2O_3	4.46	
TiO_2	5.08	(equals 4.57 Ti_2O_3)
Fe_2O_3	24.09	(total iron as Fe_2O_3)
CaO	31.06	
MgO	0.52	
	99.51	

The analysis shows that the garnet is an andradite rather high in titanium. A similar garnet is an important constituent of the ijolite and locally it is the chief dark mineral. Some parts of the ijolite are made up of coarse anhedral garnet and nepheline in about equal amounts with a little pyroxene, apatite, perofskite, biotite, magnetite, etc. Grains of garnet several centimeters across are not uncommon.

BLUE ANATASE

Beautiful, dark blue crystals of anatase were found in narrow veinlets and in the adjoining altered country rock about half a mile north of the Lot Mine. The veinlets are only a few millimeters across although the rock on either side is altered for several millimeters. These veinlets were found only in a single dike of a dioritic rock a few hundred feet across, but in this dike were observed in abundance for a distance of nearly a mile and doubtless continued beyond the limits of observation. They are commonly nearly parallel to the walls of the dike, but some trend across the dike, thus forming a network; they probably filled shrinkage joints in the diorite.

The anatase originally formed somewhat less than half the vein filling; the other minerals of the filling are altered to limonite and no trace of their original character was found. In addition to occurring in the vein anatase is present in disseminated crystals in the adjoining altered country rock.[6]

The anatase crystals are commonly well formed and are bounded by a large number of faces. Their habit is pyramidal, tabular, or prismatic. In size they reach a centimeter in greatest dimension. In color the mineral varies from deep blue to almost black. The lighter colored crystals are translucent and some, if of sufficient size, might make beautiful gem stones with their deep blue color and highly adamantine luster. An approximate chemical analysis showed that the blue mineral is essentially TiO_2. Optically it is uniaxial, negative, has a strong birefringence and an index of refraction (ω) of about 2.56.

[6] Specimens shown us by Mr. Frank L. Hess, of the Geological Survey, from near Hot Springs, Arkansas, show anatase and pyrite in veinlets and the accompanying altered country rock and somewhat resemble the material described in this paper.

MINERALOGY.—*Cebollite, a new mineral.* ESPER S. LARSEN and W. T. SCHALLER,[1] Geological Survey.

At several places, notably six-tenths of a mile southwest of the forks of Beaver Creek near Powderhorn, Gunnison County, Colorado, some of the melilite of the occurrence described in the preceding paper is altered to a dull, compact, white to greenish, fibrous aggregate, which on microscopical and chemical study proved to be a new mineral, for which the name *Cebollite*[2] is here proposed. In some specimens the melilite is replaced by a fibrous aggregate of cebollite with little else while in others bodies of the vesuvianite-garnet diopside type of alteration are scattered through the cebollite. In general the two types of alteration appear to be distinct. Thin sections show that the cebollite is in microscopic fibers, commonly arranged normal to the original cleavage of the melilite, or in fan-like or arborescent aggregates.

Physical properties. Cebollite has a hardness of about 5 and a specific gravity of about 2.96. It fuses at about 5 to a clear glass. On account of the small size of the fibers cleavage could not be recognized.

Optical properties. The mineral is white to greenish gray, The fibers are very minute and the optical properties could be determined only approximately. The indices of refraction as measured by the immersion method are: $\alpha = 1.595 \pm 0.003$; $\beta = 1.60$; $\gamma = 1.628 \pm 0.005$. The extinction is parallel and the elongation is positive. The fibers are too minute to yield a satisfactory interference figure but the mineral is biaxial and positive. The axial angle could not be accurately measured but 2E is about $80 \pm 10°$ and hence 2V is about 58°. The mineral is probably orthorhombic. Cebollite may be identical with the mineral described by Rosenbusch[3] as an alteration product of melilite and considered by him to be a zeolite.

[1] Published with permission of the Director of the United States Geological Survey.

[2] Pronounced Cĕ- vŏi- 'īte. From Cebolla Creek in whose drainage the mineral was collected. As in the preceding paper, locations are with reference to the topographic map of the Uncompahgre quadrangle, Colorado.

[3] Mikroskopische Physiographie der Mineralien und Gesteine, I : 2, 4te Aufl., p. 72.

Chemical properties. The material selected for analysis represented the completely altered melilite and consisted mainly of cebollite but contained considerable garnet, diopside, and vesuvianite so intimately admixed that separation was found impossible. The analysis made by W. T. Schaller in the laboratory of the U. S. Geological Survey is given below in Column 1. In Column 2 the analysis is computed free from the insoluble portion which represents diopside, garnet, etc. In Column 3 the analysis of the fresh melilite is given for comparison.

Analysis of Cebollite

By W. T. Schaller

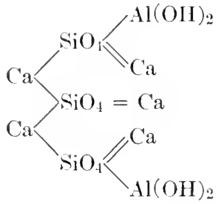
	1	2		Ratios		3
SiO_2	27.06	33.02	0.550	3.26	3 × 1.09	44.13
Al_2O_3	11.49	14.02	0.137	0.94	1 × 0.94	10.80
Fe_2O_3	2.81	3.43	0.021			
FeO	0.17	0.21	0.003			2.04
MnO						0.16
MgO	3.84	4.69	0.117	4.74	5 × 0.95	4.35
Na_2O	2.10	2.57	0.041			3.40
K_2O	tr.	tr.				tr.
CaO	29.27	35.72	0.638			34.63
H_2O-	none	none				
H_2O+	5.13	6.26	0.348	2.06	2 × 1.03	0.49
Insol.	18.05					
	99.92	99.92				100.00

1. Cebollite from 0.6 of a mile south of the forks of Beaver Creek, Gunnison County, Colo.
2. Analysis computed free from insoluble portion, diopside, garnet, vesuvianite, etc.
3. Melilite from Beaver Creek, Gunnison County, Colo.

The formula derived from the analysis is $3SiO_2.Al_2O_3.5RO.2H_2O$, in which R is chiefly Ca with smaller amounts of Mg, Na_2, and Fe. The ratio of Na_2O : MgO + FeO : Ca is about 1 : 3 : 16. Considering all the RO as CaO, the formula of cebollite, $H_4Al_2Ca_5Si_3O_{16}$ may be written in two ways, as follows:

1. .... $(SiO_4)_3.Ca_5.[Al(OH)_2]_2$.
2. .... $(SiO_4)_3.(CaOH)_4.Ca.Al_2$.

The powdered mineral, treated with water, does not react alkaline with phenolpthalein and adopting the suggestion of Clarke that for silicates the presence of the (CaOH) group is indicated by such a reaction, the second of the above two formulas becomes untenable and the formula of cebollite, $(SiO_4)_3 . Ca_5[Al(OH)_2]_2$, is written structurally.



The mineral gelatinizes with acids and gives off water when heated in a closed tube.

Cebollite does not appear to be closely related to any other known minerals. It may belong to the zeolites although it contains a larger amount of MgO than is common in minerals of that group.

MINERALOGY.—*Wurtzite at Goldfield, Nevada.* F. L. RANSOME, Geological Survey.

In a report[1] on the geology and ore deposits of Goldfield, Nevada, sphalerite was recorded as being present in small quantity associated with some of the gold ore. Since that work was published, the studies of Allen and his associates[2] and of B. S. Butler[3] have given new significance to the occurrence of the hexagonal sulphide of zinc, wurtzite, which has generally been regarded as a rather rare mineral partly, no doubt, because it has been frequently overlooked.

Allen and Crenshaw have shown that the presence of wurtzite

[1] Ransome, F. L., The geology and ore deposits of Goldfield, Nevada. U. S. Geol. Survey Prof. Paper 66, 1909.

[2] Allen, E. T., Crenshaw, J. L., and Merwin, H. E., The sulphides of zinc, cadmium, and mercury; their crystalline forms and genetic conditions. Am. Jour. Sci. (4) **34**: 341–396. 1912.

[3] Geology and ore deposits of the San Francisco and adjacent districts, Utah. U. S. Geol. Survey Prof. Paper 80, pp. 93–95, 149–150, and 153–158. 1913.

is to be expected where ore containing zinc sulphide has been deposited by acid solution at temperatures below 300°C. The Goldfield ores, containing alunite and marcasite, two minerals formed in an acid environment, are believed to have been deposited comparatively near the surface by the mingling of descending waters containing sulphuric acid with ascending thermal waters containing hydrogen sulphide and probably alkali sulphides. Under such conditions, at least a part of the zinc sulphide present, as was orally suggested to me by my colleague Dr. J. B. Umpleby, might crystallize as wurtzite.

To test this suggestion some of the material collected in 1908 from the workings of the Mushett lease on the Miss Jessie claim, one of the few places in the district where zinc sulphide had been found at that time, was reëxamined. This ore was originally described as follows:

> The ore of the Mushett lease on the Miss Jessie claim northeast of the Red Top mine is structurally and mineralogically one of the most interesting in the district. The proportion of sulphides to gangue is greater than in most of the mines. The metallic minerals noted are pyrite, famatinite, bismuthinite, sphalerite, and a dark-gray mineral identical in appearance with that analyzed and described on page 116, and probably like it the new species goldfieldite. This material is rich in gold, specimens which to the naked eye show not a particle of the native metal yielding over $8000 a ton on assay. The crustification in the Mushett ore is not very regular, but the minerals have formed in the following general succession: (1) pyrite; (2) famatinite, bismuthinite, goldfieldite; (3) sphalerite; and (4) pyrite. The sphalerite in some places forms botryoidal crusts over the prisms of bismuthinite, which attain a larger size in this ore body than in other known occurrences in the district.
>
> The material forming the extreme outer crust of the nodular ores of Goldfield or filling interstices between the altered and incrusted rock fragments is in most places a soft mixture of alunite and pyrite.[4]

The so-called sphalerite is dark reddish brown, forms crusts rarely over half an inch thick and in places it shows a rather indistinct radial fibrous structure. Reëxamination shows that a little marcasite is present as minute botryoidal aggregates on some of the pyrite but is less abundant than in certain other rich Goldfield ores.

[4] Ransome, F. L., Op. cit., p. 165.

In thin section under the microscope a considerable part of the material, particularly that forming the inner portion of the crust, may be seen to consist chiefly of radial aggregates of distinctly birefringent prisms with very indefinite individual outlines. These fibers, which are clearly wurtzite, show a tendency to diverge from points on the inner surface of the crust, becoming less distinct toward their free ends where the birefringent aggregate grades into material that is chiefly sphalerite, containing here and there little flecks of wurtzite. In some aggregates the prisms have grown radially outward from small dark nuclei which appear to consist chiefly of ferruginous zinc sulphide, in part at least, wurtzite. As a rule the aggregates of wurtzite in addition to their radially fibrous structure show a noticeable although discontinuous concentric parting. In ordinary light the wurtzite and sphalerite are practically indistinguishable except in a few parts of the section where sphalerite may be recognized by its dodecahedral cleavage; but generally both sphalerite and wurtzite are traversed by a multitude of irregular cracks which mask any cleavage that might otherwise be visible.

Wurtzite in very intimate association with sphalerite and visually distinguishable from that mineral only by its birefringence, has been described from the Horn Silver mine, Utah, by B. S. Butler.[5] Mr. Butler's conclusion, which is apparently well supported, is that the wurtzite is younger than the sphalerite and was formed by the action of descending acid solutions, although, as he states, there are some features of the association of the two minerals that are difficult to account for through this explanation.

The Goldfield occurrence offers little in support of the view that the wurtzite has resulted from an external attack on the sphalerite by acid solutions. If both minerals originated by deposition from solution, present relations would indicate the sphalerite to be younger than at least a part of the wurtzite. If, however, one mineral has undergone enantiotropic change to the other, it is difficult, if not impossible, to determine which was the primary form, as such a change would not necessarily begin at the surface of a crystal grain.

[5] Op. cit., pp. 149–150. 1913.

That sphalerite, under natural condition, may change by molecular rearrangement into wurtzite was suggested by Laspeyres[6] and more definitely stated by Noetling,[7] who concluded as the result of his investigation that sphalerite is primary and wurtzite secondary in origin.[8]

The conclusion that when sphalerite and wurtzite are associated, the wurtzite is generally of secondary origin appears to have considerable support from direct observations; but this relation, if it is true, still lacks satisfactory explanation. If, for example, the wurtzite has been deposited by descending acid solutions, it is not clear why it should be so intimately associated with or replace the less soluble sphalerite. On the other hand if sphalerite, theoretically the more stable mineral at ordinary temperatures, undergoes change to wurtzite, the cause of this change is equally obscure. Although it is well known that sphalerite may be changed to wurtzite by heating to about 1100°C.,[9] this is probably not a common natural mode of formation of the latter mineral. Whether the change of sphalerite into wurtzite can be effected by treatment with acid solutions at moderate temperatures has not been determined so far as I am aware, but this question appears to be easily within the range of experiment.

The rather inconclusive evidence as to the paragenetic relationship of the two zinc sulphides at Goldfield leaves the mode of origin of the wurtzite in doubt. The suggestion is favored that the wurtzite is later than the sphalerite and represents a molecular rearrangement of that mineral. But the explanation originally offered for the deposition of the ores through a mingling of alkaline and acid solutions is quite in harmony with the supposition that the sphalerite and wurtzite crystallized at approximately the same time.

[6] Laspeyres, H., Mineralogische Bemerkungen, Zeits. f. Krist., **9**: 191. 1884.

[7] Noelting, J., Ueber das Verhältniss der sogenannten Schalenblende zur regulären Blende und zum hexagonalen Wurtzit. Inaug. Diss., Kiel, p. 28. 1887.

[8] "Jedenfalls beweisen die Untersuchungen der Blenden von Stollberg, Scharley, Bleischarley, Altenberg, Wiesloch und Miechowitz, dass die Blende primären und der Wurtzit secundären Ursprungs sein muss" (p. 29).

[9] Allen, Crenshaw and Merwin, op. cit., p. 344.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

BACTERIOLOGY.—*The characteristics of bacteria of the colon type found in bovine feces.* L. A. Rogers, William Mansfield Clark, and Alice C. Evans. Journal of Infectious Diseases, **15**: 100-123. July, 1914.

Previous work on a collection of the colon type from milk demonstrated that the gas ratio and volume are constant under uniform conditions; that, on the basis of the gas ratio and volume, the cultures may be divided into two distinct groups; and that the correlation of the fermentative ability with the gas ratio makes this distinction sharply defined.

This paper records the results of a similar study on 150 cultures isolated from bovine feces. None of these cultures liquefied gelatin and all but one formed indol from tryptophan. By the use of a simple medium and exact methods of analysis, it was found that in 149 cultures the $CO_2 : H_2$ ratio varied only from 0.98 to 1.20. One culture only gave a ratio identifying it with the high-ratio group, which made up 48 per cent of the milk series.

The 149 low-ratio (0.98–1.20) cultures were readily divided into two groups, one of which fermented dextrose, saccharose, lactose, raffinose, mannite, glycerin and dulcite, but almost invariably failed to ferment starch, inulin and adonite, while the second group fermented adonite and dulcite and failed to ferment saccharose, raffinose, starch and inulin.

These groups agree almost perfectly with two groups which may be formed from the low-ratio cultures isolated from milk. Special methods failed to give evidence, with the exception of the single culture mentioned, of the presence in bovine feces of the high-ratio group, which made up about one-half of the milk collection. L. A. R.

BACTERIOLOGY.—*Bacteria concerned in the production of the characteristic flavor in cheese of the Cheddar type.* ALICE C. EVANS, E. G. HASTINGS, and E. B. HART. Journal of Agricultural Research **2**: 167–192. June, 1914.

The organisms constantly found in Cheddar cheese in such numbers as to indicate they must function in the ripening process may be divided into four groups: First, the *Bacterium lactis acidi;* second, the *Bacterium casei;* third, Streptococcus; fourth, Micrococcus. Each of the four groups may be divided into a number of varieties on the basis of the fermentation powers.

The flora of raw milk cheese consists of all the varieties into which the four groups were divided; but the flora of pasteurized milk cheese, with the exception of the *Bacterium casei* group, is dependent upon the flora of the starter.

No Cheddar flavor is obtained in pasteurized milk cheese when the organisms of the *Bacterium lactis acidi* group alone are used as starters. The quality of the cheese is improved when starters composed of a certain combination of *Bacterium lactis acidi* and Streptococcus are added to pasteurized milk. A. C. E.

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Under this heading it is proposed to include, by author, title, and citation, references to all scientific papers published in or emanating from Washington. It is requested that authors coöperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

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PHYSICS.—*The specific heat of copper in the interval 0° to 50°C., with a note on vacuum-jacketed calorimeters.*[1] D. R. Harper 3d, Bureau of Standards.

The determinations in the temperature range 0 to 100° are interpreted to indicate that the specific heat of copper (hard-drawn probably excepted) at 50° is between 0.0926 and 0.0931.

The specimen of copper was a long annealed wire (50 meters) 99.87 per cent pure, suspended in vacuo and connected as part of an electric circuit. A measured quantity of heat could thus be imparted to it electrically and the temperature rise found by using the specimen itself as a resistance thermometer. The test specimen was thus its own calorimeter, no other substance being included in the "water equivalent" with the single exception of a few grams of mica necessary for electrical insulation. To arrange a large enough amount of copper in a form suitable for the electrical measurements, the wire was coiled into spirals containing about 150 cm. each and 32 of these, superposed with mica plates between, built up a cylinder about 10 cm. by 10 cm. containing over 2 kgm. of copper and possessing an electrical resistance of about 0.2 ohm, sufficient to permit of making the necessary measurements with requisite accuracy.

Potential leads tapped in at a distance from the ends of the wire served to define a portion whose mass was that of copper involved in the determination. The resistance of this portion

[1] To appear in the Bulletin of the Bureau of Standards, **11**, 1914.

was that which was comprehended in the thermometric factor, and the energy supplied to it during the period of heating was the product of the current in the coil by the potential drop between these leads, integrated over the time the heating circuit was closed. This potential drop was measured directly with a potentiometer and the current was measured with the same potentiometer balanced on the drop across a 0.1 ohm resistance standard connected in the series in the circuit. The time factor was obtained by automatic chronograph record of the instants when the heating current was switched on and off.

The specimen was heated 4° to 5° in each experiment, the rise in temperature being determined by the change of resistance of the specimen relative to the resistance of a 0.1 ohm manganin resistance standard immersed in an oil bath. The comparison was effected by a potentiometer, sensitive to about one part in five hundred thousand, and the current employed in making the comparison was small enough (about 0.3 amp.) that its heating effect on the specimen (about 0.001 per minute) could readily be allowed for without appreciable error.

To obtain the factor for the reduction of the increase in resistance to rise of temperature on the international hydrogen scale, the copper thermometer was compared at several temperatures with two standard platinum thermometers in a stirred oil-bath comparator.

By suspending the specimen in vacuo, the uncertainties in the cooling correction which occur at atmospheric pressure due to convection were avoided, the magnitude of the correction was increased, and uncertainty in the amount of air to be included in the water-equivalent (a source of error barely appreciable) was avoided. The efficacy of the vacuum jacket in reducing the magnitude of the cooling correction was by no means what was anticipated.

The results of 27 determinations at temperatures between 15° and 50° possess an average deviation of one part in a thousand millimeters from $0.383_4 + 0.00020\ (t\text{-}25)$ international joules per gram degree; equivalent to $0.0917 + 0.000048\ (t\text{-}25)$ calories_{20} per gram degree, if 4.182 joules equal one (20°) calorie.

PHYSICS.—*An experimental study of the Koepsel permeameter.* CHARLES W. BURROWS.[1] Bureau of Standards.

A detailed experimental study of the possibilities and limitations of the Koepsel permeameter has led to the following conclusions regarding the different factors which may affect the accuracy of the readings:

1. Readings on the two sides of the zero of the instrument may differ considerably but the mean of the two values thus obtained shows satisfactory consistency on repetition.
2. Shearing curves for different grades of material show that the correction to be applied to the observed magnetizing force is not constant for a given induction, but depends upon the nature of the test specimen. This correction is usually subtractive for points below the knee of the induction curve and additive for points above the knee.
3. An increase in the cross section of the test specimen tends to increase the observed values of the magnetizing force for points below the knee of the induction curve, and to decrease the observed values for points above the knee.
4. The length of the specimen projecting beyond the yokes produces no noticeable effect for points below the knee of the induction curve. For points above the knee the projecting ends increase the observed value of the magnetizing force.
5. If the bushings are not pushed all the way into their proper position, a higher apparent value of the magnetizing force is observed due to the increased length of the portion of the bar under test.
6. Hysteresis loops obtained by the Koepsel permeameter always show a low observed residual induction and a high observed coercive force.
7. A theoretical and experimental study of the distribution of the magnetic fluxes through different parts of the magnetic circuit shows that shearing curves of the form observed are to be expected.

Apparatus of this type if used without correction may yield data greatly in error. The results of the present study show that for small and moderate inductions the measured magnetizing force is usually in excess of its true value, sometimes by as much as 100 per cent. At high inductions the measured magnetizing force is usually too low by an error which may be as great as 25 per cent. With care, however, and the use of proper correction curves, the apparatus is capable of yielding quanti-

[1] Detailed paper to appear in the Bulletin of the Bureau of Standards.

tive normal induction data in which the error in the magnetizing force is not greater than 5 per cent.

Uncorrected hysteresis data for hard steels show values of the residual induction that are too small by an error which may be as much as 10 per cent, while the coercive forces are too large by an error which may be as much as 40 per cent.

The chief value of such an instrument is for comparative work in which it is desired to determine the degree of uniformity of material or the relative values of similar materials.

PHYSICS.—*The insulating properties of solid dielectrics.*[1] HARVEY L. CURTIS, Bureau of Standards.

Two properties of dielectrics are considered: (1) the volume resistivity and (2) the surface resistivity. The volume resistivity of a material is the resistance in ohms between two opposite faces of a centimeter cube. The surface resistivity is defined as the resistance between two opposite edges of a centimeter square of the surface film which is deposited upon the material.

In measuring the volume resistivity, mercury electrodes were employed in order to make good contact, and a guard-ring was used to prevent any errors on account of surface leakage. The effects of the temperature of the specimen, of the humidity of the surrounding air, and of the magnitude and length of application of the applied voltage were studied. The only one of these which, for ordinary laboratory conditions, affects the order of magnitude of the results is the length of application of the voltage, and this is of importance only if the volume resistivity is greater than 10^{13}. Values of the volume resistivity are given in Table I.

Since the surface resistivity depends upon the surface film any condition which will affect this film will affect the surface resistivity. Upon the surface of all insulators except the waxy materials a film of moisture collects from the surrounding air. The thickness and conductivity of this film depends upon the material of which the insulator is composed and upon the relative

[1] Detailed paper to appear in the Bureau of Standards Bulletin.

TABLE 1

VOLUME RESISTIVITY OF SOLID DIELECTRICS

(Materials arranged in order of decreasing resistivity)

Material	*Resistivity ohms-cm.*	*Material*	*Resistivity ohms-cm.*
Special Paraffin.....over	5000×10^{15}	Paraffined Mahogany......	40×10^{12}
Ceresin............over	5000×10^{15}	Stabalite..................	30×10^{12}
Fused Quartz.......over	5000×10^{15}	Plate Glass.................	20×10^{12}
Hard Rubber.............	1000×10^{15}	Hallowax No. 1001.........	20×10^{12}
Clear Mica..............	200×10^{15}	Dielectrite.................	5×10^{12}
*Sulphur.................	100×10^{15}	Bakelite No. 5199 RGRB...	5×10^{12}
*Amberite................	50×10^{15}	Bakelite No. 150...........	4×10^{12}
*Rosin...................	50×10^{15}	Gummon...................	3×10^{12}
*Mica (India ruby slightly stained)...............	50×10^{15}	Tegit.......................	2×10^{12}
G. E. No. 55 R..........	40×10^{15}	Opal glass..................	1×10^{12}
Hallowax No. 5055 B.....	20×10^{15}		
Mica (Brown African clear)..................	20×10^{15}	Paraffined Poplar..........	500×10^{9}
Bakelite L558............	20×10^{15}	Bakelite No. G5200 RGR..	400×10^{9}
*Electrose No. 8..........	20×10^{15}	Paraffined Maple...........	300×10^{9}
*Parowax (paraffin).......	10×10^{15}	Bakelite No. 1.............	200×10^{9}
Glyptol..................	10×10^{15}	Bakelite No. 190...........	100×10^{9}
*Shellac..................	10×10^{15}	Italian Marble.............	100×10^{9}
Kavalier Glass...........	8×10^{15}	Bakelite Micarta...........	50×10^{9}
*Insulate No 2............	8×10^{15}	Bakelite No. G 5074.......	40×10^{9}
*Sealing Wax.............	8×10^{15}	Black Condensite..........	40×10^{9}
*Yellow Electrose.........	5×10^{15}	Yellow Condensite.........	40×10^{9}
*Duranoid................	3×10^{15}	Vulcabeston...............	20×10^{9}
*Murdock No. 100........	3×10^{15}	White Celluloid............	20×10^{9}
*Yellow Beeswax.........	2×10^{15}	Hard fiber.................	20×10^{9}
Khotinsky Cement.......	2×10^{15}	Black Galalith	20×10^{9}
*G. E. No. 40............	1×10^{15}	Lavite.....................	20×10^{9}
*G. E. No. 55A..........	1×10^{15}	White Galalith.............	10×10^{9}
[6]Moulded Mica..........	1×10^{15}	Hemit.....................	10×10^{9}
		Red Fiber.................	5×10^{9}
		Marble Pink Tenn.........	5×10^{9}
		Marble Blue Vermont......	1×10^{9}
Unglazed Porcelain......	300×10^{12}		
Redmonite (157,4)......	200×10^{12}	Ivory......................	200×10^{6}
Black Electrose..........	100×10^{12}	Slate......................	100×10^{6}
Tetrachlornaphthalene...	50×10^{12}	Bakelite No 140..........	20×10^{6}
Mica (India ruby stained)	50×10^{12}		
German Glass...........	50×10^{12}		

* Apparent resistivity taken after the voltage had been applied for fifteen minutes.

humidity of the surrounding air. For some materials the surface resistance at 1 per cent humidity is 10^{11} times larger than at 95 per cent humidity, though for the majority of materials the surface resistance does not change by a factor of more than 10^6 under these conditions. Since the change is not uniform it has been found necessary to construct curves showing the change of surface resistivity with humidity.

PHYSICAL CHEMISTRY.—*The thermal dehydration of stilbite, thaumasite, and the hydrates of magnesium sulphate and of copper sulphate.* H. E. MERWIN. Geophysical Laboratory.

The method of removing from substances the water which comes off readily only at high temperatures, as outlined in the study of metahewettite,[1] is here applied to a part of the water which is lost readily at ordinary temperatures. About 0.5 gram of material, powdered to pass 40-to-60 mesh, is held in a thin layer between an outer 5-inch test tube and an inner, inverted, 3-inch test tube, the bottom of the latter having been drawn out and having a small opening. The combination is immersed nearly to the top in an oil or nitrate bath, heated to the temperature and for the time desired, and weighed. The immediate object is to determine the rate of loss of water as the temperature is gradually increased. Breaks in the rate should represent definite hydrates if such exist, provided such hydrates have sufficiently differing vapor pressures at the temperatures considered. Some characteristic breaks are shown in figure 1. Temperature is plotted in one direction and in the other either the number of molecules of water to one molecule of anhydrous salt or the percentage loss in weight. The circles or the shapes of the closed areas represent the rate of dehydration. The diameter of a circle is proportional to the amount of water lost during the last heating divided by the time of heating. In cases where the circles overlapped considerably they were replaced by two continuous lines through the ends of each diameter normal to the curve. The periods of heating were 5 minutes.

[1] Hillebrand, Merwin and Wright, Am. Phil. Soc. Proc., **53**: 45. 1914.

$CuSO_4.5H_2O$ (Fig. 1, *B*) loses 2 and 2 molecules of water readily and then 1 molecule at a much higher temperature. At 25° the vapor pressure at which both the 5- and the 3-hydrates can exist is about 7 mm. of mercury; and the 3- and 1-hydrates, about 4.7 mm.; for the 1- and 0-hydrates, about 0.8 mm.[2]

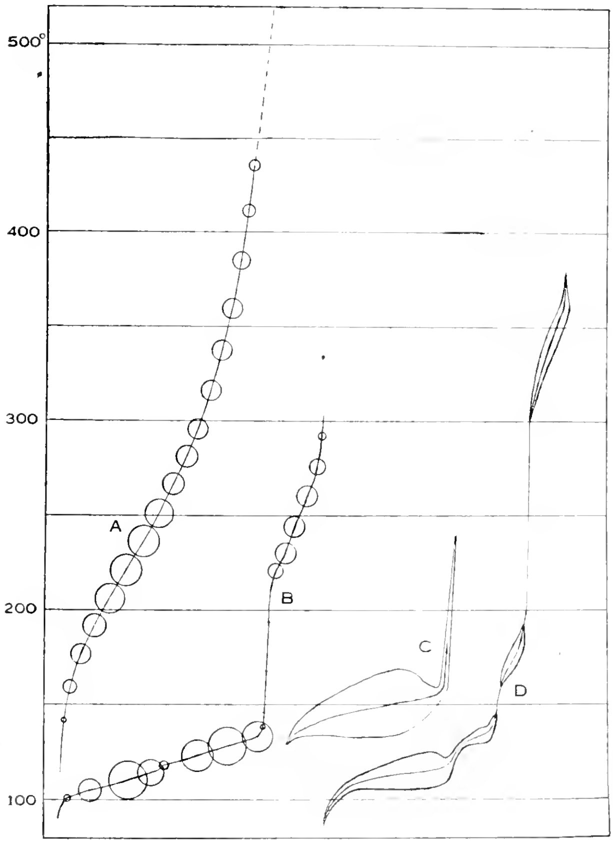

Fig. 1

Stilbite (fig. 1, *A*) loses water continuously without the least evidence of a break. Ten-minute periods of heating gave a curve of the same general shape slightly below this one. The total loss on ignition was 17.6 per cent.

$MgSO_4.7H_2O$ (fig. 1, *D*) shows four distinct periods of maximum evolution of water; the last three represent one molecule each. The first one, during which 4 molecules of water were lost, may indicate the decomposition of the 7-hydrate direct to the 3-hydrate; or intermediate hydrates which decompose immediately may be formed. Such intermediate hydrates, all having about the same vapor pressure, are

[2] Foote, H. W., and Scholes, S. R., Journ. Am. Chem. Soc., **33**: 1324.

known at lower temperatures.[1] The 2- and the 3-hydrates have not been known before, I believe. The temperature intervals were 4°, below 152°; 10°, between 152° and 212°; and 20°, above 212°.

Thaumasite, $CaSO_4.CaCO_3.CaSiO_3.15H_2O$ (fig. 1, *C*). Fourteen molecules of water are expelled much like the first 4 of magnesium sulphate. The last one is much more firmly held. The temperature intervals were 3°.

PHYSICAL CHEMISTRY.—*Equilibrium in the system: lead acetate, lead oxide, water.*[2] R. F. JACKSON, Bureau of Standards. Communicated by G. K. Burgess.

In order to obtain a firm basis for investigating the clarification of raw sugar, a study has been made of the basic acetates of lead from the standpoint of the Phase Rule. The analysis of the basic lead acetates was performed by measuring the volume of standard acid neutralized by the basic lead and the volume of reagent required for the total precipitation of lead. For precipitating lead either sulphuric acid or sodium oxalate was used in excess. In the former case the excess was measured by precipitation with barium chloride, in the latter by titration with potassium permanganate.

The basic acetates were synthesized by the interaction of neutral acetate and lead hydroxide. The reaction proceeded very rapidly and produced some striking phenomena. In one instance the reacting substances quickly formed a solution which rapidly solidified to a relatively insoluble crystalline compound. In another case the unmixed components had the appearance of nearly dry solid material, but upon vigorous shaking formed a mobile liquid. The explanation of this is in the formation of a very soluble basic compound. The equilibria were established by at least 48 hours' agitation at constant temperature. The solid phases capable of existence are as follows:

Neutral lead acetate $Pb(C_2H_3O_2)_2 . 3\ H_2O$ consists of brilliant monoclinic prisms. It is stable in equilibrium with solutions of itself and its solubility increases very rapidly in solutions of

[1] See Foote and Scholes, loc. cit.

[2] Detailed paper to be published in the Bureau of Standards Bulletin.

increasing basicity. Its saturation curve is continuous with that extending into acid solutions. The solubility of the neutral acetate in neutral solutions is 35.50 per cent. The extreme basic solution in equilibrium with the neutral acetate contains 15.89 per cent PbO and 48.95 per cent $Pb(C_2H_3O_2)_2$.

The tetra-lead-monoxy-hexa-acetate $3\ Pb(C_2H_3O_2)_2.PbO.3H_2O$ crystallizes in needles which are usually minute, but may attain the length of half a centimeter. It is exceedingly soluble in water and forms solutions of density 1.93 to 2.28. The solutions contain at the extremes of the saturation curve 15.89 per cent PbO, 48.95 per cent $Pb(C_2H_3O_2)_2$ and 24.74 per cent PbO, 49.21 per cent $Pb(C_2H_3O_2)_2$. The substance is unstable in contact with solutions of itself, but for its existence in equilibrium with a solution it depends upon an excess of dissolved basic lead. On account of the small size and softness of the crystals and the high density of the mother liquor it is practically impossible to isolate the pure substance.

The tri-lead-dioxy-diacetate $Pb(C_2H_3O_2)_2.2\ PbO.4\ H_2O$ consists of ill-formed needles which may be so small as to seem amorphous. It is capable of existence in contact with solutions of itself but under such conditions has a solubility of but 13.3 per cent. Its saturation curve however possesses a very great length. The extremes of solubility are 7.4 per cent PbO 4.8 per cent $Pb(C_2H_3O_2)_2$ and 24.74 per cent PbO, 49.21 per cent $Pb(C_2H_3O_2)_2$.

Lead hydroxide is stable in equilibrium with solutions containing as much as 7.4 per cent PbO and 4.8 per cent $Pb(C_2H_3O_2)_2$.

MINERALOGY.—*The identity of empressite with muthmannite.* WALDEMAR T. SCHALLER, Geological Survey.

The name empressite has been given[1] to a silver telluride, AgTe, from Colorado. A consideration of the data given does not seem to justify its specific separation from the earlier described muthmannite.[2]

[1] Bradley, W. M., Empressite, a new silver-tellurium mineral from Colorado. Amer. Jour. Sci. (4), **38**: 163. 1914.

[2] Zambonini, F., Über den Muthmannit, ein neues Mineral, Zeitschr. Kryst. Min., **49**: 246. 1911.

Empressite is "massive in structure, careful inquiries having failed to locate any material showing crystal faces. The mineral occurs in very fine granular and compact masses associated with galena and native tellurium." Its properties could therefore be only partly determined. The following compilation of the pub-ished properties of empressite and muthmannite shows their relationship.

	EMPRESSITE	MUTHMANNITE
Structure	Massive	Platy elongated crystals, not measurable
Color	Pale bronze[1]	Very light brass yellow[2] to grayish white[3]
Streak	Grayish black to black	Iron gray.
Cleavage	Not determined	Good, parallel elongation
Hardness	3. – 3.5	2 – 2+
Solubility	Readily sol. in hot dilute HNO_3	Decomposed by HNO_3, gold separating
Formula	AgTe	(Ag, Au)Te

1. On fracture surfaces.
2. On the exposed surface.
3. On fresh cleavage surfaces.

All three analyses of muthmannite, as given by Zambonini, show considerable gold, but *in every one the silver predominates molecularly*. In Zambonini's analysis, the ratio of gold to silver is 116 to 244; the gold forms less than one-third of the bases.

The following are the published analyses of muthmannite, the last three being quoted by Zambonini.

ANALYSES OF MUTHMANNITE

LOCALITY	"EMPRESSITE" COLORADO	NAGYAG ?	NAGYAG	NAGYAG
Analyst	Bradley	Zambonini	Schrauf	Scharizer
Ag	45.17	26.36	21.0	19.44
Au		22.90	31.0	34.97
Fe	0.22	trace		
Pb		2.58		
Cu		trace		
Insol	0.39			
Te	54.75	46.44	48.0	45.59
	100.53	98.28	100.0	100.00

The analytical figures do not express the relationships as clearly as the molecular ratios which are therefore reproduced below:

RATIOS OF MUTHMANNITE ANALYSES

	BRADLEY	ZAMBONINI	SCHRAUF	SCHARIZER
Te	1.00	1.00	1.00	1.00
Ag	0.97	0.67	0.52	0.50
Au	0.00	0.32	0.42	0.49
(Ag + Au)	0.97	1.02	0.94	0.99

[1] Includes 0.03 Pb.

The ratio of Te to (Ag + Au) is 1 : 1 in all four analyses, and the silver also predominates over the gold in all four analyses. The mineral described as empressite is therefore a pure muthmannite, whereas the other three minerals analyzed are muthmannite with gold replacing part of the silver: they can be more accurately described as auric muthmannite.

ECONOMICS.—*An objective standard of value—Correction and addendum.*—ALFRED J. LOTKA. Communicated by G. K. BURGESS.

In the paper on this subject published in the issue of this Journal dated August 19, 1914, the following changes should be made:

Page 413, in the first line of the paragraph following equation (6), for "The ophelimities Ω_1, Ω_2 . . ." read: "The marginal ophelimities ω_1, ω_2 . . ."

In the fourth line of the same paragraph, for "the ophelimities" read: "the marginal ophelimities."

Page 416, equation (13), for $\mathbf{v}''_2$ read $\mathbf{v}'_2$.

Page 417, in the proportion (18), for $\mathbf{v}'_1$ $\mathbf{v}'_2$ read $\mathbf{v}'_1 : \mathbf{v}'_2$.

Page 417. The method by which the proportion (18) is derived from equations (11) and (14) is inadequate.

This proportion (18) follows by an application of the theory of exchange, coupled with the principle introduced in this paper, namely, that in a community in which the sense of value were perfect, economic activities and transactions, such as exchange upon the market, would be conducted in such manner as to make the rate of increase per head, r, of the community a maximum.

In these circumstances, if $m_1, m_2, \ldots f_1, f_2, \ldots$ are the quantities of the commodities $A_1, A_2, \ldots F_1, F_2, \ldots$ consumed by a representative individual per unit of time, we must have

$$\frac{\partial r}{\partial m_1} dm_1 + \frac{\partial r}{\partial m_2} dm_2 + \ldots + \frac{\partial r}{\partial f_1} df_1 + \frac{\partial r}{\partial f_2} df_2 + \ldots = 0 \quad \text{(I)}$$

for all values of $dm_1, dm_2, \ldots df_1, df_2, \ldots$ compatible with the equations of exchange

$$\left.\begin{aligned}
dm_1 &= d\mu_2 + d\mu_3 + \ldots + d\varphi_1 + d\varphi_2 + \ldots \\
\mathbf{v}_2\, dm_2 &= -\mathbf{v}_1\, d\mu_2 \\
\mathbf{v}_3\, dm_3 &= -\mathbf{v}_1\, d\mu_3 \\
&\ldots\ldots \\
\mathbf{v}'_1\, df_1 &= -\mathbf{v}_1\, d\varphi_1 \\
\mathbf{v}'_2\, df_2 &= -\mathbf{v}_1\, d\varphi_2 \\
&\ldots\ldots
\end{aligned}\right\} \quad \text{(II)}$$

where $d\mu_2$ is the quantity of A_1 taken in exchange for A_2
$d\mu_3$ is the quantity of A_1 taken in exchange for A_3

. . . .

$d\varphi_1$ is the quantity of A_1 taken in exchange for F_1
etc., etc.

By (I) and (II) we then have

$$\left.\begin{aligned}
&\frac{\partial r}{\partial m_1}(d\mu_2 + d\mu_3 + \ldots + d\varphi_1 + d\varphi_2 + \ldots) - \frac{\partial r}{\partial m_2}\frac{\mathbf{v}_1}{\mathbf{v}_2} d\mu_2 \\
&- \frac{\partial r}{\partial m_3}\frac{\mathbf{v}_1}{\mathbf{v}_3} d\mu_3 - \ldots - \frac{\partial r}{\partial f_1}\frac{\mathbf{v}_1}{\mathbf{v}'_1} d\varphi_1 - \frac{\partial r}{\partial f_2}\frac{\mathbf{v}_1}{\mathbf{v}'_2} d\varphi_2 - \ldots = 0
\end{aligned}\right\} \quad \text{(III)}$$

This relation must hold for all arbitrary values of the infinitesimals $d\mu_2, d\mu_3, \ldots d\varphi_1, d\varphi_2, \ldots$

It follows that

$$\mathbf{v}_1 : \mathbf{v}_2 : \ldots : \mathbf{v}'_1 : \mathbf{v}'_2 : \ldots : \frac{\partial r}{\partial m_1} : \frac{\partial r}{\partial m_2} : \ldots \frac{\partial r}{\partial f_1} : \frac{\partial r}{\partial f_2} : \ldots \quad (18)$$

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

BOTANY.—*Discussion of chemical analysis in distinguishing Jeffrey pine.* W. H. Lamb. Proceedings of the Society of American Foresters, **9**: 338–341. 1914.

This is a discussion in connection with a paper by C. Stowell Smith on "Turpentine Possibilities on the Pacific Coast," in which the occurrence of heptane or abietine in Jeffrey pine (*Pinus jeffreyi*), and turpene in western yellow pine (*Pinus ponderosa*) is pointed out as a means of distinguishing these two closely related trees, since heptane differs materially in its properties from turpene, which is the principal constituent of the more commonly known turpentine oils. Conescale and leaf differences are discussed, illustrated, and correlated with chemical evidences in establishing Jeffrey pine as a distinct species.

W. H. L.

FORESTRY.—*Effect of varying certain cooking conditions in producing soda pulp from aspen.* Henry E. Surface. Bulletin of the U. S. Department of Agriculture, **80**: 1914. Pp. 63.

Experiments were made with aspen (*Populus tremuloides*) by the soda process of paper manufacture to determine what effect the varying of individual cooking conditions would have upon the yield and properties of the pulp and the consumption of cooking chemicals. The cooking conditions investigated were: (1) amount of caustic soda per pound of wood, (2) duration of cooking at maximum temperature, (3) maximum temperature (pressure) of cooking, and (4) initial concentration of the cooking chemicals. In each of the four series of tests all the conditions were held as nearly constant as possible except the one under investigation, which was varied in successive tests or "cooks" according to a definite plan.

It was found that the four conditions of cooking named influenced the yield and properties of the pulp by influencing the severity of the cooking reactions. Severity of cooking is an effect mainly of the amount of caustic soda consumed per unit of wood. Increasing the amount of concentration of the chemical or the pressure of cooking produces a quicker reaction and hence one more complete in a given length of time. Increasing the duration results in a more complete reaction because of the longer time allowed for the available caustic soda to be consumed. Greater severity of cooking is accompanied by a decrease in the yield of crude pulp, and usually of screened pulp unless screenings are present in considerable quantity. The decreased yields obtained on more severe cooking result in a greater cost of wood and soda ash per ton of pulp. As a rule, the small cost of bleaching powder incident to the more easily bleached pulp produced by thorough cooking only partially offsets the greater cost of soda ash and wood. While the amount of bleach required decreases with an increase in the severity of cooking, a point is soon reached where the decrease in bleach is not commensurate with that in yield. Increasing the initial amount of digester liquid increases the condensation and steam consumption (and hence the cost) because of the greater volume to be heated; increasing either the duration or pressure has a similar effect because of the greater losses of heat by radiation. Yields (bone-dry basis) of well-separated, unbleached pulps as high as 56 or 58 pounds per hundred pounds of wood can be obtained from aspen if the wood is of the best quality. Yields of from 54 to 55 per cent were obtained which required only from 10 to 11 per cent of bleach. Yields under different cooking conditions varied from 46 to 58 pounds per hundred pounds of wood, or about 26 per cent. Aspen may be successfully cooked with total durations of from 3 to 4 hours, and with from 20 to 25 pounds of caustic soda charged per hundred pounds of wood, provided the other cooking conditions are properly maintained.

FINDLEY BURNS.

FORESTRY.—*Suitability of longleaf pine for paper pulp.* HENRY E. SURFACE and ROBERT E. COOPER. Bulletin of the U. S. Department of Agriculture, **72:** 1914. Pp. 26.

The recent development in Europe of the sulphate process of paper making, and the superior quality of the product made from resinous woods, has turned attention to longleaf and other Southern pines as a possible source of pulp in this country. These pines have long, thick-walled fibers, and also high specific gravities, implying large yields per cord. The principal product of the sulphate process is an undercooked, non-bleaching brown pulp, known as "kraft" pulp, which produces a remarkably strong paper, very resistant to wear. The waste wood from the lumber industry in the South suggests a source of cheap raw material.

Tests were made on longleaf pine (*Pinus palustris*). These tests were of two kinds: (1) autoclave tests, comprising several series of cooks made to determine the effects of varying the cooking conditions in the sulphate process, and (2) semi-commercial tests, including cooks made by both the sulphate and soda processes, in the first process employing such cooking conditions as the autoclave tests indicated would give good results, and in the second employing cooking conditions that would give results comparable with those obtained from the sulphate cooks.

The experiments, while not complete, show conclusively (1) that longleaf pine is well adapted for the manufacture of natural-color kraft pulps and papers; (2) that the sulphate process of paper making applied to this wood affords products of better quality and of higher yields than does the soda process; (3) that kraft papers can be made from longleaf pine equal or superior in quality to the imported and domestic kraft papers now on the market; and (4) that the high specific gravity of the wood and the resultant high yield of pulp per cord give longleaf pine an advantage possessed by few, if any, other commercially important woods suitable for pulp making. The autoclave tests indicate that there should be a certain combination of values for the variable cooking conditions which will result in the most economical method of operation.

Findley Burns.

FORESTRY.—*Balsam fir.* Raphael Zon. Bulletin of the U. S. Department of Agriculture, **55**: 1914. Pp. 68, with plates and text figures.

Balsam fir (*Abies balsamea*) has become commercially important during the last 20 years through the enormous expansion of the pulp industry and the increase in the price of spruce. It constitutes numerically about 20 per cent of the coniferous forests in northern New York and Maine, and is abundant in many parts of New Hampshire, Vermont, northern Michigan, northern Wisconsin, and Minnesota. Wherever it grows it is closely associated with spruce, the two species almost constantly contesting for occupancy of the ground. Under present methods of lumbering, however, balsam fir is increasing at the expense of spruce in the second-growth throughout the entire range of the two species. Balsam fir, while to some extent inferior to spruce as construction material, has a definite place in the pulp and lumber industries. The inferiority of pulp containing a large amount of balsam is probably not altogether due to the inferiority of the balsam wood, but to deficient knowledge of how properly to manufacture it into paper. The tree grows much faster throughout its entire life than spruce, but is shorter lived and reaches maturity long before the latter. Virgin balsam should be cut at an age of from 100 to 125 years, while spruce, as it grows at present in the wild woods, should be cut at an age of from 175 to 200 years. The best silvicultural system of cutting is that of selection cutting in small groups. Under this system the natural reproduction of both spruce and balsam fir is assured, with the possibility of increasing the proportion of spruce in the new stand.

FINDLEY BURNS.

BACTERIOLOGY.—*Ability of Streptococci to survive pasteurization.* S. HENRY AYERS and W. T. JOHNSON, JR. Journal of Agricultural Research, **2:** 321–330. July 15, 1914.

The thermal death-points of 139 cultures of Streptococci isolated from cow feces, from the udder and mouth of the cow, and from milk and cream, showed a wide variation when heated in tubes of milk for 30 minutes.

At 60°C. (140°F.), the lowest pasteurizing temperature, 89 cultures or 64.03 per cent survived; at 62.8°C. (145°F.), the usual pasteurizing temperature, 46 or 33.07 per cent survived; and at 71.1°C. (160°F.) 2.58 per cent of the cultures survived; all were destroyed at 73.9°C. (165°F.).

The streptococci from the udder were, on the whole, less resistant and those from milk and cream more resistant to heat than those from the mouth of the cow and from cow feces.

Among the 139 cultures of Streptococci there were 22 that formed long chains, which, for the purposes of the paper, were considered as typical Streptococci. The others were considered atypical. The typical Streptococci were much less resistant to heat than were the atypical.

This work indicates that two classes of Streptococci survive pasteurization: (a) Streptococci which have a low majority thermal death-point, but among which a few cells are able to survive the pasteurizing temperature; (b) Streptococci which have a high majority thermal death-point. In the latter case the bacteria survive because the majority thermal death-point is above the temperature used in pasteurization. This ability to resist destruction by heating is a permanent characteristic of certain strains of Streptococci.

S. H. A.

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ASTRONOMY.—*A special method of finding the Sumner line.*[1]

G. W. Littlehales, Hydrographic Office.

Whenever the hour-angle of the observed celestial body is within two minutes of being a multiple of ten minutes at the time of observation, an easy solution presents itself of the problem of finding the azimuth and altitude for the purpose of laying down the Sumner line by the Saint Hilaire method. In such a case, we may assume the position of the observer to be in a latitude represented by the integral number of degrees of latitude next to the latitude by dead reckoning and in a longitude which will make the local hour-angle of the observed body an exact multiple of ten minutes, and we may then, by availing ourselves of simple resources, find the azimuth and altitude that the observed body would have to an observer situated in the assumed geographical position.

Since the United States Hydrographic Office has completed the publication of the azimuths or true bearings of celestial bodes for all declinations up to 70°, north and south, at intervals of ten minutes of hour-angle for the entire circuit of the heavens, and for parallels of latitude of the observer extending to 70° from the equator, the value of the azimuth, required in the circumstances presented, may be taken out from these tables without any interpolation, save alone between adjacent columns for the declination. The parts of the astronomical tri-

[1] The Sumner line is a locus of the observer's geographical position comprising so much of an arc of the circle of equal altitude as covers the limits of uncertainty in reckoning.

angle, besides the co-latitude, thus becoming known are the azimuth angle and its opposite side of polar distance and the hour-angle, whose opposite side is the complement of the required altitude. The calculation of the required altitude is therefore effected by the proportionality between the sines of the sides of the spherical triangle and the sines of their opposite angles, thus:

$$\sin z : \sin t :: \sin p : \sin Z \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

in which z represents the zenith distance of the observed body, t, the hour-angle; p, the polar distance; and Z, the azimuth. Since $z = 90° - h$, the complement of the altitude, the formula may also be written,

$$\cos h = \sin t.\ \sin p.\ \mathrm{cosec}\ Z \ldots\ldots\ldots\ldots\ldots (2)$$

or in logarithmic form as follows:

$$\log \cos h = \log \sin t + \log \sin p + \log \mathrm{cosec}\ Z \ldots\ldots (3)$$

So that the logarithmic cosine of the required altitude is found by adding together three logarithms, and all the logarithms used are taken from one table, which is No. 44 in the collection of mathematical tables of the *American Practical Navigator* issued by the Navy Department at Washington. But, if an occasion should arise in which logarithmic tables were lacking, it would not be laborious to solve this problem by means of natural functions alone as indicated in the equations numbered 1 and 2.

The difference between the altitude, thus calculated as the altitude that the observed body would have if the observer stood in the assumed geographical position, and the corrected altitude measured in the actual position of the observer, gives the length of the intercept, or altitude-difference, which, when laid off from the assumed position, along the direction of the azimuth and toward or away from the direction of the observed body according as the observed altitude is higher or lower than the calculated altitude, marks the point through which the line of position of the observer passes at right angles to the azimuth of the observed celestial body. The first differential of h with respect to Z, obtained by differentiating equation (2), gives the following relation:

$$\frac{dh}{dZ} = \cot h \cot Z$$

From which it appears that as long as the product of cot h cot Z is a proper fraction, the uncertainty in the calculated value of h will never exceed the uncertainty in the value of Z, that there will be no uncertainty in the calculated value of h when the observed body is on the prime vertical and also when it is in the zenith, and that there will be a maximum uncertainty when the observed body is on the meridian.

The curve of maximum numerical uncertainty in the calculated value of h, derived from the second differential equation of h with respect to Z, may be drawn for any given latitude, L, from the equation:

$$\cos^3 Z - \cos^2 h \cos Z - \sin h \cos h \tan L = 0$$

For purposes of illustration, the solution of the example, stated as follows under Article 372 of the *American Practical Navigator*, is given:

At sea May 18, 1915, A.M., in latitude 41° 33′ N., longitude 33° 30′ W., by dead reckoning, the mean of a series of observed altitudes of the sun's lower limb was 29° 41′ 00″; the mean watch time, $7^h\,20^m\,45.3^{sec}$; C.C., + $4^m\,59.2^{sec}$; I.C., − 0′ 30″; height of eye 23 feet; C. − W., $2^h\,17^m\,06^{sec}$. Required the Sumner line.

Mean W. T.	$7^h 20^m 45.3^{sec}$	Eq. T.	$3^m 44.48^s$	Dec	19° 22′ 27.9″ N
			$-\ .07^{sec}$		+ 33.65″
		H.D.	-2.3^h		
C − W	+2 17 06	G.M.T.		G.M.T.	$-2^h.3$
Chro.T	9 37 51.3	corr.	+0.16	corr.	−77.4″ = −1′ 17.4″
C.C.	+4 59.2	Eq.T.	3 − 44.6	Dec.	19−21 11N
G.M.T.	17^d 21 42 50.5	(Plus to mean time)		p	70 38 49
Eq.T.	+3 44.6				
G.A.T.	21 46 35.1				
Lon.by DR 33° 30′	2 14 00				
L.A.T.	19 32 35.1				

Under the principles laid down, it now becomes the object to assume a geographical position in the nearest longitude to that given by the dead reckoning which, when applied to the Greenwich apparent time, will make the local apparent time or hour-angle a multiple of ten minutes, and in a latitude represented by the nearer whole-degree of latitude to the latitude given by the dead reckoning. Accordingly, the longitude of the assumed position would be 34° 08′ 46.5″ W., or $2^{h}\,16^{m}\,35.1^{sec}$ W., which, applied to the Greenwich apparent time, gives the local apparent time $19^{h}\,30^{m}$; and the latitude of the assumed position should be 42° N.

From the Azimuth Tables (H. O. Pub. No. 71), for latitude 42° N. and hour-angle $19^{h}\,30^{m}$, i.e., L.A.T. $7^{h}\,30^{m}$ A.M., we obtain:

corresponding to Dec. 19° N., Azimuth N. 90° – 01 E.
corresponding to Dec. 20° N., Azimuth N. 89° – 06 E.

Therefore corresponding to Dec. 19° 21′ 11″ N., Azimuth N. 89° 42 E.

The altitude that a celestial body in this declination would have, in this azimuth and hour-angle, to an observer in the assumed geographical position in latitude 42° N. and longitude 34° 08′ 46.5″ W. is now calculated from equation 3 as follows:

$t = 19^{h}\ 30^{m}$ log sin	= 9.96562	Mean of obs'd alt.	29° 41′ 00″
$p = 70°\ 38'\ 49''$ log sin	= 9.97474	I. C.	– 30
$Z = 89°\ 42'$ log cosec	= 10.00001		29 40 30
Calculated $h = 29°\ 20'\ 34''$ log cos	= 9.94037	Corr. Table 46	9 35
Corrected measured h = 29 50 05		Corr. meas'd h	29 50 05
Δh = 29′ 31″ toward			

This intercept of $29\frac{1}{2}'$, being laid off from the assumed geographical position along the bearing, N. 89° 42′ E., of the observed celestial body, gives the point through which the line of position of the observer is to be drawn at right angles to the bearing. Since the corrected measured altitude is higher than the calculated altitude, the intercept is, in this case, laid off toward the observed body, and gives a line of position agreeing with that found by drawing a line through the geographical positions deduced in the solution of this problem under Article 372 of the *American Practical Navigator*.

It will be useful to point out that, with azimuth tables in which the interval between the hour-angles is only four minutes, like those of Burdwood and of Davis issued by the British Admiralty to the Royal Navy, this simplified method of finding the Sumner line is more generally applicable in the solution of observations upon celestial bodies situated within the limits of declination for which the tables are computed.

PHYSICS.—*A watthour meter method of testing instrument transformers.*[1] P. G. AGNEW, Bureau of Standards.

Ratio and phase-angle measurements of instrument transformers can easily be made by the use of two precisely similar watthour meters, which may be either of the portable type, or of the house type provided the disk has been graduated in 100 divisions. The meters should be adjusted to very nearly the same rate.

The method depends upon the use of a standard transformer whose ratio and phase angle have been determined in some laboratory equipped for the purpose. The standard transformer must have the same nominal range as the one under test.

For voltage transformers an auxiliary current is passed in series through the current coils of the two meters. The voltage coil of each meter is connected to one of the transformers, and readings are taken showing the difference in speeds of the meters. The meters are then interchanged and readings again taken. If the meters have been operating at, or very near unity power factor, the ratio of the transformer under test is easily computed in terms of the ratio of the standard. The formula is

$$\frac{R_2 - R_1}{R_1} = \tfrac{1}{2}\left(\frac{a_1 - a_2}{a_2} + \frac{b_1 - b_2}{b_2}\right)$$

where R_1, R_2 = ratios of the transformers.

a_1, a_2 = Number turns of meter A when connected to transformers 1 and 2, respectively.

b_1, b_2 = same for meter B.

Similarly the difference in phase angles can be determined by running the meters at low power factor, which may be conveniently done by taking the auxiliary current from one of the other

[1] Detailed paper to appear in the Bureau of Standards Bulletin.

phases of a three-phase source. If the meters are working at the power factor $\cos\theta$, current lagging,

$$\tan \alpha_2 = \tan \alpha_1 + \frac{1}{\tan\theta}\left[\frac{a_1 - a_2}{2\,a_1} + \frac{b_1 - b_2}{2\,b_1} - \frac{R_2 - R_1}{R_1}\right]$$

where the α's are the phase angles of the transformers, counted as positive for the reversed secondary voltage leading the primary voltage.

For current transformers the method of connecting the coils is inverted compared with the case of the voltage transformer. An auxiliary voltage is applied to the voltage coils of the meters in parallel, the current coils being connected alternately to the two transformers. Care should be taken not to open the secondary circuit of a current transformer while current is passing in the primary. The formula for the difference in ratios is the same as for the voltage transformer. The formula for phase angle is correct as given both for the voltage transformer with lagging current and for the current transformer with leading current. If the conditions are vice versa the + sign before the bracketed term should be changed to −.

It is, however, not necessary to depend upon this equation for determining which transformer has the greater phase angle. The following facts can be used as criteria for experimentally determining the question.

1. Adding a noninductive load to a voltage transformer always tends to lag the secondary voltage.

2. Increasing the resistance in the secondary of a current transformer tends to advance the phase of the secondary current.

The experimental results show that by taking runs of approximately 100 turns each the method is capable of determining ratio to 0.02 per cent or 0.03 per cent and phase angle to one, or two minutes. In commercial work shorter runs would suffice. Results as good as this were also obtained with the speed of the meter doubled by shunting the magnets. Separate direct experiments showed that the modern induction meter, even with the drag magnets shunted so as to give double speed for normal torque will repeat in consecutive runs under constant conditions to a precision of about 0.01 per cent at full load.

There are cases in which it may be convenient to determine a lump correction for both ratio and phase angle instead of determining and correcting for them separately, for example, the case of a watthour meter and a current transformer metering the power supplied to an inductive load. This may even be extended to the case of the combination of a current and a voltage transformer.

Portable watthour meters are more convenient than the house type with graduated disks as the trouble of counting is eliminated. In testing current transformers a five-ampere range is more economical of time than a ten-ampere range. One-ampere or two-ampere ranges should not be used with current transformers as the impedance introduced into the secondary is too great.

It is important that the constants of the standard transformer should have been tested under actual working conditions of load, including the meter.

The accuracy of the method is ample for commercial requirements, the results are independent of ordinary line fluctuations, and no special apparatus is required.

PHYSICS.—*Various modifications of thermopiles having a continuous absorbing surface.*[1] W. W. COBLENTZ, Bureau of Standards.

In a previous paper (Bull. Bur. Standards No. 188) an account was given of the construction and the behavior of thermopiles composed of bismuth and silver wires with rectangular absorbing surfaces of tin attached to the junctures of these two metals. The novelty of the design consists in a series of overlapping receivers, forming a continuous surface which has all the advantages of a good bolometer, with none of its disadvantages. The present paper deals with the construction and the behavior of various modifications of this type of thermoelement, adapted to various problems in biology, physiology, psychology, physics, and astronomy.

It was found that, by joining the thermoelements—two in series—parallel, the heat capacity of the composite receiver was

[1] Detailed paper to appear in the Bureau of Standards Bulletin.

reduced and the time to attain temperature equilibrium, after exposing the receiver to radiation, was shortened so that a maximum galvanometer deflection is attained in three to five seconds.

It is shown that the radiation sensitivity of a composite receiving surface is proportional to the square root of the area of the exposed surface. However, this relation does not hold true for the single receivers attached to the individual thermo-junctions. In the latter there is an optimum size of the receiver required to compensate for the loss of heat by conduction along the wires, and by radiation from the surface. Using thermo-elements of bismuth wire 0.1 mm. in diameter, and silver wire 0.036 mm. in diameter, this optimum size of receiver is of the order of 1.5 by 1.5 mm.

In the tests on the relation of external resistance to the internal resistance of the galvanometer it is shown that there may be a considerable departure from equality of the two resistances (the galvonometer resistance may be two to three times the internal (thermopile) resistance) without seriously affecting the efficiency of the galvanometer.

Tests on various samples of bismuth wire, show that the thermoelectric power, against silver, varies from 75 to 80 microvolts.

The construction and test of sensitivity of a thermopile of bismuth alloy is given. The alloy was bismuth + 5 per cent tin. Wires of alloy when joined with pure bismuth wire had a thermoelectric power of 127 microvolts. In spite of this high intrinsic thermoelectric power, the radiation sensitivity of the completed thermopile was not any higher than that of the thermopiles constructed of bismuth and silver, which elements have a 55 per cent lower thermoelectric power. This is due to the high resistance of the alloy.

A thermopile constructed of bismuth and iron, which, like the above bismuth tin alloy has a higher thermoelectric power, was no more sensitive than the thermopiles constructed of bismuth and silver. The conclusion arrived at is that the production of a thermopile having a high radiation sensitivity is more dependent upon nicety of construction than upon the use of materials having a high thermoelectric power.

The construction and tests of a radiometer attachment for monochromatic illuminators is given. This device consists of a linear thermopile, which moves in vertical ways in front of the exit slit of a spectroscope. It is useful in measuring the energy value (mechanical equivalent) comprised in the different wave lengths of light used as stimuli, in biological, chemical, physical, and physiological investigations.

The method of construction, and tests are given of a thermopile to be used for absolute measurements of radiation. The device consists of a linear thermopile of bismuth and silver, with a continuous receiving surface, in front of which is situated a strip of manganin or platinum, which is blackened electrolytically with platinum black. This strip of metal is exposed to radiation and in turn radiates to the thermopile which causes a galvanometer deflection. The strip of metal is then heated electrically to cause a similar deflection of the galvanometer needle; and the power expended gives a measure of the radiation in absolute value. The instrument gives a value of the coefficient of total radiation of a black body which is in excellent agreement with values obtained by other methods.

Among the group of special designs, the stellar thermoelements may be mentioned. When used with a reflecting mirror, 92 cm. (26 inches) in diameter, and an ironclad Thomson galvanometer of ordinary sensitivity, it was possible to make quantitative measurements of the total radiation from stars down to the 5.3 magnitude, while high qualitative measurements were made on stars down to the 7th magnitude. The application of the thermoelement to solve astronomical problems appears therefore to be feasible.

The design and tests are given of an absolute thermopile for the measurement of nocturnal radiation; also of a thermopile to be used as a photometer to measure the blackness of star images on photographic plates. A novel design for a special biological problem consisted in the construction and testing of a linear thermopile, in which the receiver was bent into a U-shaped trough. The test showed that if the object (say muscle, or nerve) evolved heat at the rate of 1×10^{-9} g-cal. sec.$^{-1}$ it can be detected.

The appendix consists of notes on (1) galvanometer mirrors, (2) vacuum galvanometers, (3) the most efficient combination of thermopile and galvanometer resistance, and (4) the maintenance of high vacua by means of metallic calcium. The calcium is contained in a quartz glass tube which is attached to the vacuum (stellar) thermopile. The thermopile container is exhausted by means of an oil pump, and the stopcock is closed. Thereafter the vapors given off are removed by heating the metallic calcium with an alcohol lamp. The device is thoroughly reliable, as evidenced by the fact that it was carried to the Lick Observatory, Mt. Hamilton, California, and back, the vacuum having been maintained for over two months with no signs of failure of the calcium.

CHEMISTRY.—*The calculation and comparison of mineral analyses.* C. E. VAN ORSTRAND, Geological Survey[1] and FRED. E. WRIGHT, Geophysical Laboratory.

Two different methods have recently been suggested[2] for the calculation and comparison of mineral analyses and each method is considered by its proposer to be the best method available for the purpose. Now the term "best" depends on the criteria which are used in comparing the different methods and before proper decision can be made in such instances, it is essential that the criteria themselves be examined in detail and with particular reference to their competency and bearing on the final result. The present problem has to do with data of observation and is therefore subject to the criteria and methods in current use in the exact sciences for the discussion and comparison of such data.

It will be of interest in the following pages to treat the problem from this viewpoint and to determine the exact relations

[1] Published with the permission of the Director of the U. S. Geological Survey.

[2] W. T. Schaller, The calculation of mineral formulas. J. Wash. Acad. Sci., **3**: 97–98. 1913; R. C. Wells, The interpretation of mineral analyses. J. Wash. Acad. Sci., **3**: 416–423. 1913.

between the different methods which have been proposed and thus to ascertain which method is the best. It may be stated in anticipation of the final results that the methods of dealing directly with the data of observation are superior both from a theoretical and a practical standpoint to the new methods which have been suggested. Too strong emphasis cannot be placed on the importance of the direct comparison of the data of observation. Division or multiplication of the weight percentages of the analysis by different numbers automatically assigns different weights to these values; by this procedure a really large error can be made to appear small and practically negligible and vice versa, a small error relatively large and important. This fact was emphasized by the writers in a recent article[3] but a more detailed discussion of certain phases of the subject seems now desirable in view of the statements in the paper by Wells cited above.

The chemical analysis of a mineral presents in quantitative form the weight percentages of the various chemical elements of which it has been found to consist. In mineral analytical work chemists consider carefully a number of factors among which the following are the more important: Purity of substance to be analyzed (to insure proper purity microscopic examination and selection of the individual mineral grains is often necessary); fineness of grinding of material; purity of chemical reagents; precision of chemical balance and weights; accuracy of atomic weights used; contamination from utensils employed; accuracy of the chemical methods for separating and for determining the chemical elements present; personal skill of the analyst. Most of these factors can be either eliminated or their influence definitely determined and proper correction made for them by the chemist. In addition to these and other analytical factors the presence of foreign elements in solution in the crystal state, is always to be considered in the final result; this may at times be so serious as to veil completely the simple chemical formula of the mineral compound analyzed.

Systematic and accidental errors. In the chemical analysis of a mineral the actual weight percentage relations between

[3] J. Wash. Acad. Sci., **3**: 223-231. 1913.

the various chemical elements are given as they have been found to exist in that mineral. In the analysis the chemist has eliminated, to the best of his ability, the systematic errors in his observational data and the figures in his analysis are subject only to the errors of observation over which he has no control or to systematic errors of which he has no knowledge. It is with such errors that the observer, who studies and compares chemical analyses as given in final form by the analyst, has to contend. It may be possible, as will be shown later, to detect and to compute systematic errors of a certain kind in an analysis but it is, of course, not possible, in general, to free a chemical analysis of its systematic errors by any purely mathematical procedure. Nor is it the purpose of the present paper to discuss such methods but rather the methods which have to do with the accidental errors of observation. In all data of measurement such errors creep in because no instrument or method is absolutely accurate and because no observer is capable of making perfect observations. In the discussion of such data the method of least squares is universally adopted. It has for its object the adjustment and comparison of observations in which the errors are accidental. The term *accidental* is here used in a technical sense to imply that positive and negative errors (departures from the true value) of equal numerical magnitude are equally probable. The principle of least squares is based on the Gaussian law of distribution, a law which has been abundantly verified experimentally not only in the theory of errors but also in other fields of science and has led to results of the greatest importance.

In the mathematical discussion below it is proved that all the methods which have been suggested for the adjustment and comparison of chemical analyses are least square methods and differ chiefly in the manner of assigning weights to the observed data. This fact enables us to fix definitely the significance of each method and to ascertain its good and its weak features.

The adjustment of least squares. To show that the methods, which have been proposed are special cases of the general least square solution let us put

x = theoretical weight number
y = observed weight percentage
y' = computed weight percentage
$v = y - y'$ = residual
p = weight of the observation.

The quantity p is an abstract number indicating the relative value or worth of an observation in comparison with other observations. The arithmetic mean of n observations, for example, is supposed to be worth n times as much as a single observation; its weight would therefore be n times the weight of a single observation.

Adopting first the observation equations

$$\left.\begin{array}{ll} mx_1 = y_1 & (\text{weight } p_1) \\ mx_2 = y_2 & (\text{weight } p_2) \\ ------- & \\ mx_n = y_n & (\text{weight } p_n) \end{array}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

we obtain the least square solution

$$m = \frac{p_1x_1y_1 + p_2x_2y_2 + \quad . \quad . \quad . \quad + p_nx_ny_n}{p_1x_1^2 + p_2x_2^2 + \quad . \quad . \quad . \quad + p_nx_n^2} \quad . \quad . \quad . \quad (2)$$

in which the residuals ($v_1, v_2, \quad . \quad . \quad . \quad v_n$) are subject to the condition

$$p_1x_1v_1 + p_2x_2v_2 + \quad . \quad . \quad . \quad + p_nx_nv_n = 0. \quad . \quad . \quad . \quad (3)$$

Some special cases in which the weights are simple functions of x are the following:

$$m = \frac{y_1}{x_1} \quad . \quad . \quad . \quad . \quad . \quad (p_1 = \infty, \ p_2 = c_2 \quad . \quad . \quad p_n = c_n) \quad . \quad . \quad (4)$$

$$m = \frac{\frac{y_1}{x_1} + \frac{y_2}{x_2} \quad . \quad . \quad . \quad \frac{y_n}{x_n}}{n} \quad . \quad . \quad (p_1 = x^{-2}, \quad . \quad . \quad p_n = x_n^{-2}) \quad . \quad . \quad (5)$$

$$m = \frac{y_1 + y_2 + \quad . \quad . \quad + y_n}{x_1 + x_2 + \quad . \quad . \quad + x_n} \quad . \quad . \quad (p_1 = x^{-1} \quad . \quad . \quad . \quad p_n = x_n^{-1}). \quad . \quad (6)$$

$$m = \frac{x_1y_1 + x_2y_2 + \quad . \quad . \quad + x_ny_n}{x_1^2 + x_2^2 + \quad . \quad . \quad . \quad + x_n^2} \quad . \quad . \quad (p_1 = \quad . \quad . \quad = p_n = 1). \quad . \quad (7)$$

$$m = \frac{x_1^2 y_1 + x_2^2 y_2 + \quad . \quad . \quad + x_n^2 y_n}{x_1^3 + x_2^3 + \quad . \quad . \quad . \quad + x_n^3} \quad . \quad . \quad (p_1 = x_1 \quad . \quad . \quad p_n = x_n). \quad . \quad (8)$$

A more general solution is obtained by adopting the observation equations:

$$\left.\begin{array}{ll} a + mx_1 = y_1 & \text{(weight } p_1) \\ a + mx_2 = y_1 & \text{(weight } p_2) \\ - - - - - - - - - - - & \\ a + mx_n = y_n & \text{(weight } p_n) \end{array}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

The least square solution of these equations gives the normal equations:

$$\left.\begin{array}{l} (p_1 + \quad . \quad . \quad . \quad + p_n)\, a + (p_1 x_1 + \quad . \quad . \quad . \quad + p_n x_n)\, m = p_1 y_1 + \quad . \quad . \quad + p_n y_n \\ (p_1 x_1 + \quad . \quad . \quad . \quad p_n x_n) a + (p_1 x_1^2 + \quad . \quad . \quad . \quad + p_n x_n^2) m = p_1 x_1 y_1 + \quad . \quad . \quad p_n x_n y_n \end{array}\right\} (10)$$

from which the most probable values of a and m are readily determined. In this case the residuals satisfy the two equations

$$p_1 v + p_2 v_2 \quad . \quad . \quad + p_n v_n = 0$$

$$p_1 x_1 v_1 + p_2 x_2 v_2 + \quad . \quad . \quad + p_n x_n v_n = 0$$

The condition that the computed values $(y'_1, y'_2, \quad . \quad . \quad . \quad y'_n)$ satisfy the relation

$$y'_1 + y'_2 + \quad . \quad . \quad . \quad + y'_n = 100$$

can be imposed by writing in addition to the n observation equations (9) the observation equation

$$na + (x \;+ x_2 \quad . \quad . \quad + x_n)\; m = 100 \quad (\text{weight } \infty) \; . \quad . \quad (11)$$

and then solving the system of $n + 1$ equations in the usual manner; or we may substitute the value of a obtained from (11) in (9) and then solve equation (2) for m. The general result of the adjustment of the $n + 1$ equations (9) and (11), is represented graphically in figure 1.

The coördinates of the point P are

$$x = x_1 + x_2 + \quad . \quad . \quad . \quad + x_n, \; y = 100$$

and the assignment of different weights, in the least square solution, to the points $P_1, P_2, \; . \; . \; . \; P_n$ has the effect of rotating the line $O'P$ through a small angle $\pm\, \alpha$ about P as center. If the weights are defined by some inverse power of x_1 (equations 5 and 6), points near the origin O will have weights approximately equal to infinity, and the line will tend to pass through these points while the more distant points will have practically no influence in fixing the final position of the line. In other words, the assignment of a large weight presupposes that the actual error of the weighted quantity is very small and that the adjusted line should therefore pass nearer to these points than to other points in the system having smaller weights. The reverse

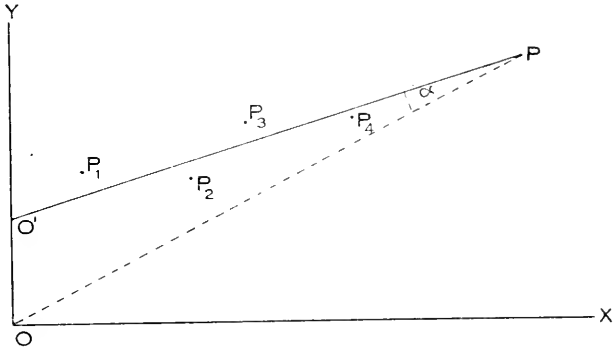

Fig. 1

is true when the weights are proportional to some direct power of x (e.g. equation 8). These and other conclusions follow from the law that weights are to each other as the inverse squares of the corresponding probable errors.

$$p_1 : p_2 : p = \frac{1}{r_1^2} : \frac{1}{r_2^2} : \frac{1}{r^2} \quad \ldots \ldots \ldots \quad (12)$$

Another method of adjustment on the basis of 100 in which the constant ratio m is not taken into account consists in writing the observation equations in the form:

$$\left.\begin{array}{ll} z_1 = y_1 & (\text{weight } p_1) \\ z_2 = y_2 & (\text{weight } p_2) \\ - - - - - - - & \\ z_n = y_n & (\text{weight } p_n) \end{array}\right\} \quad \ldots \ldots \ldots \quad (13)$$

If now y'_1 = most probable value of the unknown quantity z_1

y'_2 = most probable value of the unknown quantity z_2

— —

y'_n = most probable value of the unknown quantity z_n

$d = 100 - (y_1 + y_2 + \quad . \quad . \quad . \quad + y_n),$

then we have from Gauss' method of correlatives

$$\left.\begin{array}{ll} y'_1 = y_1 + v_1 & v'_1 = - \dfrac{p^{-1} d}{p_1^{-1} + p_2^{-1} + \quad . \quad . \quad + p_n^{-1}} \\ . \quad . \quad . \quad . \quad . & . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \\ y'_n = y_n + v_n & v'_n = - \dfrac{p_n^{-1} d}{p_1^{-1} + p_2^{-1} + \quad . \quad . \quad + x_n^{-1}} \end{array}\right\} \quad (14)$$

Equations (1) to (14) express in concise mathematical form the different least square equations for the adjustment of the observational data given in a chemical analysis. They can be applied directly to the discussion of a particular method of adjustment by a proper assignment of the weights involved. Let us now examine the methods of Schaller and Wells in the light of the above equations.

Schaller begins his computation by dividing the observed weight percentages by the atomic weights. The weights of the mol numbers thus obtained are therefore in accordance with (12) proportional to the squares of the ratio of the atomic weights to the probable errors:

$$p_1 : p_2 : \quad . \quad . \quad . \quad . \quad : p_n = \frac{A_1^2}{r_1^2} : \frac{A_2^2}{r_2^2} : \quad . \quad . \quad . \quad . \quad : \frac{A_n^2}{r_n^2}$$

in which $A_1, A_2, \quad . \quad . \quad A_n$ are the atomic weights and $r_1, r_2, \quad . \quad . \quad . \quad r_n$ the probable errors of the original analysis.

He then employs equation (5) with the computed mol numbers as the x values and the theoretical molecular ratios as the y values thus adopting two systems of independent weights, a procedure which is not necessarily justifiable. A third system of weights is introduced in reducing these numbers to approximate multiples of unity. His final comparison on the basis of equal weights is therefore theoretically incorrect.

The method of Van Horn and Cook[4] which Schaller proposed to improve can be obtained by substituting the appropriate quantities in equation (3) but to assign arbitrarily the weight infinity to a particular weight percentage is evidently contrary to the analytical facts and the method is accordingly not rigorous.

Wells takes the observed weight percentages for the x values and substitutes them in equations (14) with the weights $p_1 = x_1^{-1}$, $p_2 = x_2^{-1}$, . . . $p_n = x_n^{-1}$. This system of weights results from the assumption that the difference between the observed sum and 100 is a sum either of positive or of negative systematic errors, each one of which is proportional to the corresponding observed percentage number. He then finds the differences between the new values and the theoretical weight percentages derived from the chemical formula ("absolute discrepancies") and finally divides each value thus obtained by its formula weight percentage and finds its "relative discrepancy in per cent." In other words he weights each "absolute discrepancy" and thus introduces a new set of weights. The arithmetic mean of these relative discrepancies "the mean relative discrepancy" taken without regard to algebraic signs is considered by Wells to be the best simple value which can be found to indicate the order of agreement of a mineral analysis with the formula. It is evident however that in each of his methods. Wells has practically repeated Schaller's errors in a slightly different form, and in addition has adopted a final criterion which consists in taking the average of quantities of unequal weight.

On page 417[5] Wells objects to the use of equations (6) and (7) on the basis that constant errors, and systematic errors, proportional to the x values, are not taken into account. In our first paper we used the term systematic error in a sense different from that adopted by Wells. We referred to those cases in which the method of analysis of any given component gives results which are consistently too large or too small, but

[4] Am. J. Sci. (4), **31**: 518. 1911.

[5] *Loc. cit.*

are in no way related to the other errors of the system. Systematic errors of the kind Wells describes are readily detected and easily separated from the random errors of the system by an application of any of the equations (5) to (8) inclusive; but preferably by means of equation (7) for the reason that it is more easily interpreted, and that, except for certain special cases, there is no adequate reason for assigning the weights imposed by the remaining equations. Both constant and systematic errors may be evaluated by means of equation (9), and, if it is desired to impose the condition that the sum of the adjusted values equals 100, we include equation (11) with equations (9) and solve in the usual manner.

To illustrate the method, let us take the data used in the papers referred to above. Substituting the values from columns (1) and (2) in equations (10) and putting the weights equal to unity, we find

$$a = 0.030 \qquad m = 0.049646.$$

The theoretical value of m is

$$m' = \frac{100}{2009.61} = 0.049761,$$

hence there are systematic errors proportional to the difference of these two quantities. Multiplying the difference ($m' - m = 0.000115$) by the successive values of x, we obtain the values in column (5) which represent the probable systematic errors of the system.

	1	2	3	4	5	6	7	8	9	10	11	12	13
	Weight numbers (x)	Weight percentages (y) observed	Weight percentages (y') computed	Residuals obs.—comp.	Systematic errors	Weight percentages (y) assumed	Weight percentages (y') computed	Residuals obs.—comp.	Weight percentages (y') computed	Residuals obs.—com.	Theoretical weight percentage (x)	Weight percentage (y') computed	Residuals obs.—comp.
S	352.79	17.46	17.54	−0.08	−0.041	17.47	17.55	−0.08	17.52	−0 06	17.56	17.55	−0.09
As	150 00	7.56	7.48	+0.08	−0.017	7.62	7.54	+0 08	....	......	7.46	7.47+	+0.09
Ag	1191.85	59.22	59.20	+0.02	−0.137	59.02	59.00	+0.02	59 20	+0 02	59.31	59.20	+0.02
Cu	314.97	15.65	15.67	−0.02	−0 036	15.67	15.69	−0.02	15.65	0 00	15.67	15.66+	−0 01
	2009.61	99.89	99.89			99.78					100.00	99.88+	

The probable constant error is $a = 0.030$. Referring to figure 1, we see that $a = OO'$, and m is the tangent of the angle which the adjusted line makes with the x axis. Hence it follows that the ordinates of this line are each too long by the amount 0.03, and at the same time, since $m < m'$, these ordinates are too short by the amounts given in column (5). The random errors of the system are the residuals tabulated in column (4). Again, let us apply the same method to the adjustment of the values of column (6). Proceeding in the same manner as before, we find the constants,

$$a = 0.128,$$
$$m = 0.049396,$$

and the computed weight percentages of column (7). By comparing these values of a and m with the preceding values, it is easy to show that a constant error, $+ 0.10$ and a systematic error $- 0.005\ y$ has been added to each of the values of column (2). A correct application and interpretation of our equations thus leads to a complete solution of the problem.

Wells objects to the use of formula (7) on the basis that the computed sum does not equal 100 or the observed sum. This objection is not necessarily valid for various reasons.

1. The observed weight percentages contain small errors, consequently in accordance with the principles of probability, the observed sum is likewise in error.

2. The composition of a mineral is unknown. It is therefore more nearly representative of the observed facts to adjust accurately such percentages as have been obtained, leaving the remainder for future determinations. Adjustments of this kind are not on the same basis as the adjustments of the angles of a triangle where it is known a priori that the sum of the angles is equal to 180°.

3. Adjustment on the basis of 100 does not necessarily lead to correct results. To illustrate, by an extreme example, let it be assumed that *As* has not been determined in the above analysis. The computed values of the remaining elements as obtained from equation (7) are given in column (9). It will be noted that the values are sufficiently accurate to enable us to decide correctly in regard to the three elements involved, whereas mere expansion to 100 would in this case lead to an absurd result. Any method of averages will at times lead to incorrect results when one or more of the elements are present in very small quantities. An obvious remedy consists in assigning large weights to these quantities.

4. Even though one might admit that adjustment on the basis of 100 is legitimate, there is no valid reason for assuming that mere expansion or contraction to 100 on the basis of proportionality is necessarily a correct solution of the problem. This solution is only one of many which can be obtained by the substitution of different weights in equation (14); an entirely different set of solutions can be obtained by substitution of the weights in the group of equations (9), (10), and (11).

Column (12) gives the computed weight percentages when the theoretical weight percentages are substituted in equation (9) instead of the theoretical weight numbers. The method is theoretically correct, but slightly less precise than the first method, on account of using smaller coefficients. Tests for systematic errors are readily made for the reason that the theoretical value of m is always equal to unity.

Conclusion.—In the adjustment of the data of a mineral analysis it is always best to deal directly with the actual errors of observation. Any method of adjustment which involves division or multiplication of the actual errors amounts to the adoption of a complicated system of weights; this is generally unjustifiable, and always renders the final result more difficult of correct interpretation.

By treating the problem from the standpoint of the least square adjustment of an empirical formula, we not only adopt a method in current use in the more exact sciences, but we obtain thereby a generality which enables us to form a correct opinion of the various methods of adjustment, and also to discover the nature of the errors involved, and thus to obtain a complete solution of the problem. In the present paper it has been shown that all of the methods which have been proposed are least square methods and differ chiefly in the manner of assigning weights to the data of observation.

Rigorous methods of calculation are given above by means of which weights may be properly taken into account. To apply these methods of computation, the chemist may either assign weights, using his own judgment as a guide, or he may determine the probable error of each percentage involved and then compute the weights from formula (12). The latter is the rigorous method of procedure and should be adopted whenever practicable.

In general, however, it is not essential that weights be assigned to the observed values. It is generally sufficient to compare the theoretical values directly with the absorved values, a method which chemists adopted from the first and have used consistently up to the present time. For the comparison of several analyses of the same mineral the established method of direct comparison of the weight percentages listed in the analyses is usually sufficient and satisfactory.

In case it is desired to test for systematic errors, or to obtain a more precise agreement between observation and theory, equation (6) or (7) should be used. Equation (6) is the simplest from the standpoint of computation, but necessitates the use of weighted residuals. Equation (7) is a little more difficult to compute but the difficulty of using weighted residuals is avoided. Since there are not, in general, sufficient data available to enable one to assign weights correctly, it follows that equation (7) most nearly represents the facts. The values obtained from (6) differ only slightly from those obtained from (7) and may be used as a sufficient approximation. Equation (5) is entitled to consideration for the reason that the sum of the percentage residuals vanishes. (See equation 3.) It is defective in that a preponderance of weight is given to points near the origin. The same is true of (6), but to a much less degree. The application of the remaining equations, of which there is an infinite number, involves the use of weights for which no valid reason can be given except for certain special cases.

Percentage errors are best computed from the differences between the theoretical weight percentages and the observed, or the computed, weight percentages.

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PHYSICS.—*Avogadro's constant and atmospheric transparency.*

F. E. Fowle, Astrophysical Observatory, Smithsonian Institution.[1]

In this communication are given coefficients for the transmissibility of radiation through the dry air vertically above Mount Wilson together with factors and a formula for computing the transmissibility for moist air for other zenith distances and altitudes above sea-level where dust has become a negligable quantity (above 1000 meters). No account is, however, taken in this formula of selective absorption.

By means of Rayleigh's formula connecting the scattering of light passing through a gas with the number of molecules, these coefficients have been used to compute the number of molecules under standard conditions. The merits of the present reductions over those of an earlier paper by the author lie in using the index of refraction proper to each wave-length in place of a mean value, in better values for the transmission coefficients and in a more accurate value for the barometric pressure, the value before used being taken at an appreciable higher altitude on the mountain than our observatory. The mean results give for Loschmidt's number or the number of molecules in a cubic centimeter of a gas at 0°C. and 76 cm. pressure

$$n_0 = (2.70 \pm 0.02) \times 10^{19}$$

[1] This paper, read before the Philosophical Society, October 10, 1914, will appear in full elsewhere, probably in the Astrophysical Journal.

and for Avogadro's constant or the number of molecules per gram molecule

$$N = (6.05 \pm 0.04) \times 10^{23}.$$

The agreement of the above value for n_0 with what is perhaps the best value from other methods, $(2.705 \pm 0.005) \times 10^{19}$ (Millikan), must give weight to the accuracy of the estimation of the atmospheric losses in the determinations of the solar radiation by the Smithsonian Observatory. Some criticism is made of the procedure of L. V. King who uses our observed moist-air transmission coefficients for a similar purpose, mainly in that he uses coefficients for wave-lengths where selective absorption is present and for such losses Rayleigh's formula does not hold.

A remnant of the volcanic dust from the eruption of Mount Katmai, Alaska, in 1912, scattering somewhat less than 3 per cent of the incident radiation, is indicated by the 1913 transmission coefficients. It is perhaps worth noting that, fine as this dust must be to have remained suspended in the upper air over a year, its scattering of radiation scarcely varies with the wave-length, at least between the limits 0.38μ and 0.81μ.

PHYSICS.—*Measurement of the extraordinary refractive index of a uniaxial crystal by observations in convergent light on a plate normal to the optic axis.* H. E. MERWIN, Geophysical Laboratory.

During an investigation of the optical properties of the trioxides of arsenic and antimony, it was found that attempts to crush the tabular, hexagonal crystals into grains which could be suitably oriented for the determination of the extraordinary refractive index, resulted in producing aggregates, probably due to gliding. The possibility of measuring ϵ by a study of the interference rings on basal plates in convergent polarized light was then considered.

The figure represents a vertical section through a basal plate of an optically negative uniaxial crystal. The wave-normals for the ordinary and the extraordinary wave originating from the same incident wave are shown. They form with the optic axis the angles α and α_1, within the crystal, and the angle β in the air where they are parallel. The emergent waves are supposed to totally interfere in one of the observed dark rings. In r and s, between normals from the surface, there are the same number of waves, then the difference in phase between the two waves entering the microscope is expressed by the equation $\frac{\omega\, m}{\lambda} - l = \frac{m_1 \epsilon_1}{\lambda}$, in which l is the number of wave-lengths that the extraordinary wave is in advance of the ordinary wave as determined by the serial number of the dark ring, counted outward from the optic axis; λ is the wave-length in air; ω the ordinary refractive index; and ϵ_1 the refractive index of the extraordinary wave whose normal makes the angle α_1 with optic axis. e is the thickness of the section.

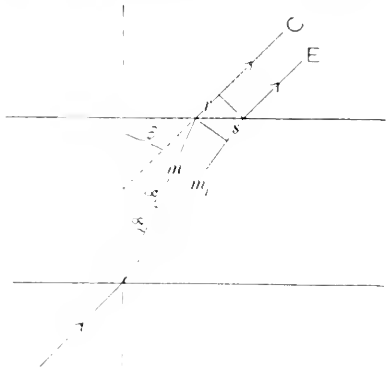

Fig. 1

$$\sin \alpha = \frac{\sin \beta}{\omega}, \text{ and } m = \frac{e}{\cos \alpha}$$

Then $m = \dfrac{e}{\sqrt{1 - \dfrac{\sin^2 \beta}{\omega^2}}}$

Now $m_1 = m \cos (\alpha_1 - \alpha) = m (\cos \alpha \cdot \cos \alpha_1 + \sin \alpha \cdot \sin \alpha_1) \ldots\ldots (1)$

Then $\frac{\omega m}{\lambda} - l = \epsilon_1 m (\cos \alpha \cdot \cos \alpha_1 + \sin \alpha \cdot \sin \alpha_1)$ for a negative crystal. For a positive crystal l is positive, therefore in the general case, after substituting

$$\frac{\omega e}{\lambda \cos \alpha} \pm l = \frac{\epsilon_1 e (\cos \alpha \cdot \cos \alpha_1 + \sin \alpha \cdot \sin \alpha_1)}{\lambda \cos \alpha} =$$

$$\frac{\epsilon_1 e}{\lambda} \left(\cos \alpha_1 + \sin \alpha_1 \frac{\sin \alpha}{\cos \alpha} \right) \ldots\ldots\ldots\ldots\ldots (2)$$

$$\frac{\omega e}{\lambda\sqrt{1-\frac{\sin^2\beta}{\omega^2}}} \pm l = \frac{\epsilon_1 e}{\lambda}\left(\sqrt{1-\frac{\sin^2\beta}{\epsilon_1^2}} + \frac{\frac{\sin^2\beta}{\epsilon_1\,\omega}}{\sqrt{1-\frac{\sin^2\beta}{\omega^2}}}\right)$$

$$\frac{\omega}{\frac{1}{\omega}\sqrt{\omega^2-\sin^2\beta}} \pm \frac{l\lambda}{e} = \sqrt{\epsilon_1^2-\sin^2\beta} + \frac{\sin^2\beta}{\sqrt{\omega^2-\sin^2\beta}}.$$

$$\sqrt{\epsilon_1^2-\sin^2\beta} = \frac{\omega^2}{\sqrt{\omega^2-\sin^2\beta}} + \frac{\sin^2\beta}{\sqrt{\omega^2-\sin^2\beta}} \pm \frac{l\lambda}{e}.$$

$$\epsilon_1^2 = \omega^2 + \left(\frac{l\lambda}{e}\right)^2 + \frac{2\,l\,\lambda}{e}\sqrt{\omega^2-\sin^2\beta} \quad \ldots\ldots\ldots\ldots (3)$$

A simpler equation than (3), which for such angles as are measurable by the microscope contains an entirely negligible error not greater than 2 or 3 units in the 5th decimal place, is derived as follows: assume that the cosine of the very small angle $(\alpha_1 - \alpha)$ equals 1, then in (1) $m = m_1$, and in (2)

$$\frac{\omega e}{\lambda\cos\alpha} \pm l = \frac{\epsilon_1 e}{\lambda\cos\alpha} \text{ or } \epsilon_1 = \omega \pm \frac{l\,\lambda\cos\alpha}{e} = \omega \pm \frac{l\lambda}{e}\sqrt{1-\frac{\sin^2\beta}{\omega^2}} \quad (3a)$$

Equation (3) gives exactly, and equation (3a) almost exactly the refractive index of the extraordinary wave whose normal makes with the optic axis the angle α_1 within the crystal, and the angle β in the air.

From the general equation of the index ellipsoid

$$\epsilon = \frac{\omega\sin\alpha_1}{\sqrt{\frac{\omega^2}{\epsilon_1^2}-\cos^2\alpha_1}} = \frac{\frac{\omega\sin\beta}{\epsilon_1}}{\frac{1}{\epsilon_1}\sqrt{\frac{\omega^2}{\epsilon_1^2}-\left(1-\frac{\sin^2\beta}{\epsilon_1^2}\right)}}$$

$$\epsilon = \frac{\omega\sin\beta}{\sqrt{\omega^2-\epsilon_1^2+\sin^2\beta}} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

Substituting[1] (3)

[1]Substituting (3a) we have $\epsilon = \dfrac{\omega\sin\beta}{\sqrt{\omega^2-\left(\omega \pm \frac{l\lambda}{e}\sqrt{1-\frac{\sin^2\beta}{\omega^2}}\right)^2+\sin^2\beta}}$. (6a)

This value of ϵ, though not precisely correct, has no measurable error.

$$\epsilon = \frac{\omega \sin \beta}{\sqrt{\omega^2 - \left[\omega^2 + \left(\frac{l\lambda}{e}\right)^2 \pm \frac{2l\lambda\omega}{e}\sqrt{1 - \frac{\sin^2 \beta}{\omega^2}}\right] + \sin^2 \beta}} \quad \ldots (5)$$

$$\epsilon = \frac{\sin \beta}{\sqrt{1 - \left(\sqrt{1 - \frac{\sin^2 \beta}{\omega^2}} \pm \frac{l\lambda}{e\,\omega}\right)^2}} \quad \ldots\ldots\ldots\ldots (6)$$

This is a true equation for the extraordinary refractive index of a uniaxial crystal.[2]

From measurements of β and l on two rings of the same section, equations can be formed from (6) which when solved simultaneously permit the elimination of one of the constants ω, ϵ, λ, e. However, the resulting equations have no practical application, for very slight errors in the observed values of β may make very large errors in the values calculated.

If ω, ϵ and λ are known e, the thickness of the plate, is readily and accurately found thus:

By transposition (4) becomes $\epsilon_1 = \sqrt{\omega^2 + \sin^2 \beta\left(1 - \frac{\omega^2}{\epsilon^2}\right)}$

Then by substituting (3a)

$$\omega \pm \frac{l\lambda}{e}\sqrt{1 - \frac{\sin^2 \beta}{\omega^2}} = \sqrt{\omega^2 + \sin^2 \beta\left(1 - \frac{\omega^2}{\epsilon^2}\right)}$$

From which $e = \dfrac{l\lambda\sqrt{1 - \frac{\sin^2 \beta}{\omega^2}}}{\sqrt{\omega^2 + \sin^2 \beta\left(1 - \frac{\omega^2}{\epsilon^2}\right)} - \omega}$

From the idea of the isochromatic surface several roughly approximate formulas[3] have been developed which contain a term in which the double refraction appears. These assume

[2] This equation is identical with equation g (expressed in the form of equation 6) of the article by F. E. Wright in this issue; the present equation is derived, however, by a different method.

[3] See Preston's The Theory of Light, pp. 393–345; and Duparc and Pearce's Traité de Technique Mineralogique et Pétrographique, pp. 312–313.

that the angle α within the crystal is known. This angle cannot be obtained from microscopic measurements unless one of the indices of refraction is known.

For measuring the dark rings a standardized microscope with screw micrometer ocular is most satisfactory, but a cross-grating ocular can be used effectively, especially if, when the rings are closely spaced, the readings are made along the diagonals of the squares. The average of readings in the four quadrants should be taken. If this is done, errors due to distortion by the tube nicol and to lack of precise perpendicularity of the plate to the optic axis are largely compensated. If the plate lacks 5° of being normal to the optic axis no appreciable error will result.

As shown by measurements on several plates of arsenic triiodide and calcite the angle β can be found within about 0.2°. The corresponding calculated value of $\omega - \epsilon$ is in error 2 per cent when $\beta = 10°$, 1 per cent when $\beta = 20°$, and $\frac{7}{10}$ per cent when $\beta = 35°$.

PHYSICS.—*Measurements of refractive indices on the principal optical sections of birefracting minerals in convergent polarized light.* FRED. EUGENE WRIGHT, Geophysical Laboratory.

The principal optical sections of birefracting minerals play an important rôle in petrographic microscope work. They are parallel to the planes of symmetry of the optic ellipsoid and exhibit, in convergent polarized light, characteristic interference figures. On any given principal optical section two of the three principal refractive indices of the mineral can be measured directly by the immersion method. The third principal refractive index of the mineral can also be determined by use of the phenomena observed on the same section in convergent polarized light. The methods available for this determination involve some computation and have not been used to any extent by petrologists; but, in exceptional cases, especially on thin tabular crystals, the usual methods may prove inadequate and the methods outlined below may then be used to advantage to obtain accurate results. The usefulness of such formulas has recently been shown by H. E. Merwin, of this Laboratory, in the measurement of the refractive indices of minute uniaxial crystal flakes of arsenic iodide; Dr. Merwin measured the angular width of the concentric interference rings and from these computed the refractive index ϵ by means of a formula[1] which he found to furnish accurate results for uniaxial sections normal to the axis.

Derivation of formulae.[2] For the particular case of principal sections the accurate formulae can be derived directly as follows: Let figure 1 represent a principal section of a birefracting plate. Let KC be the incident, plane-polarized beam of light (in air); CA and CB, the two refracted wave normals; AD and BE the two parallel emergent beams (in air), which enter the objective and are brought to focus in its upper focal plane whence they pass through the analyzer to the eye of the observer. For the incident and refracted wave normals the general relations (invariants) obtain

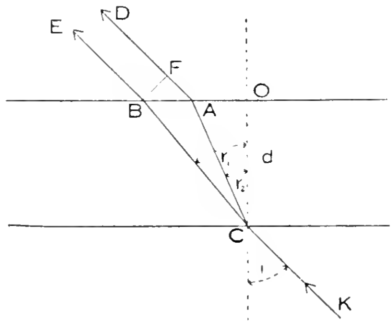

Fig. 1

$$n_0 \sin i = n_1 \sin r_1 = n_2 \sin r_2 \ldots\ldots\ldots\ldots (1)$$

in which i is the angle of incidence; r_1, the angle of refraction of the faster wave; r_2, the angle of refraction of the slower wave; n_0, the refractive index of air (for present purposes n_0 may be considered = 1); n_1, the refractive index of the faster wave; n_2, the refractive index of the slower wave. The interference phenomena are the result, primarily, of the difference in optical path between the two refracted waves, starting at C and attaining again a common wave front at BF. This path-difference is expressed by the equation:

$$\Delta = k \cdot \lambda = n_2 \cdot CA + n_0 \cdot AF - n_1 \cdot CB$$

[1] J. Wash. Acad. Sci., **4**: 532, equation (6a). 1914.

[2] The derivation of the formulae for the general case of any section of a birefracting mineral is given in text books on crystal optics (Pockels, Lehrbuch der Kristalloptik. Chaps. II, IV, IX, 1906).

or

$$k\lambda = n_2 \cdot \frac{d}{\cos r_2} + n_0 \cdot d\,(\tan r_1 - \tan r_2)\,\sin i - n_1 \cdot \frac{d}{\cos r_1} \quad ..(2)$$

in which Δ is the path difference; λ, the wave length of the interfering bands; k, the number of wave lengths included in the path-difference Δ. From (1) and (2) we obtain the relation:

$$\frac{k \cdot \lambda}{d} = n_2 \cos r_2 - n_1 \cos r_1 \ldots\ldots\ldots\ldots (3)$$

$$\frac{k \cdot \lambda}{d} = \frac{n_2}{\frac{CA}{d}} - \frac{n_1}{\frac{CB}{d}} \ldots\ldots\ldots\ldots (3a)$$

an equation which in the form (3a) states that the path-difference for unit thickness of plate is equal to the difference between

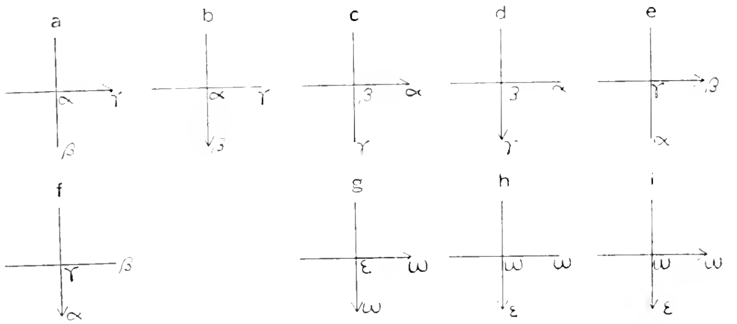

Fig. 2

the reciprocals, referred to air, of the paths CA and CB of the two refracted wave normals.

Values for the terms $n_1 \cos r_1$, and $n_2 \cos r_2$ in equation (3), can be deduced from the general equation of the index surface referred to the principal axes

$$\frac{\nu_1^2}{\frac{1}{\alpha^2} - \frac{1}{n^2}} + \frac{\nu_2^2}{\frac{1}{\beta^2} - \frac{1}{n^2}} + \frac{\nu_3^2}{\frac{1}{\gamma^2} - \frac{1}{n^2}} = 0 \ldots\ldots\ldots\ldots (4)$$

in which ν_1, ν_2, ν_3 are the direction cosines of the refracted wave normal, n, its refractive index and α, β, γ, the principal refractive indices of the mineral.

To apply these formulas to a particular case, let us consider a plate to be cut normal to α and the plane of incidence to be the $\alpha\,\gamma$ plane (fig. 2a). Under these conditions

$$n_1 = \beta,\ r_1 = r_\beta;\ \nu_1 = \cos r_2,\ \nu_2 = 0,\ \nu_3 = \sin \gamma_3;$$

and equation (4) becomes

$$\frac{\cos^2 r_2}{\frac{1}{\alpha^2} - \frac{1}{n^2}} + \frac{\sin^2 r_2}{\frac{1}{\gamma^2} - \frac{1}{n^2}} = 0$$

from which we obtain on expansion

$$n_2^2 \cos^2 r_2 = \gamma^2 \left(1 - \frac{n_1^2 \sin^2 r_1}{\alpha^2}\right) = \gamma^2 \left(1 - \frac{\sin^2 i}{\alpha^2}\right) = \gamma^2 \cos^2 r_\alpha$$

if we consider r_α to be the angle of refraction of the wave which satisfies the equation

$$\sin i = \alpha \cdot \sin r_\alpha \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Equation (3) can now be written

$$\frac{k \cdot \lambda}{d} = \gamma \sqrt{1 - \frac{\sin^2 i}{\alpha^2}} - \beta \cos r_\beta \ldots\ldots\ldots\ldots (6)$$

or

$$\frac{k \cdot \lambda}{d} = \gamma \cos r_\alpha - \beta \cos r_\beta \ldots\ldots\ldots\ldots (6a)$$

For purposes of computation equations (5) and (6a) are more convenient than (6).

The equations for the different cases indicated in figure 2[3] are:

$$\frac{k \cdot \lambda}{d} = \gamma \cos r_\alpha - \beta \cos r_\beta \quad \text{and} \quad \sin i = \alpha \cdot \sin r_\alpha \ldots a \text{ (fig. 2)}$$

$$-\frac{k \cdot \lambda}{d} = \beta \cos_\alpha \quad - \gamma \cos r_\gamma \quad \text{and} \quad \sin i = \alpha \cdot \sin r_\alpha \ldots b \text{ (fig. 2)}$$

$$-\frac{k \cdot \lambda}{d} = \alpha \cos r_\beta - \gamma \cos r_\gamma \quad \text{and} \quad \sin i = \beta \cdot \sin r_\beta \ldots c \text{ (fig. 2)}$$

[3] In each small figure of figure 2 the arrow represents the trace of the plane of incidence on the horizontal plane.

$$\frac{k \cdot \lambda}{d} = \gamma \cos r_\beta - \alpha \cos r_\alpha \quad \text{and} \quad \sin i = \beta \cdot \sin r_\beta \ldots . d \text{ (fig. 2)}$$

$$\frac{k \cdot \lambda}{d} = \beta \cos r_\gamma - \alpha \cos r_\alpha \quad \text{and} \quad \sin i = \gamma \cdot \sin r_\gamma \ldots . e \text{ (fig. 2)}$$

$$-\frac{k \cdot \lambda}{d} = \alpha \cos r_\gamma - \beta \cos r_\beta \quad \text{and} \quad \sin i = \gamma \cdot \sin r_\gamma \ldots . f \text{ (fig. 2)}$$

For uniaxial minerals these equations reduce to the following, in which the positive of the $\pm$ sign should be used for a positive mineral, the negative sign for a negative mineral.
(1) Section normal to the principal axis

$$\pm\frac{k \cdot \lambda}{d} = \omega (\cos r_\epsilon - \cos r_\omega) \text{ and } \sin i = \epsilon \cdot \sin r_\epsilon \ldots\ldots g \text{ (fig. 2)}$$

(2) Section parallel to the principal axis

$$\pm\frac{k \cdot \lambda}{d} = (\epsilon - \omega) \cos r_\omega \ldots\ldots\ldots\ldots\ldots\ldots h \text{ (fig. 2)}$$

$$\pm\frac{k \cdot \lambda}{d} = \epsilon \cos r_\epsilon - \omega \cos r_\omega \text{ and } \sin i = \epsilon \sin r_\epsilon \ldots\ldots . i \text{ (fig. 2)}$$

It is of interest to note that in the case of normal incidence ($i = r = 0$) all of the above equations reduce to the ordinary expression for the birefringence $\frac{k \cdot \lambda}{d} = n_2 - n_1$ (i.e., path-difference varies with thickness of plate and with the birefringence.) In the case of a section normal to a bisectrix the path-difference for waves along an optic axis (binormal) is zero and the angle of refraction is half the optic axial angle ($r_\beta = V$); thus from equation a we find

$$0 = \gamma \cos {}_\alpha - \beta \cos V_\alpha \text{ or}$$

$$\cos V_\alpha = \frac{\gamma}{\beta} \cdot \cos r_\alpha \ldots\ldots\ldots\ldots\ldots (7)$$

from which the usual expression $\cos^2 V_\alpha = \dfrac{\frac{1}{\alpha^2} - \frac{1}{\beta^2}}{\frac{1}{\alpha^2} = \frac{1}{\gamma^2}}$ can be easily derived. Equation (6) is a convenient form to use for computing the third refractive index, provided the optic axial angle and two of the refractive indices are known.

Methods of measurement. The above equations express relations between certain quantities which can be measured as follows:

d, thickness of plate, measured either by a micrometer or a spherometer or by one of the standard microscope methods. On thin plates (a few hundredths of a millimeter thick) the error may amount to 10 per cent; on thicker plates the percentage error is correspondingly less. On many sections the thickness is best found by computation from the interference fringes. The exact path-difference, $k{\cdot}\lambda$, is ascertained by direct count of the interference bands.

n_1, n_2, two of three principal refractive indices of the mineral measured on the given plate either by the immersion method or other standard method. Error should not exceed 0.001.

i, the angle of incidence for the interference line selected, is measured by use of the petrographic microscope equipped with Bertrand lens and either a screw-micrometer ocular or a graduated scale in the eye-piece. On sections of minerals of strong birefringence or on thick plates the interference bands are sharp and the errors of reading should be considerably less than 1°. With thin plates and minerals of medium or weak birefringence the accuracy of the readings is less because of the wide interference lines, but in this case the need for greater accuracy decreases so that on nearly all plates the measurements should furnish refractive index values which are adequate for most purposes.

In certain cases the thickness is difficult to determine; also the order, k, of the interference line may be uncertain, or only one refractive may have been determined. These and other problems can be solved by the measurement of several interference lines. Thus in case the measurement of the thickness is not feasible, we have on a section normal to α for two interference bands, which can be measured, the equation

$$\frac{k_1}{k_2} = \frac{\gamma \cos \ _{\alpha 1} - \beta \cos r_{\beta 1}}{\gamma \cos r_{\alpha 2} - \beta \cos r_{\beta 2}} \quad \ldots\ldots\ldots\ldots\ldots (8)$$

in which $\cos r_{\alpha 1}$ and $\cos r_{\alpha 2}$ are the unknowns, depending on i_1 and i_2 and α. This equation is most readily solved by assuming a value approximately correct for α; for this value of α, $\cos r_{\alpha 1}$ is computed by means of equation (5). The value of $\cos r_{\alpha 2}$

is then derived from equation (8) and from it and $i_{\alpha 2}$ a second value for α obtained, which will probably be either higher or lower than that originally assumed; a second value for α is accordingly chosen and the computation repeated; the new value of α will probably also be too low or too high. If now the four values thus obtained be plotted on ordinates to scale and a straight line be drawn connecting the assumed values, and a second line connecting the computed values, the intersection of these two lines furnishes a value of α which is sufficiently exact for most purposes. Analogous methods of procedure can be used in solving for two unknown refractive indices, or for path-differences, or for wave length of light employed.

In the special case of a section normal to one of the bisectrices the optic axial angle can be computed with a fair degree of accuracy from measurements on interferences fringes, even though the actual optic axes are outside the field of view. For this purpose, several interference lines are measured to obviate the determination of the thickness of the plate. In case only one interference band is visible the method is still applicable, provided a plate of known path-difference (e.g. $\frac{1}{2}\lambda$) be inserted below the condenser and the path-difference of the interfering waves be increased or decreased a definite fraction of a wave length.

Measurements on crystal plates.

(1) *Uniaxial. Plate normal to axis.* (Equation *g*)

(a) Calcite plate (V. and H. collection No. 22). Optically negative; d = 0.233 mm. (computed); λ = 0.000589 mm.; ω = 1.658; ϵ = 1.486.

k	1	2	3	4	5	6	7	8
i	10°3	15°0	18°4	21°4	24°0	26°5	28°5	30°5
ϵ	1.477	1.485	1.485	1.483	1.486	1.488	1.486	1.485

With the exception of the first value of ϵ in this table (interference band too wide for accurate readings) the computed values of ϵ do not vary greatly and the average value, ϵ = 1.4854, is sufficiently accurate for most purposes.

(b) Zircon plate (V. and H collection No. 26) optically positive; d = 0.545 mm. (computed); λ = 0.000589 mm.; ω = 1.930; ϵ = 1.983.

k	1	2	3
i	26°1	38°8	48°0
ϵ		1.984	1.984

In this instance the refractive index was computed from equation g for $k = 1$ and $k = 2$ and from equation g for $k = 1$ and $k = 3$. The agreement is satisfactory.

(2) *Uniaxial. Plate parallel to axis.* (Equation h)

Calcite plate (V. and H. collection No. 23.) Optically $-$; $d = 0.082$ mm.; $\lambda = 0.000589$ mm.; $\omega = 1.658$; $\epsilon = 1.486$.

k	24	23	22	21	20	19
i	0	16°.5	23°.5	29°.8	33°.2	37°.5
ϵ	1.486	1.487	1.487	1.485	1.487	1.486

Average $\epsilon = 1.4863$. On this section the path-difference in wave lengths for the different interference lines was ascertained by computation, the plate being too thick for the determinination of the path-differences by ordinary methods of compensation.

(3) *Biaxial. Plate normal to a bisectrix.* (Equations e, f)

Anhydrite. Plate approximately normal to the acute bisectrix γ; $\lambda = 0.000589$ mm.; $\alpha = 1.570$; $\beta = 1.575$; $\gamma = 1.613$.

(a) Plane of incidence $\gamma\ \alpha$ plane. (Equation f)

k	1	0	-1
i	17°.0	35°.3	43°.5

$\gamma = 1.615$ (computed from equations for $k = 1$ and $k = -1$); $\gamma = 1.609$ (computed from equation for $k = 0$).

(b) Plane of incidence $\gamma\ \beta$ plane. (Equation e)

k	2	3	4
i	25°.4	39°.3	48°.5

$\gamma = 1.608$ (computed from equations for $k = 2$ and $k = 3$); $\gamma = 1.607$, (computed from equations for $k = 2$ and $k = 4$).

The values of γ thus obtained vary within relatively large limits. This may be due to the fact that the section was not exactly normal to the bisectrix and also that the values of α and β are slightly in error. In this instance γ is considerably larger than α and β and in computing γ a slight variation in either α or β produces a relatively large variation in γ. The mean of the values listed above is 1.610 or 0.003 less than the refractive index γ given for anhydrite.

(4) *Biaxial. Plate perpendicular to the optic normal.* (Equations c, d)

Selenite. Plate parallel to cleavage plane (010). Normal to β; $d = 0.700$ mm. (measured by micrometer); $\lambda = 0.000589$ mm.; $\alpha = 1.5204$; $\beta = 1.5227$; $\gamma = 1.5296$.

(a) Plane of incidence $\beta\alpha$ plane. (Equation c)

k	11	12
i	27°.4	57°.2
β	1.523	1.523

(b) Plane of incidence $\beta\ \gamma$ plane. (Equation d)

$k = 10$; $i = 51°.2$; $\beta = 1.522$.

Average $\beta = 1.5227$

In this instance the path-difference, in terms of wave length, for the different interference lines was computed.

These examples suffice to show the order of accuracy of the different methods and also to indicate the variety of problems to which the formulae are applicable. At best, however, these methods are of limited application, although in special cases they render good service.

TECHNICAL PHYSICS.—*The laws of lubrication of horizontal journal bearings.* M. D. HERSEY, Bureau of Standards. Communicated by E. BUCKINGHAM.

I. RELATION OF LAWS OF LUBRICATION TO BEARING DESIGN

1. The two laws of lubrication needed in designing. In the design of horizontal journal bearings, after all questions of strength and rigidity have been disposed of, there usually remains a question as to length and diameter, which must be settled by reference to the laws of lubrication. Evidently too short a bearing is in danger of abrasion, while too long a bearing entails needless dissipation of power.

Let the "coefficient of friction," f, be defined by the equation

$$f = \frac{F}{L} \tag{1}$$

in which F is the frictional resisting force and L the load on the bearing perpendicular to its axis. Let the "bearing pressure," p, be defined by the equation

$$p = \frac{L}{lD} \tag{2}$$

in which l is the length of the bearing and D the diameter of the journal. Let p_0 denote the "carrying power" or greatest permissible bearing pressure. Then the shortest permissible length of a bearing, l_0, may be calculated from the equation

$$l_0 = \frac{L}{D} \cdot \frac{1}{p_0} \tag{3}$$

while the power dissipated in this bearing at a speed of n revolutions per unit time will be

$$P = \pi \,.\, D n \,.\, L \,.\, f \tag{4}$$

Equations (3) and (4) are purely formal and their practical use demands a knowledge of some relation

$$f = \varphi_1 (p, n, D, l, \text{etc}) \dots\dots\dots\dots\dots\dots (5)$$

between the coefficient of friction and all the physical conditions governing the action of lubrication; together with some relation

$$p_0 = \theta_1, (n, D, l, \text{etc.}) \dots\dots\dots\dots\dots\dots (6)$$

between carrying power and the various controlling factors. Equations (5) and (6) symbolize the two laws of lubrication which are needed in designing. They may be called the "law of friction" and the "law of carrying power" respectively.

2. Assumptions relating to carrying power. In designing bearings it is of the utmost importance to decide whether carrying power and speed shall be assumed to vary in the same or in opposite directions. The former assumption is the one commonly given in text-books. But the latter assumption appears to represent the practice of the General Electric Company,[1] and will be shown in this paper[2] to be directly deducible from physical facts.

II. THE DYNAMICS OF LUBRICATION

3. Scope of the problem and method of attack. This paper is limited to the consideration of horizontal journal bearings lubricated with clean oil and running under steady conditions. We exclude metallic contact (very heavy load with very low speed), also the case of any appreciable thrust due to forced lubrication. With these restrictions, our problem is to map out the laws of lubrication as completely as can be done on the ground of commonly accepted physical principles. But it will appear that we need not exclude oil-grooves, ring-oiling, eccentric load, worn (i.e. non-circular) bearings, or any other purely geometrical irregularities. Thus, we attack a more general case than could be handled by mathematical reasoning alone.

Under the above limitations we may regard the frictional resistance of a bearing as due entirely to the force required to shear the oil; while the tendency of a journal to center itself at high speeds may be attributed to the wedging action of the oil

[1] Alford, Bearings and their Lubrication (1911), p. 81.

[2] See equation (27).

film as it is dragged under the journal at the point of nearest approach. Let the film thickness at this point be x, while c denotes the mean radial clearance. Call the ratio $\frac{x}{c}$ the relative film thickness. Then *if* it be granted that *all bearings are equally safe when running with the same relative film thickness*, we may conveniently define carrying power as that bearing pressure which reduces the relative film thickness to some prescribed value $\left(\frac{x}{c}\right)_0$. The determination of f and p_0 as indicated in equations (5) and (6) therefore demands a physical analysis of the effect of various conditions on F and x respectively.

4. Physical conditions governing the action of lubrication. Temperature is evidently a governing factor, and will in turn depend in some complicated way on the speed. But temperature can influence friction and film thickness only indirectly, through its effect on the clearance and on the viscosity of the oil. The problem may therefore be simplified by treating the dynamics of the case separately from heating effects.

The dynamical factors on which F and x may depend will evidently include the size and shape of the journal and bearing, which may be specified by D, $\frac{l}{D}$, $\frac{c}{D}$, and such other length-ratios r', r'', etc., as may be needed to fix the shape of the oiling arrangements, deviation from circular section due to wear, etc.; the load, L, and its line of action, specified by length-ratios r''', etc.; the speed of the journal specified by the number of revolutions n, per unit time; the relative oil supply, specified by the ratio, S, of the volume of oil in the bearing to the whole volume of the clearance space; and the mechanical properties of the lubricant, the viscosity μ being usually the only effective property. *If* the foregoing list includes *all* the determining factors we may write symbolically

$$F = \varphi_2\left(n, L, \mu, D, \frac{c}{D}, \frac{l}{D}, S, r\right) \tag{7}$$

$$x = \psi_2\left(n, L, \mu, D, \frac{c}{D}, \frac{l}{D}, S, r\right) \tag{8}$$

in which r stands for all the length ratios r', r'', r''', etc., and in which φ_2 and ψ_2 are unknown functions.

While the list in question does include all the determining factors met with in *ordinary* cases, it certainly does not include all that might be encountered in extreme cases. For example, with exceptionally high speeds and wide clearances the effects of centrifugal force and of turbulent motion would begin to be felt, thus involving the density of the oil in addition to its viscosity. The question of just where the dividing line comes between "ordinary" and "extreme" cases is an important one but must be passed over in the present abridged report.

5. Derivation of general form of the laws of lubrication by dimensional reasoning. A straight forward application of the principle of dimensional homogeneity[3] to equations (7) and (8) throws them at once into the form

$$F = L \cdot \varphi_3\left(\frac{\mu n D^2}{L}, \frac{c}{D}, \frac{l}{D}, S, r\right) \tag{9}$$

and

$$x = c \cdot \psi_3\left(\frac{\mu n D^2}{L}, \frac{c}{D}, \frac{l}{D}, S, r\right) \tag{10}$$

Combining (9) and (10) with (1) and (2), then gives

$$f = \varphi\left(\frac{\mu n}{p}, \frac{c}{D}, \frac{l}{D}, S, r\right) \tag{11}$$

and

$$\frac{x}{c} = \psi\left(\frac{\mu n}{p}, \frac{c}{D}, \frac{l}{D}, S, r\right) \tag{12}$$

or

$$\frac{p}{\mu n} = \theta\left(\frac{x}{c}, \frac{c}{D}, \frac{l}{D}, S, r\right) \tag{13}$$

Now when $\left(\frac{x}{c}\right) = \left(\frac{x}{c}\right)_0$, $p = p_0$ by definition. Hence from (13), calling θ_0 the value of the function θ when $\left(\frac{x}{c}\right) = \left(\frac{x}{c}\right)_0$,

$$p_0 = \theta_0 \cdot \mu n \tag{14}$$

[3] See for example, Buckingham, Windage Resistance of Steam Turbine Wheels, Bull. Bureau of Standards, **10**: 191–234, 1913; Physically Similar Systems, Phys. Rev., **4**: 345–376, 1914.

Equations (11) and (14) correspond to equations (5) and (6) respectively, and contain the two laws of lubrication in their most general form.

If two bearings are geometrically similar as regards their essential parts, the values of $\frac{c}{D}$, $\frac{l}{D}$, and the additional ratios r needed for fixing the shape (including the roughness) are the same for both: if the bearings are similarly loaded as regards direction and point of application of the force, the remaining ratios r of equation (11) are the same for both. If, finally, the bearings have the same relative oil supply or are similarly lubricated the value of S is the same for both. Under these conditions equation (11) reduces to

$$f = \Phi\left(\frac{\mu n}{p}\right) \tag{11a}$$

Hence equation (11) states that in geometrically similar bearings which are similarly loaded and lubricated, *the coefficient of friction depends only on the single variable* $\frac{\mu n}{p}$. Equation (14) states that *the carrying power of any bearing is directly proportional to the product of viscosity by revolutions per unit time:* the constant of proportionality

$$\theta_0 = \theta\left[\left(\frac{x}{c}\right)_0, \frac{c}{D}, \frac{l}{D}, S, r\right] \tag{14a}$$

being the same for all geometrically similar bearings which are similarly loaded and lubricated and which are similarly safe, *i.e.* $\left(\frac{x}{c}\right)_0 =$ constant.

6. *Dynamically similar bearings.* Any two geometrically similar bearings B and B' which are similarly loaded and lubricated ($S = S'$) and which are running at the "corresponding" speeds, pressures and viscosities defined by the equation

$$\frac{\mu n}{p} = \frac{\mu' n'}{p'} \tag{15}$$

must, by equations (11) and (12), have the same coefficient of friction and the same relative film thickness. Such bearings may be termed dynamically similar. The power dissipated in either of them may be calculated from a test made on the others, for by (4)

$$\frac{P}{P'} = \frac{D}{D'} \cdot \frac{n}{n'} \cdot \frac{L}{L'} \tag{16}$$

Moreover by (13) and (15) it follows that $\theta_0 = \theta_0'$, hence by (14)

$$\frac{p_0}{p_0'} = \frac{\mu}{\mu'} \cdot \frac{n}{n'} \tag{17}$$

Thus if the safe load and therefore the carrying power of one bearing has been established experimentally, the carrying power of the other can at once be calculated.

7. *Relation of friction to film thickness.* This is as far as the problem can be carried by the foregoing general type of reasoning. Further information must be obtained by experiment or by making some assumption as to the geometrical form of the oil film. In the particular limiting case of a perfectly cylindrical bearing free from end-effects and cavitation (i.e., completely lubricated) it is a simple matter to deduce the relation

$$f = \frac{\pi^2 \cdot \frac{D}{c} \cdot \frac{\mu n}{p}}{\sqrt{\frac{x}{c}\left(2 - \frac{x}{c}\right)}} \tag{18}$$

Equation (18) merits careful scrutiny. It is an expression for the coefficient of friction of a bearing constrained to run with a given film thickness. While the coefficient of friction for any given value of $\frac{\mu n}{p}$ is excessively high at very small film thicknesses, it will have fallen to within 16 per cent of its minimum value when the film thickness has become as large as half the clearance. Hence the relation

$$f_c = \pi^2 \cdot \frac{D}{c} \cdot \frac{\mu n}{p} \tag{19}$$

to which (18) reduces when $x = c$, may conveniently be used as an approximate expression for the coefficient of friction, f. In order to learn just how large $\frac{\mu n}{p}$ must be in order to thicken up the film to any given value we should need to know the complete form of the function ψ in equation (12); but for all thicknesses greater than $\frac{c}{2}$, the value of f_c from (19) may be used for f with an error certainly less than 16 per cent.

III. AN APPROXIMATE TREATMENT OF THERMAL EFFECTS

8. Effect of thermal expansion. This can be shown to be negligible compared with other outstanding uncertainties.

9. Effect of temperature on viscosity. The viscosity-temperature curves of most lubricating oils can be closely fitted by the empirical equation

$$\mu = \frac{\mu_1 T_1}{T} \tag{20}$$

in which T denotes $t - \tau$, t being the temperature of the oil, and τ an empirical constant not greatly different from the solidifying temperature. The subscript designates values at room temperature; thus $T_1 = t_1 - \tau$ and $\mu = \mu_1$ when $t = t_1$.

10. Relation of temperature to speed. From (19) and (20)

$$f_c = \pi^2 \cdot \frac{D}{c} \cdot \frac{\mu_1 n}{p} \cdot \frac{T_1}{T} \tag{21}$$

Assume Newton's law of cooling and let h be the heat carried off in unit time by the air, by the jacket water, or otherwise, per unit temperature elevation above room temperature. Then if J denote the mechanical equivalent of heat, equation (4) leads to the condition for equilibrium

$$\frac{\pi D n L f}{J} = h\,(t - t_1) = h\,(T - T_1) \tag{22}$$

At high enough values of $\frac{\mu n}{p}$ that f_c may be written f, we may solve (22) for the relative temperature T getting

$$T = \frac{T_1}{2}(1 + \sqrt{1 + kn^2}) \tag{23}$$

or for the actual permanent running temperature t getting

$$t = \tau + \tfrac{1}{2}(t_1 - \tau)\left(1 + \sqrt{1 + kn^2}\right) \tag{24}$$

in which the constant k is given by the relation

$$k \equiv \frac{4\pi^3}{Jh} \cdot \frac{\mu_1}{T_1} \cdot \frac{l}{c} \cdot D^3 \tag{25}$$

11. An approximate expression for the coefficient of friction. From (23) and (21), writing f for f_c, approximately

$$f = \pi^2 \cdot \frac{D}{c} \cdot \frac{\mu_1 n}{p}\left(\frac{2}{1 + \sqrt{1 + kn^2}}\right) \tag{26}$$

The coefficient of friction therefore increases less rapidly than the speed, this falling off being more pronounced the larger the value of the heating constant k.

12. An approximate expression for carrying power. Similarly substituting from (23) into (14)

$$p_0 = \theta_0 \cdot \mu_1 n\left(\frac{2}{1 + \sqrt{1 + kn^2}}\right) \tag{27}$$

Carrying power therefore increases less rapidly than speed, approaching asymptotically the limiting value

$$(p_0)_{max} = \frac{2}{\sqrt{k}} \cdot \theta_0 \mu_1 \tag{28}$$

IV. EXPERIMENTS

13. Purpose. The writer made a series of experiments on friction and carrying power at the Massachusetts Institute of Technology in 1909. Their purpose was to determine the influence of viscosity, oil-supply, and other factors on friction, and to test experimentally the notion that carrying power may increase with speed.

14. Apparatus. The journal was of hardened steel running in a brass bearing 3 inches long by 1 inch in diameter, the radial clearance having been 0.002 inch when the bearing was new. Film thickness variations were studied electrically by measuring the resistance of the oil film. Four oils were used: sperm, lard, ordinary mineral machine oil, and a heavy cylinder oil. The chief source of uncertainty was in the determination of absolute viscosities. The friction observations themselves were relatively free from error. The machine was provided with an ordinary *complete* bearing. The only feature which need be emphasized is that the conditions of practice were thus more closely reproduced than could have been done on any machine with only a half-bearing (as in the Tower type), or in which the two halves of the bearing are *both* forced against the journal by external pressure (as in the Thurston type).

15. Summary of qualitative results. The following results were obtained:

WITH INCREASE OF:	OVER THE RANGE FROM:	THE COEFFICIENT OF FRICTION, f:	THE FILM THICKNESS, x:
speed, n............	300 to 1500 r.p.m.	increased; $f \propto n$, nearly.	increased; at first slowly, then rapidly, then slowly, approaching a limit.
bearing pressure, p.	40 to 250 lbs. per sq. in.	decreased; $f \propto \frac{1}{p}$ nearly.	decreased; approaching zero asymptotically.
viscosity, μ.........	10^{-7} to $14 \cdot 10^{-7}$ in., min., lb.-wt. units.	increased; $f \propto \mu$, nearly.	increased.
oil feed	2 to 60 drops per min.	decreased; at first rapidly, but only slightly after 10 drops per min.	increased; at first rapidly, then slowly.

Any change in viscosity produced the same effect whether the viscosity was altered by changing oils or by changing temperatures. There was no indication of complete "film rupture," the film thickness decreasing continuously with increasing load as far as the observations were carried. The above cited evidence that film thickness increases with speed and viscosity and decreases with increase in load, leads at once to the conclusion that carrying power increases when speed increases.

16. Relation of friction to $\frac{\mu n}{p}$. The results of about 200 independent determinations of the coefficient of friction of sperm, lard, and machine oils at 10 or more drops per minute may be represented by the equation:

$$f = 0.002 + 6800\frac{\mu n}{p} \tag{29}$$

for values of $10^7 \frac{\mu n}{p}$ between 1 and 40. The average deviation of the observed points from this straight line is about 15 per cent. There is no systematic tendency for the points corresponding to the respective oils to cluster together. Equation (29), then, is a particular form of the general equation (11a) for approximately complete lubrication. It would be applicable to any completely lubricated bearing loaded in the ordinary manner, which is geometrically similar to the experimental bearing in every respect, including the effect of wear. Equation (29) is cited primarily as an experimental verification of the conclusion that in any given bearing with a given oil supply, the coefficient of friction depends only on the single variable $\frac{\mu n}{p}$.

A shorter series of experiments with cylinder oil over the interval from $10^7 \frac{\mu n}{p} = 30$ to 250 led, with the same degree of approximation, to the equation

$$f = 0.015 + 6800\frac{\mu n}{p} \tag{30}$$

The difference in the constant terms of the two equations is doubtless due to the fact that, with this very heavy oil, the bearing did not completely fill itself. If this surmise is correct, we have an illustration of the effect of S in equation (11).

V. GENERAL INFERENCES

17. Relating to the coördination of existing data. Since, by equations (11) and (12), the laws of lubrication may involve, in addition to the variable $\frac{\mu n}{p}$, any of the quantities $\frac{c}{D}, \frac{l}{D}$, S, and the r's, in attempting to coördinate data obtained by different observers we must consider the possible influence of all these factors.

18. Relating to future experiments. (1) In formulating the laws of lubrication it has been seen that μ, n, and p can occur only when combined into the single variable $\frac{\mu n}{p}$; hence the influence of all three of these quantities may be found by experimenting with any one of them. (2) It is legitimate to determine the dynamical and thermal properties of bearings by separate experiments. For example, the laws of friction may be studied under isothermal conditions; while thermal characteristics, such as the constant k of equations (23) to (28), might be determined with a perfectly stationary dummy bearing, in which the heat is generated by a heating coil instead of by friction. (3) The conception of dynamically similar bearings will make it possible to evaluate the constants needed in design by the use of models without waiting for the complete determination of the laws of lubrication.

MINERALOGY.—*Babingtonite from Passaic County, New Jersey.*

Clarence N. Fenner, Geophysical Laboratory.

In the deposits of zeolitic minerals occurring in the Watchung trap ridges of northern New Jersey certain cavities which are found in abundance evidently testify to the former presence of some mineral which has been removed in solution. These cavities or casts are familiar to many mineralogists who have visited the localities referred to and the nature of the mineral which formerly filled them has been a matter of considerable speculation, but no very satisfactory conclusion has been reached.

The casts are seen most frequently among masses of quartz, prehnite, datolite, or pectolite. Among other minerals some indication of their presence may at times be found, but often they have been filled with later minerals and their outlines have been more or less obliterated. The mineral which formerly occupied the cavities evidently occurred most frequently in radiating groups, sometimes extending from a centre in various directions, sometimes assuming a rather flattened or fan-like form. A length of 3 or 4 inches is not uncommon, and in one instance the impressions of a group of fan-like crystals was observed, which measured $8\frac{1}{2}$ inches (21.5 cm.) in length and $7\frac{1}{2}$ inches (19 cm.) in greatest breadth. Apparently a considerable portion of the centre of the group had been broken away, so that the original length was probably 3 or 4 inches greater. In cross-section the casts of individual crystals are either lozenge-shaped or nearly rectangular. Both forms are often associated in the same hand-specimen.

In an article[1] which the present writer published several years ago it was shown that the various minerals which are found in these deposits exhibit a well-defined sequence of deposition and that during earlier periods in their history the assemblage of minerals differed greatly from that now found. The earliest period was characterized by the formation of large quantities of quartz, albite, and the mineral represented by the casts, together with a small amount of garnet, hematite, and sulphides. The question of the nature of the mineral which had been present in such abundance and had been removed was considered most interesting and considerable time was given to an attempt to obtain a clue to its nature. In one of the microscopic sections a few small crystals of some unrecognized mineral were found, and in occasional hand-specimens out of several hundred which were gone over some small and almost entirely decomposed remnants of the same substance were discovered. A slight description of the mineral was given and from its general characteristics it was considered to be a rather abnormal amphibole, perhaps

[1] The Watchung Basalt and the Paragenseis of Its Zeolites and Other Secondary Minerals; Annals N. Y. Acad. Sci., XX, 2, Pt. II, 93-187. 1910.

arfvedsonite. Certain slight bits of evidence pointed to the likelihood that this represented the mineral of the casts.

In subsequent visits to these localities a constant watch was kept for further evidence on the matter, but it was not until the past summer (July, 1914) that much of value was found. At that time a visit to the Francisco quarry at Great Notch resulted in the discovery of a larger quantity of the mineral than had been seen at any previous time. The amount was still very small, the largest mass having a greatest dimension of only 20 mm., and the total weight collected was probably little more than a gram. The relations were such, however, as to connect the mineral quite definitely with the casts, and it was possible to make determinations which showed the mineral to be the rare species, babingtonite (Ca, Fe, Mn) $SiO_3 + Fe_2(SiO_3)_3$.

In several instances the small crystal-remnants found occupy portions of the characteristic cavities of rectangular or lozenge-shaped sections in quartz, or are intergrown in a blade-like form with quartz-crystals. In almost all cases alteration has produced a decomposition-product on the crystal surfaces of a woolly or asbestos-like material, nearly white in color, which obscures the original crystal-faces. The same substance frequently penetrates deeply within the crystals along cracks or cleavage planes. This feature would render it very difficult to pick out pure material from the small quantity of the mineral at hand in sufficient amount for a satisafctory quantitative analysis, and this was not attempted. It was necessary, therefore, to establish its identity by other means. The unaltered material is nearly black and opaque in mass, but translucent and brown or dark-green in thin fragments. The lustre is shining or splendent—nearly that of anthracite.

Through the kindness of Dr. E. T. Wherry of the National Museum, several specimens of babingtonite were loaned from their collection and it was thus made possible to make direct comparisons with undoubted material.

In the determination of properties the material used was either that from Great Notch or that in the microscopic section prepared several years ago, which came from Paterson.

Chemical and physical properties. Qualitative tests on small portions of the mineral gave strong reactions for iron, manganese, lime, and silica. Tests for alumina, titanium oxide, magnesia, and alkalies gave no indication of the presence of these.

Before the blowpipe the mineral fuses without difficulty to a black, slightly magnetic globule. Babingtonite from Baveno, Italy (Nat. Mus. No. 86,183) and from Norway (Nat. Mus. No. 78,559) gave the same test.

There is a very perfect, nearly scaly cleavage, which gives a mirror-like surface. By comparison with the National Museum crystals from Italy and Norway this is seen to be the cleavage parallel to the basal pinacoid *c*, when the crystal is set up in the position which Dauber has chosen.[2]

In the prism zone the cleavage is of columnar or fibrous appearance.

In babingtonite crystals from Italy and Norway vertical striation of faces in the prism zone is prominent. In a rough crystal which was broken out of the aggregate in the New Jersey specimen the same appearance was very evident. Moreover, in the casts similar striations frequently appear.

A determination of specific gravity on apparently unaltered fragments picked out under a binocular, using Rohrbach's solution according to Merwin's method,[3] gave a density of 3.398 at 21°.

The optical properties were found to be as follows: Greatest index of refraction in sodium light (immersion method) = 1.74. Birefringence, $\gamma - \alpha = 0.032$. Optical character biaxial and positive. The axial angle, 2 V, is evidently large, the bar of the interference figure being nearly straight. Hintze gives 2 V = 60°–65°. In the New Jersey mineral a rather larger angle is suggested by the slight curvature of the bar, but babingtonite from Buckland, Mass. (Nat. Mus. No. 80,668), and from Norway

[2] Crystallographers differ in their choice of positions for setting up the crystals. The position chosen by Dana and Hintze brings out the crystallographic similarity to the monoclinic pyroxenes, but the dominant habit of growth of the crystals is prismatic in the direction of Dauber's prism zone. (See article by C. Palache and F. R. Fraprie in Proc. Amer. Acad. Arts and Sci., **38**, 11: 383–393. 1902). Dauber's orientation is adopted in the present paper.

[3] H. E. Merwin, Am. J. Sci., (4) **32**: 425–428. 1911.

(Nat. Mus. No. 78,559) gave the same figure. Dispersion is very noticeable. Pleochroism is remarkably strong. In thin sections α = dark green, β = claret, γ = pale brown. Absorption formula $\alpha > \beta = \gamma$. Extinction angles up to 43° between γ and the basal cleavage were observed. Vogt (quoted by Hintze) gives an angle of 44° for the extinction-direction on sections parallel with *o* (011).

Palache and Fraprie, in the article cited, give for the angle between *b* and *g*, two prominent faces in the prism zone, 64°39′. In the lozenge-shaped casts from New Jersey the faces are usually

	PROPERTIES OF BABINGTONITE AS GIVEN BY VARIOUS AUTHORITIES	PROPERTIES OF BABINGTONITE FROM NEW JERSEY
Composition	(Ca, Fe, Mn) SiO_3 + $Fe_2(SiO_3)_3$	Qualitative reactions for CaO, Fe, Mn, SiO_2.
Color	Greenish- or brownish-black	Greenish- or brownish-black.
Lustre	Vitreous, splendent	Vitreous, splendent.
Cleavage	Perfect on base, less so on prism 110	Perfect on base, columnar or fibrous on prism zone.
Fracture	Imperfectly conchoidal	Imperfectly conchoidal.
Fusibility	Easily fusible to a black, magnetic globule	Easily fusible to a black, magnetic globule.
Hardness	5.5–6	About 6.
Density	3.35–3.37	3.40.
Index of refraction	n = 1.72 (Winchell)	γ = 1.74.
Birefringence	$\gamma - \alpha = 0.032$	$\gamma - \alpha = 0.032$.
Optical character	Biaxial, positive. 2 V = 60° – 65°	Biaxial, positive. 2 V large.
Dispersion	Strong	Strong.
Pleochroism	Intense α = strong emerald green β = pale violet brown γ = deep-brown	Intense. α = dark blue-green. β = claret. γ = pale brown.
Crystal angle between 010 and 210	64° 39′ (Palache and Fraprie)	Average of 35 measurements of casts gives 64° 18′.
Crystal angle between 110 and 210	89° 18′ (Palache and Fraprie)	Casts nearly rectangular.
Extinction angle	44° with basal cleavage	43° with basal cleavage.

slightly irregular, but by making a large number of measurements under the microscope, the average should give a close approximation to the true value. Thirty-five measurements of the acute angle were made, and the average was 64°18′.

In Palache and Fraprie's measurements the angle between *g* and *h*, the latter being a prismatic face of less prominent development in their crystals, was measured as 89°18′. This probably corresponds to the casts of nearly rectangular cross-section which were often observed. No measurement of this angle was attempted, as thin laminae of quartz frequently project from the face corresponding to *h*.

The results of various tests on the New Jersey mineral are tabulated above in comparison with the properties of babingtonite. From this table it is evident that the mineral under discussion agrees perfectly in all important respects with babingtonite.

As a further confirmation etching-tests with hydrofluoric acid were made upon cleavage-flakes (parallel with the base *c*) of this mineral and of babingtonite from Baveno, Italy (Nat. Mus. No. 86,183). The two were placed together in a platinum basket and suspended for five seconds in boiling commercial hydrofluoric acid. With both specimens the etch-pits were very minute and required careful observation with a high-power objective to be satisfactorily studied, but, so far as could be determined, the shape and size were the same in the two instances. Figure 1 shows their character.

Fig. 1. Etch-figures on babingtonite, produced by action of hydrofluoric acid. Magnification 250 ×.

Hintze and Dana cite but few localities where babingtonite has been found and it may be classed among the rarer minerals. The crystals are generally of minute size. Its usual occurrence appears to be in granite, syenite, gneiss, etc., apparently not generally as an original igneous constituent, but associated with such minerals as epidote, garnet, alkali feldspars, and quartz, in cavities. Palache and Fraprie[4] describe its occurrence at Somerville, Mass., where it is found "in veins and pockets composed chiefly of prehnite, which traverse a large dyke of diabase." Quartz, epidote, feldspar, laumontite, stilbite, chabazite and other

[4] C. Palache and F. R. Fraprie, loc. cit.

minerals are associated with it. The general relations appear quite similar to those in New Jersey.

It seems quite remarkable that in New Jersey it should have been formed in such abundance and in crystals of such great size, and that later it should have been almost totally removed. Its disappearance cannot well be ascribed to weathering, for in many instances the casts have been filled with minerals of an early period of deposition. The formation and subsequent removal of the mineral indicate that for it the conditions of chemical stability were satisfied for a brief period only during the processes of general mineral deposition.

ZOOLOGY.—*The correlation between the bathymetrical and the geographical range in the recent crinoids.* AUSTIN H. CLARK, National Museum.

In a paper published about a year ago[1] I remarked that the geographical range of a crinoid species, genus or higher group is approximately proportionate to its bathymetric range, but at that time I did not have the facts upon which I based the deduction in such form as to be able to present them in a convincing manner.

While the bathymetric range of any type can mean but one thing—the number of fathoms (or meters) between the highest and the lowest limit of the zone in which it occurs—the geographical range may be interpreted in two different ways: (1) as the actual area, calculated as the sum of the geographical units within which the type is actually known to occur, or (2) as the area in which the type potentially occurs, that is, the area over which physical conditions are such as to suggest that, if not found at all points within it now, it has or may have, occurred at all points within it at some time in the not remote past.

According to the first method a count is made of the units of area within which the type has actually been taken; the figures are therefore of very varying value for different groups, for many types, undoubtedly with an enormous geographical range, have been taken at only a very few widely scattered localities, while

[1] Internationale Revue der gesamten Hydrobiologie und Hydrographie, Bd. 6, Heft 1, S. 29.

others, with a much more restricted geographical range, have been reported from all points within a very large area.

The second method first of all calls for the determination of some restricted region as the center of distribution, for it makes considerable difference in calculating the potential geographical range of a group like the Thysanometrinæ, occurring from southern Japan southward to the Admiralty Islands, and again in the Caribbean Sea, whether we assume the center of distribution to be the Malayan region, and therefore that the connection between the two localities is westward from the line between southern Japan and the Admiralty Islands, or whether we assume some other center of distribution, and a connection eastward through Oceania and over Central America.

I have elsewhere[2] given my reasons for considering the Malayan region as the center of distribution for the recent (and later fossil) crinoids, explaining the similarity between the fauna of southern Japan and Hawaii and the Caribbean Islands as the result of their present similar isolation from the Malayan region, an isolation which has permitted the persistence on the periphery of the area inhabited by the crinoids as a whole of types which in all the intermediate regions have been extirpated by more efficient competitors of subsequent origin.

If we divide the map of the world into areas measuring 15° on each side, we find that the number of such divisions covering the geographic ranges of each of the families of recent crinoids is as follows:

Capillasterinæ	42	Thysanometrinæ	5
Comactiniinæ	28	Zenometrinæ	19
Comasterinæ	30	Perometrinæ	12
Zygometridæ	12	Heliometrinæ	68
Himerometridæ	22	Bathymetrinæ	12
Stephanometridæ	14	Pentametrocrinidæ	13
Mariametridæ	30	Atelecrinidæ	7
Colobometridæ	31	Pentacrinitida	20
Tropiometridæ	33	Apiocrinidæ	2
Calometridæ	10	Phrynocrinidæ	2
Ptilometrinæ	10	Bourguetierinidæ	20
Thalassometrinæ	36	Holopodidæ	2
Charitometridæ	18	Plicatocrinidæ	14
Antedoninæ	43		

[2] Internationale Revue der gesamten Hydrobiologie und Hydrographie, Bd. 6. Heft 1, S. 24.

Plotting these together with the maximum range for each family (fig. 1), we notice very little similarity between the two lines. It is interesting to observe, however, that in the left half of the diagram, including all of the better known families, the agreement between the geographical and the bathymetrical ranges

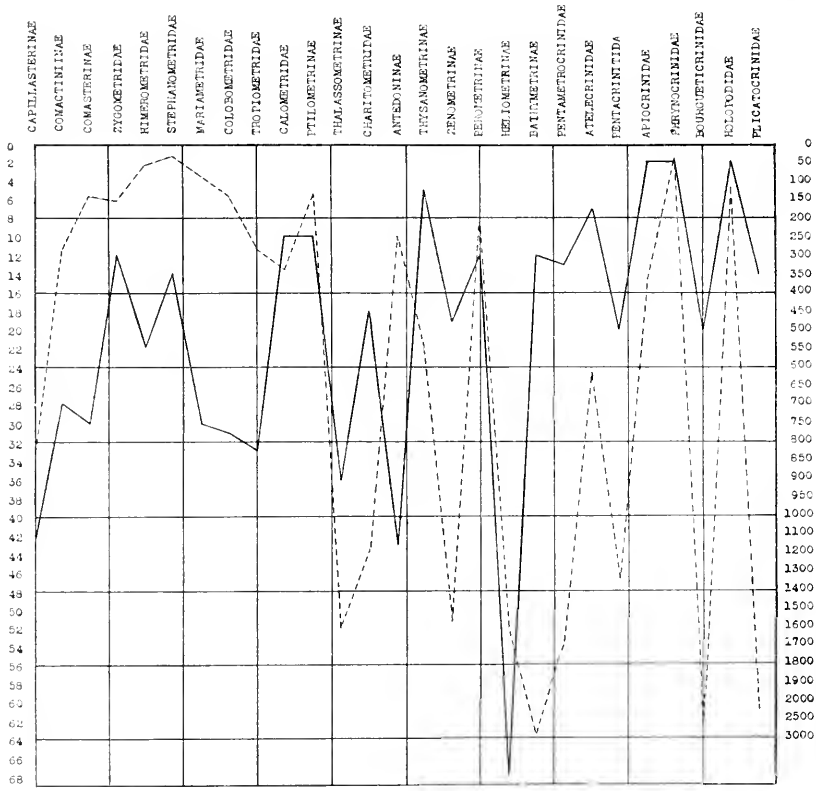

Fig. 1. Comparison between the maximum bathymetric range (. . . .) and the geographical range, expressed as the sum of the areas of 15° on each side within which the families occur (———).

is somewhat closer than in the right half, which includes the rarer types.

There is a very grave source of error in comparing the geographical and the bathymetrical ranges of any animal group by this method, and that is that single observations are always of far greater value from a bathymetric than from a geographic standpoint, so that, broadly speaking, our knowledge in regard to the bathymetric distribution of animal types is much more detailed than our knowledge of the limits of the geographical range of the same types.

The bathymetric range is measured on a single line assumed to extend perpendicularly downward from the surface to the deepest part of the sea. But the points on this line are determined from observations everywhere. That is, the entire volume, or cubical content, of the ocean basins furnishes data projected upon a single line. For example, a certain type occurs in Alaska in 5 fathoms, in the Crozet Islands in 1600 fathoms, and off Greenland in 300 fathoms; its bathymetric range is, therefore, from 5 to 1600, or 1595, fathoms.

Thus our knowledge of the bathymetric ranges of the larger groups is reasonably complete, as a result of this method of reducing to terms of a single dimension records which, strictly speaking, are taken in three dimensions.

With the geographical ranges calculated as the sum of all the areas measuring 15° on each side within which a given type occurs the case is very different. Investigation has largely been localized within certain restricted areas which, for some reason or other, have proved to be especially interesting, or where exceptional opportunities for study have been presented. Within these areas there are very numerous records all of which, though marking different steps in, and increasing our knowledge of, the bathymetic scale, fall in the same geographical unit, and hence are the geographical equivalent of only a single record.

Intensive study of any one locality increases our knowledge of the bathymetric distribution of all the endemic types, while adding nothing to our knowledge of the geographical distribution of the same types; similarly future investigations in many of the now little known regions of the world will greatly increase our knowledge of the geographical range of many groups, at the same time giving us nothing new in reference to their bathymetrical range.

Thus it is evident that the comparison of the bathymetric ranges of the families of recent crinoids, which for the most part are known to within a comparatively small limit of error, with the geographical ranges calculated as the sum of the units measuring 15° on each side within which they occur, though apparently perfectly logical, at the present state of our knowledge is not practicable, and cannot give results of value.

If we assume that the Malayan region is the center of distribution of the recent crinoids, a very simple way of expressing the comparative potential geographical range of the several crinoid types becomes possible. If we multiply the number of units of 15° between the meridians bounding the region inhabited by each type by the number of units of 15° between the parallels of latitude bounding the same regions, always reckoning east and west and north and south from the Malayan region, we will obtain for all types (excepting only the Holopodidæ which, alone among the crinoid families, does not occur in the Malayan region) strictly comparable areas expressed in units of 15° on each side, that is, including 225 "square" degrees each.

The geographical ranges of the families of recent crinoids expressed in these units are:

Capillasterinæ	30 × 6 = 180	Thysanometrinæ	18 × 4 = 72
Comactiniinæ	30 × 6 = 180	Zenometrinæ	24 × 10 = 240
Comasterinæ	12 × 6 = 72	Perometrinæ	17 × 4 = 68
Zygometridæ	6 × 5 = 30	Heliometrinæ	24 × 12 = 288
Himerometridæ	10 × 5 = 50	Bathymetrinæ	24 × 10 = 240
Stephanometridæ	9 × 4 = 36	Pentametrocrinidæ	16 × 10 = 160
Mariametridæ	12 × 6 = 72	Atelecrinidæ	20 × 3 = 60
Colobometridæ	20 × 6 = 120	Pentacrinitida	20 × 6 = 120
Tropiometridæ	19 × 6 = 114	Apiocrinidæ	1 × 2 = 2
Calometridæ	5 × 6 = 30	Phrynocrinidæ	6 × 2 = 12
Ptilometrinæ	5 × 5 = 25	Bourgueticrinidæ	16 × 10 = 160
Thalassometrinæ	24 × 8 = 192	Holopodidæ	2 × 2 = 4
Charitometridæ	20 × 6 = 120	Plicatocrinidæ	24 × 9 = 216
Antedoninæ	18 × 6 = 108		

On the accompanying diagram (fig. 2) are shown the maximum bathymetric range of each family of recent crinoids (in a dotted line) and the geographical range calculated according to the method just described (in an unbroken line).

The correspondence between the bathymetric range and the geographical range as thus calculated is very striking, bringing our very forcibly the fact that the potential geographical range of a given group is proportionate to its bathymetrical range.

It will be noticed that, in the comparison between the bathymetrical and the geographical ranges as given on the diagram, 3000 fathoms in depth is the equivalent of 256 × 225, or 6400, square

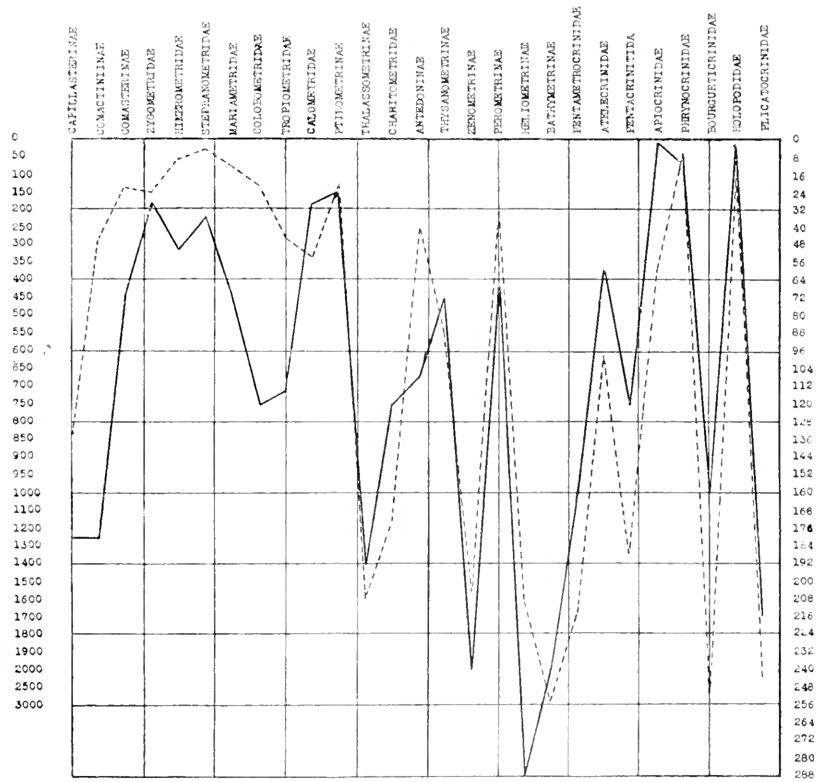

Fig. 2. Comparison between the maximum bathymetric range (. . . . .) and the geographical range expressed, in units of 15° square (225 square degrees), as the product of the number of degrees on the equator between the meridians passing through the limits of the distribution West and East of the Malayan region, times the number of degrees between the Parallels of Latitude bounding the area of occurrence of the Families of Recent Crinoids (———).

degrees; therefore every fathom of increase in the bathymetric range of a given type implies an increase of approximately 2.13 square degrees in the geographical range, and every increase of

100 fathoms in the bathymetric range is correlated with an increase of 213.33 square degrees in the geographical range.

In the families confined to comparatively warm water the geographical range is somewhat greater than the bathymetrical range, when 100 fathoms is considered as the equivalent of 213.33 square degrees, while in the families confined to cold water, and the families represented in the polar regions, the reverse is the case. This indicates that the curve representing the decrease in area of the units measuring 15° on each side from the equator to the poles is less marked than the curve representing the difference in the temperature between the surface water and that of the abysses (which plays a very important part in the bathymetrical distribution of marine organisms) from the equator to the poles.

This method of comparing the bathymetrical and the geographical range of marine organisms which at no time during their developmental history are pelagic takes no account of the land masses within the geographical areas as calculated. These land masses appear to be negligible; in other words, we appear to be justified in considering them as everywhere potentially habitable by the crinoids occurring along their shores as far as the meridians of longitude and the parallels of latitude to which these crinoids now extend.

The great tropical currents flowing northward, the Gulf Stream and the Kuro-Siwo, do not act as distributors of crinoids as they do of other types of organisms, for the reason that the littoral forms which might be supposed to extend their range along the shores washed by them, but which are confined within a very limited range of temperature and of salinity, cannot survive the conditions in the winter, when the currents in the northernmost part of their course move southward and off shore, and when further southward their inshore border is chilled and freshened by drainage from the land.

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PHYSICS.—*Measurements on standards of radiation in absolute value.*[1] W. W. COBLENTZ, Bureau of Standards.

One of the chief needs in the measurement of radiant energy is a convenient standard against which the radiometer may be calibrated. The great utility of a seasoned carbon incandescent lamp as a photometric standard is well recognized, and such a lamp has every desideratum of a standard of radiation, when calibrated against a black body as the primary standard of radiation. The object of the present investigation is to establish and maintain a standard of radiation in the form of seasoned incandescent lamps, and to issue to experimenters similar standards of radiation, whereby may be obtained an accurate calibration of their radiometers in absolute value.

The incandescent lamps were standardized by two independent methods which are in agreement within 0.5 per cent. The first method consisted in comparing the radiation from a black body with the radiation from the incandescent lamp, assuming a value for the coefficient (the "Stefan-Boltzmann constant") of total radiation of the black body. For this purpose a thermopile was directed towards the black body, then towards the incandescent lamp. The second method consisted in a direct measurement, in absolute value, of the energy of the incandescent lamp with a modified form of Ångström pyrheliometer. This pyrheliometer gave a value ($\sigma = 5.61 \times 10^{-12}$ watt cm^{-2} deg^{-4})

[1] Detailed paper to appear in the Bulletin of the Bureau of Standards.

for the coefficient of total radiation which is close to the value of this constant as determined by various other methods differing widely in character.

The standard of radiation, in terms of these incandescent lamps, may therefore be considered fairly well established—at least sufficiently to fulfill present requirements. In the lamps issued to the public the intensity of the radiant energy per mm.^{2} at a distance of 2 meters from the lamp is certified, when the lamp is operated on a given current and voltage.

For rough calibrations of radiometers in absolute measure, a sperm candle or a Hefner lamp may be used. For the sperm candle, burning at a mean height, the intensity of the total radiation at a distance of 1 meter from the flame may be taken to be 29×10^{-6} g.-cal per cm^2 per second. The intensity of the total radiation at a distance of 1 meter from the Hefner lamp *without a diaphragm* may be taken to be 26×10^{-10} g-cal per cm^{-2} per second. The paper gives data also for the radiation from the Hefner lamp with a diaphragm, having a definite opening and situated at a definite distance in front of the lamp. The flame standards are unsteady, and unsatisfactory for use in refined radiation measurements.

PHYSICS.—*The emissivity of metals and oxides, II: Measurements with the micropyrometer.* G. K. Burgess and R. G. Waltenburg, Bureau of Standards.[1]

The micropyrometer[2] may be used conveniently for the approximate determination of the monochromatic emissivities of metals, oxides, etc., in microscopic quantities at high temperatures. It is possible to determine to 1 per cent the emissivity of a mass of 0.01 mgm. having an area of 0.25 mm.^{2} and a thickness of 0.005 mm. The determination of the temperature-coefficient of emissivity is readily made, as well as the detection of variation of emissivity with change of state, as at the melting point.

Assuming the emissivity for solid platinum to be 0.33 for red light of wave length $\lambda = 0.65\mu$ and 0.38 for $\lambda = 0.55\mu$, the fol-

[1] Detailed paper to appear in the Bulletin of the Bureau of Standards.

[2] This Journal, **3**: 7. 1912.

lowing among other results have been obtained as shown in the table.

For none of the metals examined was there a marked temperature coefficient in the range 900 to 2000°C. and for the most of them this coefficient is negligible, the monochromatic emissivity usually agreeing also with the value at 20°C. For the white metals the emissivity usually shows very slight or no change at the melting point, but for gold, silver, copper, and uranium there is a marked discontinuity with red light. For palladium, there are anomalies in the behavior of the emissivity in the region of the melting point, in that the value of emissivity proper to the liquid may persist after freezing, constituting an undercooling radiation effect. For platinum the fact that there is a change in emissivity, for $\lambda = 0.65\mu$, on melting would influence the constancy of the Violle standard of light as usually defined in terms of the luminous radiation from platinum at its melting point.

EMISSIVITIES OF METALS AND OXIDES WITH MICROPYROMETER

Metals	Cu	Ag	Au	Pd	Pt	Ir	Rh	Ni	Co	Fe	Mn	Ti
$e_\lambda = 0.65\mu$ solid......	0.10	0.04	0.14	0.33	0.33	0.20	0.29	0.36	0.36	0.37	0.59	0.63
$e_\lambda = 0.65\mu$ liquid	0.15	0.07	0.22	0.37	0.38		0.30	0.37	0.37	0.37	0.59	0.65
$e_\lambda = 0.55\mu$ solid.......	0.38	0.35	0.38	0.38	0.38			0.44				0.75
$e_\lambda = 0.55\mu$ liquid......	0.36	0.35	0.38					0.46				0.75
	Zr	Th	Y	Er	Be	Cb	V	Cr	Mo	W	U	
$e_\lambda = 0.65\mu$ solid.......	0.32	0.36	0.35	0.55	0.61	0.49	0.35	0.39	0.43	0.39	0.54	
$e_\lambda = 0.65\mu$ liquid......	0.30	0.40	0.35	0.38	0.61	0.40	0.32	0.39	0.40		0.34	
$e_\lambda = 0.55\mu$ solid.......		0.36			0.61	0.61	0.29	0.53			0.77	
$e_\lambda = 0.55\mu$ liquid......				0.30	0.81							
Oxides near F. P.s	NiO	CoO	Fe_3O_4	Mn_3O_4	TiO_2	ThO_2	Y_2O_3	BeO	CbO_x	V_2O_3	Cr_2O_3	U_3O_8
$e_\lambda = 0.65\mu$ solid......	0.89	0.77	0.63		0.52	0.57	0.61	0.37	0.71	0.69	0.60	0.30
$e_\lambda = 0.65\mu$ liquid.....	0.68	0.63	0.53	0.47	0.51	0.69						0.31

PHYSICS.—*A vibration electrometer.*[1] HARVEY L. CURTIS, Bureau of Standards.

Any alternating current measurement which makes use of a null method requires an instrument which will detect small

[1] To appear in the Bulletin of the Bureau of Standards.

alternating currents or voltages. One of the first instruments used for this purpose was the telephone. This is very sensitive between the frequencies of 500 and 3000 cycles per second, but at frequencies below 500 cycles the sensitiveness decreases rapidly with the frequency, so that it is very insensitive at frequencies below 100 cycles. It also responds to the harmonics of the current as readily as to the fundamental.

As a null instrument, a vibration galvanometer is often much more satisfactory than a telephone. The moving system of a vibrating galvanometer is adjusted to have the same period as that of the current to be detected, so that any harmonics in the current produce very little effect upon the deflection of the instrument. Also most vibration galvanometers have their maximum sensitiveness at low frequencies (50 to 200 cycles), though at least one form may be had which will go to frequencies as high as 3000 cycles. Since the impedance of these instruments is relatively low, they require an appreciable current to produce a deflection which can be observed. Hence in bridges where the impedance of the arms is very high, they are not very sensitive.

The vibration electrometer described in this paper was designed as a vibrating instrument having an impedance much higher than a telephone or vibration galvanometer. The need arose in connection with the measurement of some very low capacities at low frequencies. Its usefulness is limited to those cases where it is desired to detect very small currents at low frequencies. Its principal use is as a detecting instrument in a bridge having very high impedances in the arms.

The instrument is a modification of a quadrant electrometer. Instead of the quadrants there are four vertical plates, while a thin vertical vane of twice the area of a single plate corresponds to the needle of the electrometer. Two plates, separated by a narrow vertical slit, are in one plane, while opposite them in a parallel plane are the other plates. Midway between the planes is the aluminum vane, which is suspended by a bifilar suspension. This vane is maintained at constant potential by a battery, while an alternating voltage having the same period as the natural period of the vibrating system is applied to the plates. This causes mechanical forces to be applied to the vane due to electrostatic attractions and repulsions which will set the vane in vibration. Since these forces are small, it is necessary that the damping shall be small. In addition to so designing the suspension that there is very little loss of energy in it, it is necessary to keep the instrument in a vacuum.

The form of the instrument is such that the capacities can be approximately computed. Hence it is possible to develop the mathematical theory of its behavior. This has been done and the conclusions reached have been checked by experiment. The important conclusions are as follows:

1. The frequency at which maximum deflection is obtained depends upon the potential of the vane. As the potential of the vane is increased, the frequency at which maximum deflection is obtained, is decreased.
2. The deflection for a given voltage is inversely proportional to the damping.
3. As the damping is decreased, the tuning becomes sharper.
4. The power required to give unit deflection when the applied *emf* is in resonance with the instrument decreases in the same ratio as the damping.

Experimentally it has been found that the instrument will detect a current as low as 10^{-12} ampere.

RADIOTELEGRAPHY.—*A direct reading instrument for measuring the logarithmic decrement and wave length of electromagnetic waves.*[1] FREDERICK A. KOLSTER, Bureau of Standards. Communicated by E. B. Rosa.

The measurement of the logarithmic decrement at radio stations is of particular importance, since the United States laws governing radio communication specify, among other things, that the logarithmic decrement per complete oscillation in the wave train emitted by the transmitter shall not exceed two-tenths. When persistent oscillations of single frequency are emitted from a radio transmitting station much more selective receiving apparatus may be employed with advantage at re-

[1] Detailed paper to appear in the Bulletin of the Bureau of Standards.

ceiving stations, permitting sharp tuning with consequent minimizing of interference caused by stations other than those with which communication is desired. It is desirable, therefore, that the logarithmic decrement, which is a measure of the decay of a train of waves, be as small as possible.

The instrument described operates in accordance with the method of Bjerknes, but the task of making careful observations and necessary calculations required by the Bjerknes formula is eliminated. An important element of the instrument is a variable condenser, the capacity of which varies in accordance with the law of geometric progression.

The simplified Bjerknes formula may be written as

$$\delta_1 + \delta_2 = \pi \frac{C_r - C}{C} = \pi \frac{\Delta C}{C}$$

where δ_1 is the decrement of the circuit to be measured and δ_2 the known decrement of the measuring instrument. C_r is the value of capacity of the variable condenser at the point of resonance and C is a slightly different capacity of such a value that the energy in the instrument at resonance is reduced to one-half.

Since the variable condenser in the instrument varies in accordance with the law of geometric progression, then for any given displacement of the condenser plates the percentage change of capacity $\frac{\Delta C}{C}$ will be constant throughout the range of motion of the condenser. It is therefore possible to attach to this condenser an accurately divided scale from which values of $\delta_1 + \delta_2$ can be read directly. Several instruments have been constructed for the Army and Navy and for the radio inspection service of the Department of Commerce.

RADIOTELEGRAPHY.—*Quantitative experiments in radiotelegraphic transmission.*[1] L. W. AUSTIN, Naval Radiotelegraphic Laboratory.

The quantitative study of long distance radiotelegraphic transmission was begun by the Navy Department in 1909–10

[1] Detailed paper to appear in the Bulletin of the Bureau of Standards.

and continued in 1912 in connection with the testing of the high power radio station at Arlington, Virginia. This station is equipped with a 100 kw. Fessenden rotary gap sending set which gives an antenna current of approximately 100 amperes at a wave length of 3800 meters. The aerial is triangular in shape and suspended between three steel towers, two of which are 450 feet in height while the third has a height of 600 feet. The capacity of the antenna is 0.01 *m f* and the height to the center of capacity 400 feet. Short range experiments showed that the effective height of the Arlington station was only about one-half the height to the center of capacity of the antenna. This appears to be generally true of land stations and is probably due to the fact that they are not erected on sufficiently good conducting surfaces as assumed in the theory. The main scientific object of the experiments was the determination of the correctness of the Sommerfeld transmission formula

$$(1) \qquad I_R = 120\,\pi \frac{h_1\, h_2\, I_s}{\lambda\, d\, R} \cdot e^{\frac{-0.0019\, d}{\sqrt{\lambda}}}$$

where h_1 is the effective height of the sending antenna, h_2 the corresponding height of the receiving antenna, I_s the sending antenna current, λ the wave length, e the distance between the two stations, and R the effective high frequency resistance of the receiving antenna system.

The strength of the received signals was measured on the *U.S.S. Birmingham* which made a voyage to Gibraltar and return for the carrying out of the tests. The total height of the *Birmingham's* antenna was 130 feet and the height to the center of capacity 114 feet. The effective high frequency resistance was 50 ohms at 3800 meters. Signals were received by means of an electrolytic detector and their intensity was measured by the shunted telephone method which was described in the paper already cited. From the data thus obtained it was possible to determine the received antenna current I_r.

The table shows the results. Column five gives the experimental values as obtained from the smoothed curve of observations, and column three the values as calculated from the

Sommerfeld formula (1). Column four gives the calculated values as obtained from a semi-empirical formula (2) made up of the first term of the theoretical formula but with the absorption term replaced by the absorption term which was found to be correct in the experiments made in 1910. The values in column four are seen to be in very fair agreement with the observed values.

$$I_R = 120\,\pi \frac{h_1\, h_2\, I_s}{\lambda\, d\, R} \cdot e^{\frac{-0.0015\,d}{\sqrt{\lambda}}} \tag{2}$$

The Sommerfeld theory takes no account of energy which may be brought to the receiving station by means of reflection or refraction in the upper atmosphere, and it is thought probable that it is this portion of the energy which produces the difference between the observed and theoretical results.

Arlington Received on the "Salem," February–March, 1913

Resistance		Received current 10^{-6} amp.		
		Calculated		
Miles	Km.	Eq. 1	Eq. 2	Obs.
300	556	335.000	431.00	410.0
400	740	200.000	278.00	300.0
500	925	128.000	195.00	225.0
600	1110	85.200	140.00	160.0
800	1480	40.700	79.00	95.0
1000	1850	20.700	47.60	59.0
1200	2220	11.000	29.70	34.0
1500	2780	4.420	15.30	19.0
2000	3700	1.070	5.65	5.0
2500	4630	0.280	2.20	
3000	5560	0.074	0.84	

In connection with these experiments a comparison was also made between the received singals from the Fessenden spark set and those from a Poulsen arc temporarily installed at the Arlington station. It was found that, for distances up to about 1000 miles, the received antenna currents were practically the same, for the same sending antenna currents. At greater distances the arc seemed to be superior, as measured on the *Salem* and also at the U. S. Naval Radio Station at Colon, C. Z.

PHYSICAL CHEMISTRY.—*The hydration of Portland cement.*[1] A. A. Klein and A. J. Phillips. Bureau of Standards. Communicated by the Bureau of Standards.

The study of the hydration of Portland cement follows as a natural sequence to the study of its constitution. The latter has been determined by the work of the Geophysical Laboratory on the ternary system lime-silica-alumina, and for that portion of the ternary field in which Portland cement is situated, these compounds have been verified by the Pittsburgh laboratory of the Bureau of Standards.

In the present paper various hydration experiments were made on mono-calcium aluminate ($CaO.Al_2O_3$), 5:3 calcium aluminate ($5CaO.3Al_2O_3$), tri-calcium aluminate ($3CaO.Al_2O_3$), mono-calcium silicate ($CaO.SiO_2$), beta-orthosilicate ($2CaO.SiO_2$), gamma-orthosilicate ($2CaO.SiO_2$), tri-calcium silicate ($3CaO.SiO_2$), on lime burned at different temperatures and ground to various degrees of fineness, and on the following commercial cements, a high silica, a low silica, a high iron, and a high magnesia cement.

The tests consisted of (1) hydration on microscopic slides with water, without access of air, (2) hydration with superheated steam in a cylinder, according to the method proposed by Bied, (3) hydration in an autoclave, and (4) moulding with limited quantities of water, approximating those used in normal consistency mixes. Lime water and plaster of Paris solution were also used as hydrating media. Petrographic microscope methods were employed to determine the hydration processes and the final products.

The only crystalline product observed in the hydration of the aluminates was hydrated tri-calcium aluminate ($3CaO.Al_2O_3.xH_2O$) and this is only formed with a large excess of water. It crystallizes in hexagonal needles, plates, and spherulites, and is uniaxial positive. The refractive indices are $\epsilon = 1.552 \pm .003$ and $\omega = 1.535 \pm .003$. The 5:3 calcium aluminate and mono-calcium aluminate split off amorphous hydrated alumina and form the crystalline hydrated tri-calcium aluminate. The

[1] Detailed paper to appear in the Bulletin of the Bureau of Standards.

hydration of the aluminates commences quickly in all cases, but with restricted amounts of water the unhydrated grains become coated with the amorphous form and further hydration is more or less retarded, the amorphous form slowly changing to the crystalline form. With steam at atmospheric pressure the weakly basic aluminates do not hydrate above 110°, but those more basic absorb water up to 140°, tri-calcium aluminate containing high burned free lime absorbing water even at 175°.

The hydration of the aluminates in lime water reveals no new products, but in plaster solution, in addition to the same compounds formed with water, there is a compound observed with a formula, $3CaO.Al_2O_3.3CaSO_4.xH_2O$—tri-calcium sulpho-aluminate, usually referred to as "sulpho-aluminate" in cement literature. This compound is identical for the three aluminates and crystallizes in long prismatic needles. The double refraction is low, the character of the principal zone negative, and the extinction parallel. The indices of refraction are less than 1.48. It is biaxial positive with a large optic axial angle. Its formation is only incidental in the retardation of the initial set caused by gypsum. In the autoclave, crystals of both the sulpho-aluminate and gypsum are destroyed.

Burned lime hydrates with an excess of water develop either the crystalline or amorphous form of lime hydrate. A preponderance of the former is produced where the lime is coarse and high burned, while the formation of the amorphous form is favored by fine grinding and low burning. Crystallized lime hydrate occurs as flaky hexagonal crystals or as hexagonal prisms with excellent cleavage parallel to (0001). It is uniaxial negative and the refractive indices are $\epsilon = 1.581 \pm .002$ and $\omega = 1.559 \pm .002$. In the autoclave amorphous lime hydrate does not change to the crystalline form, but free lime may yield crystals of hydrate whose size depends upon the length of time of reaction, temperature and pressure.

The mono-calcium silicate and the gamma-orthosilicate do not hydrate, while the beta form of the latter hydrates but slightly with water after long periods. Lime water and plaster solution do not materially increase the hydration, whereas a solution of the calcium aluminate gives the maximum hydration and best appearing test pieces. The 28 day test pieces of beta-orthosilicate and the aluminates, while, exhibiting fairly good rigidity, have by no means the strength of corresponding neat cement briquettes. The aluminates are completely hydrated, but the beta-orthosilicate shows only a comparatively slight hydration. The hydration product of the silicate is amorphous hydrated orthosilicate, there being no lime hydrate split off and no needles of hydrated mono-calcium silicate formed, as noted by others.

The tri-calcium silicate hydrates readily and quickly with all concentrations of water, the products of hydration being crystallized lime and amorphous hydrated ortho-silicate. Moulded specimens set hard in 5 hours and show no disintegration after 28 days in water. It has no favorable effect on the hydration of beta-orthosilicate. Mixtures of it and the aluminates show first the beginning of hydration of the aluminates, followed shortly by the hydration of the silicate. Moulded specimens of these are dense, hard, and strong, comparing very favorably with neat cement briquettes.

On the hydration of cement, the first constituent to react is the aluminate, with the formation of amorphous hydrated tri-calcium aluminate; with or without amorphous hydrated alumina. The sulpho-aluminate crystals are also formed and the low burned or finely ground lime hydrates. This occurs within a few hours after the cement is gauged. The next compound to hydrate is the tri-calcium silicate. This commences within 24 hours and is generally completely hydrated within 7 days. Between 7 and 28 days, the amorphous aluminate commences to crystallize and the beta-orthosilicate, the least reactive compound, begins to hydrate. The 24-hour strengths are due mainly to the hydration of the aluminates and of any fine grained, low burned lime present. The large increase in strength between 24 hours and 7 days is due mainly to the tri-calcium silicate hydration. The increase between 7 and 28 days is due to the hydration of the beta-orthosilicate. Where there is a decrease in strength during this period it is due to the hydration of very high burned free lime as in very high burned, high limed cements, or to the crystallization of the aluminates, as in high alumina cements. The iron compounds in a cement are resistive to hydration. Iron does not form crystalline hydration products, but occurs as a rust-like material.

The initial set of cement is affected by the action of small amounts of electrolytes in retarding coagulation of the aluminate material. With a limited amount of water, such as used in normal consistency mixes, the aluminates coagulate and separate from supersaturated solutions as amorphous bodies, the rate of coagulation being affected by such small quantities of electrolyte as to nullify the possibility of the reaction being solely a chemical one.

Failure of cement in accelerated tests is due to the growth of large lime hydrate crystals. The disrupting action results from the pressure caused by growing crystals. Cements will fail in the boiling test which contain lime sufficiently fine and high burned, so that during boiling it hydrates and crystallizes. The growth of crystals is sufficient to cause disintegration. When a cement passes the boiling test but not the autoclave test, it contains lime so coarse or high burned as not to hydrate in the boiling test, but only in the autoclave, due to the high temperature and pressure employed. Some cements will pass either test only after ageing. In this case aeration with insufficient water to allow solution and crystallization causes the lime to hydrate as amorphous hydrate, and in the accelerated tests there is no crystallization and no disintegration.

The reactions when cement is subjected to the autoclave test are not abnormal. The disintegration action attributed to the crystallization of the sulpho-aluminate has been greatly exaggerated.

MINERALOGY.—*Pintadoite and uvanite, two new vanadium minerals from Utah: A preliminary note.* FRANK L. HESS and WALDEMAR T. SCHALLER, Geological Survey.

During an investigation in the fall of 1913 by Frank L. Hess and B. S. Butler of that part of the central plateau uranium-vanadium field which lies in Utah, a number of uranium and vanadium minerals hitherto undescribed or little known were found. Some of the minerals are so mixed with impurities and are in such fine particles that mechanical separation is practically impossible and their optical characteristics can be determined only very imperfectly.

Fairly satisfactory determinations have been made of two of these minerals which have proved to be new species and it is the object of this paper to place them on record. Like most of the uranium and vanadium minerals of this field, they are highly oxidized and are hydrous. One, a green hydrous calcium vanadate, has been called *pintadoite* (peen-tȧ′-do-ite) from Canyon Pintado, in which it is found. The other, a hydrous uranium vanadate has been named *uvanite* (yu′-van-ite), a word derived from the words *u*ranium and *van*adium.

Pintadoite forms a thin green efflorescence upon the face of cliffs of sandstone belonging to the McElmo formation, which are protected by overhanging ledges from the weather. It forms circular or rounded patches like the lichens common on rocks, and though in general of a rich dark green color, many patches are in part lighter green and contain a little yellowish or salmon colored material, which may be pascoite. The contrast with the creamy or nearly white sandstones is striking and very pretty. Being a thin efflorescence it is naturally mixed with gypsum, quartz and other minerals of the sandstone. The specimen analyzed is from the Frisco No. 2 claim, on the north side of Cañon Pintado,[1] San Juan County, about 15 miles by road, northeast of Monticello, Utah, and is the dark green material. Pintadoite has also been found at numerous other places in southeastern Utah.

The mineral shows no crystal boundaries when examined microscopically, is slightly pleochroic in yellow-green, and has a moderate to high birefringence. It dissolves slowly in cold water from which it recrystallizes in twinned, lath-shaped crystals.

The analysis, by W. T. Schaller, after deducting insoluble gangue (sandstone), soluble gypsum, and reduction to 100 per cent, is given below:

[1] Locally known as East Canyon.

Analysis and ratios of pintadoite

	ANALYSIS	RATIOS	CALCULATED
CaO	22.6	0.40 or 1.87 or 2 × 0.94	24.56
V_2O_5	42.4	0.23 or 1.08 or 1 × 1.08	39.91
H_2O	35.0	1.94 or 9.07 or 9 × 1.01	35.53
	100.0		100.0

The ratios of the analysis yield the formula $2CaO.V_2O_5.9H_2O$.

Uvanite is a brownish-yellow hydrous uranium vanadate. Its mode of occurrence is similar to that of carnotite which it resembles in general appearance, but it has not such a clear bright yellow color. It has been found only at, and in the vicinity of, Temple Rock on the San Rafael Swell, Emery County, about 45 miles southwest of Greenriver, Utah. It occurs in rocks which are probably the equivalent of the upper part of the Dolores formation. Some masses of the new mineral are a centimeter thick, but these are rather rare. The mineral occurs in sufficient quantity to be of economic importance.

Examined microscopically, uvanite is seen to consist of very minute crystalline particles with a very high birefringence. The mineral is not soluble in water but dissolves very quickly in a solution of ammonium carbonate.

The analysis by W. T. Schaller is as follows:

Analysis and ratios of uvanite

	ANALYSIS	RATIOS
Insoluble	1.24	
UO_3	39.60	0.139
CaO	1.73	0.031
K_2O	0.30	0.003
MgO	0.04	
V_2O_5	37.70	0.207
P_2O_5	0.06	0.001 (with As_2O_5)
As_2O_5	0.05	
H_2O	18.28	1.106
	99.00	

In deducing a formula from the analysis, some uncertainty is felt in regard to the lime and potash. If these be present as admixed tyuyamunite and carnotite, then there must be present 35 per cent of these two minerals. As, however, special tests showed that both tyuyamunite and carnotite are insoluble in ammonium carbonate solution whereas the material analyzed dissolves therein with great ease and readiness, the assumption that the lime and potash present are due to these two minerals is disproved. It is not known whether the lime and potash are derived from the gangue or belong to the uvanite. The ratios deduced on the basis of either assumption are the same.

Ratios of uvanite analysis

NEGLECTING $CaO + K_2O$				COMBINING $CaO + K_2O$ WITH UO_3			
UO_3	0.139 or	1.91 or	2×0.96	UO_3	0.150 or	2.05 or	2×1.03
V_2O_5	0.208 or	2.86 or	3×0.95	V_2O_5	0.208 or	2.84 or	3×0.95
H_2O	1.106 or	15.22 or	15×1.01	H_2O	1.106 or	15.11 or	15×1.01

The formula derived for uvanite is $2UO_3.3V_2O_5.15H_2O$.

Analysis of another mineral from the south side of Temple Rock, Emery County, Utah, which occurs in shaley sandstone as small greenish-yellow, glistening scales, has shown it to be like uvanite, a hydrous uranium vanadate. Further investigation is being made to determine whether it is a new species or a variety of uvanite.

Pascoite[2] has been found in small quantity on the Crescent No. 3 claim, Crescent Creek, Henry Mountains, and at a number of other places in southeastern Utah, as an efflorescence (already mentioned) and in cavities in fossil wood.

ZOOLOGY.—*The relation between recent crinoids and the temperature of their habitat.* AUSTIN H. CLARK, National Museum.

I have already discussed at considerable length[1] the relation between the recent crinoids and the temperature of the water in

[1] Une étude philosophique de la relation entre les crinoïdes actuels et la température de leur habitat. Bulletin No. 294 de l'Institut Océanographique. Monaco, 1914.

[2] Hillebrand, W. F., Merwin, H. E., and Wright, F. E. Hewettite, metahewettite and pascoite, hydrous calcium vanadates. Proc. Am. Philos. Soc., **53**: 31–54. 1914.

which they live; but there are one or two points upon which further emphasis may well be placed by presentation in a somewhat different light.

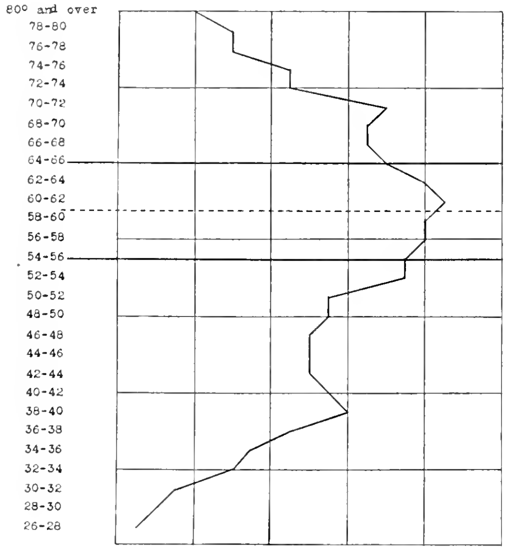

Fig. 1. The frequency of the families of recent crinoids at different temperatures.

The number of crinoid families occurring within the several divisions of 2° F. (fig. 1) which collectively make up the entire range of the class is as follows:

80° and over	4	52°–54°	15
78°–80°	6	50°–52°	11
76–78	6	48°–50°	11
74°–76°	9	46°–48°	10
72°–74°	9	44°–46°	10
70°–72°	14	42°–44°	10
68°–70°	13	40°–42°	11
66°–68°	13	38°–40°	12
64°–66°	14	36°–38°	9
62°–64°	16	34°–36°	7
60°–62°	17	32°–34°	6
58°–60°	16	30°–32°	3
56°–58°	16	28°–30°	2
54°–56°	15	26°–28°	1

According to the extent of their respective temperature ranges (fig. 2) the families of recent crinoids group themselves as follows:

1°– 6° (including families with one record only) 4

6°–12°	1	24°–30°	4
12°–18°	2	30°–36°	7
18°–24°	3	36°–42°	2

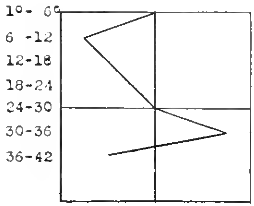

Fig. 2. Distribution of the families of recent crinoids according to their thermal ranges.

In the comatulids (fig. 3), although the Oligophreata and the Macrophreata are represented by the same number of families, six, between 50° and 55°, the families of the Macrophreata predominate at all temperatures below this, and the families of the Oligophreata at all temperatures above; but the total number of the families of the Macrophreata in excess of the total number of the families of the Oligophreata occurring below 55° is only two, while the total number of the families of the Oligophreata in excess of the total number of the families of the Macrophreata occurring above 55° is six. This indicates that the differentiation of new crinoid types is chiefly, if not entirely, confined to the warmer portions of the oceans.

There is a gradual increase in the number of the families of the Oligophreata from 30°–35°, where one only is represented, to 60°–65°, where there are six, and then a more gradual decrease as the temperature increases.

Among the families of the Macrophreata there is an increase, at first more abrupt than in the case of the Oligophreata, from 25°–30°, where one family is represented, to 50°–65°, where there are six, and then a decrease, at first much more abrupt than among the families of the Oligophreata, as the temperature increases. Thus in the Oligophreata we find the largest number of

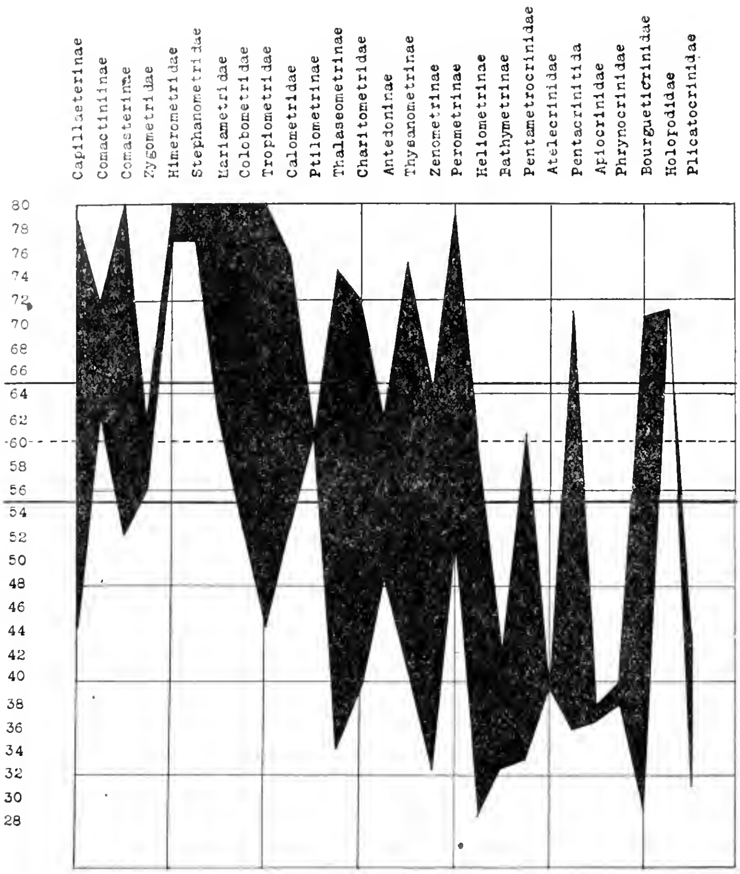

Fig. 3. Thermal distribution of the families of recent crinoids; the zone of maximum representation is between 55° and 65°, especially between 60° and 65°; it is probably within these temperatures that the very rich post-palaeozoic fauna was developed.

families between 60°–65°, in the Macrophreata between 55°–65°, the number in the case of the families of the Oligophreata diminishing gradually as the temperature increases, and the number in the case of the Macrophreata decreasing gradually as the temperature diminishes.

Examining the total for all the comatulid families, we find the largest representation between 55° and 65°, with the emphasis between 60° and 65°. The only stalked crinoids of which we have a sufficient knowledge (the Pentacrinitida and the Bourgueticrinidae) are also found at these temperatures, while three of the others (the families Apiocrinidae, Phrynocrinidae and Plicatocrinidae) are found below, and one (Holopodidae) is known only from above.

Among the comatulids we are without sufficient data in regard to five families (Himerometridae, Stephanometridae, Tropiometridae, Ptilometrinae and Atelecrinidae); but one of these (Ptilometrinae) is actually known from this temperature, while the four others are without doubt found here, if we may judge from the mean temperature of the sea at the depths at which they are known to live. At least all except four, and with little doubt all, of the comatulid families are found between 55° and 65°, and not only these, but also the two dominant families of the stalked crinoids (Pentacrinitida and Bourgueticrinidae). Thus it appears that the range of temperature between 55° and 65° (12.78° and 18.33°C.) represents the temperature most suitable for the recent crinoids.

There are certain very interesting attributes of the crinoids which are found between the temperature limits of 55° and 65°; they are all of medium size, none being very large and none very small, and they are all conservative in their characters, with never a large number of arms—usually ten only. This would appear to indicate that the range of temperature between 55° and 65° represents the temperature physiologically most suitable for the crinoids, a temperature which tends to maintain a phylogenetical conservatism and to suppress any tendency toward the extreme type of development characteristic of the crinoids of the warm water, as well as that characteristic of the crinoids of the cold water.

So far as can be seen, it is with recent species found between these temperatures that the fossil crinoids best agree, and thus the suggestion may be made that it was principally, if not entirely, within this temperature range that the crinoids of the post-palaeozoic fauna, which was characterized by a very great development of the present dominant order, the Articulata, were developed.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

METEOROLOGY.—*The total radiation received on a horizontal surface from the sun and sky at Mount Weather, Va.* HERBERT H. KIMBALL. Monthly Weather Review, **42**: 474–487. August, 1914.

At this station a Marvin pyrheliometer was employed to measure the intensity of direct solar radiation at normal incidence, and a Callendar horizontal recording pyrheliometer for measuring the total radiation received on a horizontal surface from the sun and sky. By employing a screen to eclipse the sun at intervals throughout the day, the Callendar pyrheliometer was also utilized to measure the total radiation from the sky alone. The bright receiving grids of this pyrheliometer are selectively absorptive of radiation of different wave lengths and it was therefore necessary to standardize the instrument for measurements of radiation of different degrees of blueness, varying from the color of sunlight to that of skylight. This was accomplished by comparing measurements by Callendar and Marvin pyrheliometers of the intensity of solar radiation transmitted by color screens.

The summary of measurements made between May, 1912, and September, 1914, inclusive, shows that during this period with the clearest sky the total radiation per square centimeter of horizontal surface varied from 250 calories per day on December 20 to 765 calories on June 10. On March 20 it was 605 calories, and on September 20, 515 calories. In general, the radiation received on a clear day during the half-year, December 21 to June 20, averaged about 8 per per cent more than that received during the remaining half year.

The average daily radiation in summer, including rainy and cloudy as well as clear days, was about 68 per cent of that received on the clearest days, and in winter about 63 per cent.

At noon, with a clear sky, the total radiation per minute per square centimeter of horizontal surface varied from 0.77 calorie in December to 1.55 calories in June. When clouds were near the sun but did not obscure it these rates were increased momentarily by as much as 0.15 calorie. For the period September, 1907, to September, 1914, the maximum intensity of direct solar radiation at normal incidence at noon varied from 1.37 calories in January to 1.50 calories in May and September.

The measurements show that at mid-day in summer about 18 per cent of the total radiation received on a horizontal surface was diffuse sky radiation. With a hazy sky about one-third of the total daily radiation was received in this way, as compared with one-tenth on a very clear day.

The measurements also show that at noon, on a clear mid-summer day, each square yard of horizontal surface at this station received heat energy at the rate of about 1 kilowatt, and that the total received from sunrise to sunset was equivalent to about 5 kilowatt-hours. From the middle of March to the end of August, on the clearest days, the total energy received was equivalent to 4 kilowatt-hours, or more.

H. H. K.

GEODESY.—*Primary triangulation on the one hundred and fourth meridian, and on the thirty-ninth parallel in Colorado, Utah, and Nevada.* WILLIAM BOWIE. Special Publication No. 19. Coast and Geodetic Survey. Pp. 163. 1914.

This volume contains the geographic positions and the descriptions of about 600 primary triangulation stations, which are located along the 104th meridian of longitude in Colorado, Wyoming, the Dakotas, and Montana, and along the 39th parallel of latitude in the states of Colorado, Utah, and Nevada.

The field work of the 39th parallel triangulation was completed in the late nineties, and a report on that work appeared in 1899 as Coast and Geodetic Survey Special Publication No. 4. Since that date a standard datum for all connected triangulation in this country was adopted and called the United States Standard Datum. In 1913, when this datum was adopted by Mexico and Canada, its name was changed to the North American Datum. It is not identical with that on which the Transcontinental triangulation was originally based, hence the necessity of publishing the new positions in Special Publication No. 19.

The field work on the 104th meridian triangulation was done during one season of about six months by two observing parties. As this arc is 720 miles in length, the rate of progress for each party was about 60 miles per month.

There is given an account of the remeasurement of the El Paso Base line in Colorado, which was first measured with the "Secondary Base Bars" in 1872. The remeasuring was done with 50-meter invar base tapes. The difference between the two measurements is one part is about 59,000. As the base ends were very substantially marked, when the base was established, it is believed that the discrepancy is not due to any shifting of the marks but that it is the result of an error in the first measurement, probably caused by the inability to secure the actual temperature of the metal rods of the bars by means of mercurial thermometers mounted near the rods.

Three new bases were measured on the 104th meridian with invar tapes and the probable error of each base is smaller than one part in one million. Nearly all of the observing for horizontal angles in the main scheme was done at night, the pointings being made on acetylene lamps posted at the distant stations. These lamps were of sufficient power to be seen easily over the longest lines of the scheme—about 70 miles.

The introduction of additional precise leveling elevations in the trigonometric leveling net made a readjustment of the net necessary. In consequence, a number of mountains are given elevations which differ from the elevations given in Special Publication No. 4. Except in a few cases in the vicinity of Pike's Peak, the new elevations are lower than the older ones. The changes in California and in western Nevada and in central Colorado are small, being only one foot for Mt. Elbert and Mt. Ouray in Colorado, and two feet for Mt. Grant in Nevada. The maximum change comes in Utah; Pilot Peak, for instance, having its elevation changed by 16 feet.

A discussion of the errors of triangulation indicates that when the observations are made during the day and in the afternoon, triangulation running north and south tends to deviate in azimuth towards the west. Under similar conditions an east and west arc tends to deviate towards the south. This systematic error is not present to any noticeable extent when all the observations are made at night. It is stated that the error is probably due to some effect of unequal heating of the theodolite. To minimize or overcome any such effect, the theodolite now in use on primary triangulation is fitted with a nickel-iron circle which has a much lower coefficient of expansion than that of the original circle. No data are yet available as to the accuracy obtained with a new circle.

W. B.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE WASHINGTON ACADEMY OF SCIENCES

The 92d meeting of the Washington Academy of Sciences was a delightful all day, May 16, 1914, excursion of about 150 members to Annapolis and the United States Naval Academy. Through the kindness of the Navy Department and the Superintendent of the Naval Academy, Capt. W. S. Fullam, many courtesies, including a trip up the Severn and return on torpedo boats, were extended to the visiting guests. The weather was ideal, and the excursion, under the management of the Committee on Meetings, in every way a success.

The 93d meeting of the Washington Academy of Sciences, a business meeting, with President White in the chair and attended by twenty members, was held in the Cosmos Club on May 28, 1914.

The revised by-laws, as proposed on May 5, 1914, were adopted, with but one amendment, namely, that the life membership fee shall be $75, instead of, as formerly, $100.

At the suggestion of the corresponding secretary, Dr. Burgess, it was agreed that the memorial volumes of the Royal Society of London, after being kept on exhibition for a time at the Cosmos Club, be given to Dr. L. O. Howard, who was the Academy's official representative at the meetings in question.

Dr. G. R. Olshausen, of the Bureau of Standards, was elected to resident membership.

W. J. Humphreys, *Recording Secretary.*

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 743d meeting was held on October 10, 1914, at the Cosmos Club, Vice President Eichelberger in the chair; 25 persons present.

Mr. H. H. Kimball read a paper on *Measurements of the total radiation received on a horizontal surface from the Sun and sky.* From records at Mt. Weather since 1912 of the Callendar horizontal recording pyrheliometer, it has been found that the total radiation per square centimeter of horizontal surface, with the clearest sky, varies from 250 calories per day on December 20, to 765 calories on June 10. The average daily radiation in summer is about 68 per cent of that received on clear days, and in winter it is about 63 per cent. The maximum solar radiation at normal incidence varies from 1.37 calories per minute per square centimeter in January, to 1.50 calories in May and September. The total radiation on a horizontal surface with a clear sky varies from 0.77 calories per minute in December to 1.55 calories in June. When clouds are near the Sun, but do not obscure it, the momentary rates are increased by about 0.15 calorie per minute. The diffuse sky radiation received on a horizontal surface at noon averages about 25 per cent of that received on the same surface from the Sun. On a clear summer day it amounts to from one-eighth to one-third of the total radiation. The paper was illustrated by lantern slides. The communication was discussed by Messrs. Bowie and Humphreys.

Mr. F. E. Fowle then presented an illustrated paper on *Atmospheric transparency and Avogadro's constant.* A brief summary of this paper was published in this Journal, **4**: 529–530. 1914. The paper was discussed by Messrs. Humphreys, Bowie, and Eichelberger.

The 744th meeting was held on October 24, 1914, at the Cosmos Club, President Fischer in the chair; 22 persons present.

Mr. W. W. Coblentz presented a paper on *A comparison of stellar radiometers and radiometric measurements on stars.* It was shown there is but little difference in the radiation sensitivity of stellar thermocouples constructed of bismuth-platinum or of bismuth-bismuth + tin alloy. An improved method of maintaining vacuum by means of metallic calcium was used. Measurements were made on 112 celestial bodies, including 105 stars, quantitatively on stars to the 5.3 magnitude and qualitatively to the 6.7 magnitude. It was found that red stars emit from 2 to 3 times as much total radiation as blue stars of the same photometric magnitude. Measurements were made on the transmission of radiation of stars through an absorption cell of water; these showed that, of the total radiation emitted, the blue stars have about 2 times as much radiation as the yellow stars and about 3 times as much as the red stars. A stellar thermocouple in comparison with a bolometer was found more sensitive. The investigation showed that the sensitivity required to do much successful work in stellar spectral energy curves would be 100 times that of the apparatus used, which was such that when combined with a 3-foot reflecting telescope a deflection of 1 mm. would have resulted when exposed to a candle 53 miles distant. The paper was discussed by Messrs. Swann and Wenner.

Mr. H. L. Curtis then spoke on *Insulating properties of solid dielectrics with special reference to surface films.* A summary of this paper appeared in this Journal, **4**: 492, 1914. The paper was discussed by Messrs. C. A. Briggs, Burgess, Swann, and Stillman.

The 745th meeting was held on November 7, 1914, at the Cosmos Club; President Fischer in the chair; 49 persons present.

By invitation, Mr. J. Johnston spoke on *Some effects of high pressure.* Thorough investigation of the effects producible by high pressure will yield information of very great value in its bearing upon many fundamental problems of physics and chemistry. For example, it would seem that we are much more likely to ascertain precisely what happens when a crystal melts by studying this process through a wide range of pressure. Although comparatively little systematic investigation of this domain has yet been made, several conclusions seem now to be justified; the more important are as follows: Increase of pressure raises the melting point (with but two known exceptions—bismuth and ice 1), the change produced being progressively smaller for each successive pressure increment; but there is no reason for believing that there is either a maximum melting point (as had been postulated by Tammann) or a critical end-point solid-liquid. Change of pressure may either raise or lower a transformation temperature (solid → solid) or a solubility; this implies that change of pressure may alter the number and nature of the substances crystallizing out from a cooling solution containing several components. Increase of pressure produces a decrease of electrical resistance of all the pure metals investigated (bismuth excepted), but increases the resistance of the alloys; the change of resistance of manganin or therlo is the most convenient means of measuring high pressures accurately. Change of pressure displaces the position of equilibrium of a chemical reaction, especially in reactions involving a vapor phase, since it has such a marked effect upon the concentration of the vapor. The communication was discussed by Messrs. Buckingham, Swann, Bowie, and Humphreys.

Mr. L. J. Briggs then spoke on *The Australian meeting of the British Association for the Advancement of Science.* The meeting was made possible through the generosity of the Australian Commonwealth, which placed at the disposal of the British Association a fund to defray in part the over-sea expenses of members and guests. Meetings were held at Perth, Melbourne, Adelaide, Sydney, and Brisbane, the capitals of the five states of the Commonwealth. The scientific meetings were limited to Melbourne and Sydney. Numerous excursions were arranged at each place. Free transportation was provided on all the railroads, and the over-sea members were entertained in each of the cities. Of the many interesting papers presented before the physical section, there was mentioned in particular the address of the President of the section, Professor Trouton, on *Absorption and adsorption;* Mr. C. G. Abbot's paper on *The variability of the Sun;* Sir Ernest Rutherford's paper on *Gamma rays;* and Mr. Moseley's paper on *High frequency spectra.*

J. A. Fleming, *Secretary.*

BOTANICAL SOCIETY OF WASHINGTON

The ninety-eighth regular meeting of the Botanical Society of Washington was held October 6, 1914, in the Cosmos Club. Forty members and two guests were present. The following scientific program was given:

P. H. Dorsett, *The botanical garden of Rio de Janeiro, Brazil* (with lantern).

W. F. Wight, *Andean origin of the cultivated potato* (with lantern and specimens).

Both papers are to be published elsewhere.

The fourteenth annual meeting of the Botanical Society of Washington was held at 1.30 p.m., October 23, 1914. The customary reports were presented and approved and the following officers were elected for the ensuing year: Dr. R. H. TRUE, President; Mr. G. N. COLLINS, Vice President; Prof. C. E. CHAMBLISS, Recording Secretary; Dr. PERLEY SPAULDING, Corresponding Secretary; Mr. H. C. GORE, Treasurer, and Mr. W. E. SAFFORD, Vice President to the Washington Academy of Sciences.

The ninety-ninth regular meeting of the Botanical Society of Washington was held November 3, 1914 in the Cosmos Club. Forty-nine members and three guests were present. Mr. WILSON POPENOE was unanimously elected to membership. The scientific program was:

PAUL POPENOE, *The date palm in antiquity* (with lantern). The speaker referred particularly to the influence of the date palm on the religion of the Semitic peoples. Prized for the food and drink it furnished, it was revered because of the mystery of sex emphasized by its monoeciousness, and became identified with the primitive mother goddess of fertility. A sacred palm in a garden at Eridu, near the mouth of the Euphrates river, is thought by many investigators to be the origin of the Tree of Life of the Garden of Eden, described in Genesis. The culture of the palm was thoroughly known at a very early period, the Babylonian inscriptions giving reason to believe that it was more skillful 1900 years B.C. than it is in that region 1900 years A.D.

W. E. SAFFORD, *The economic plants of ancient Peru.* This paper was based upon collections and observations made by the speaker while cruising along the Peruvian and Chilian coast, in 1887, and while acting as Commissioner for the World's Columbian Exposition to Peru and Bolivia, in 1891 to 1893. Prehistoric graves were opened at Caldera, Iquique, Arica, the Rimac valley, Ancon, Chimbote, Truxillo, and the vicinity of Payta. The material obtained is mainly in the Field Columbian Museum at Chicago and the United States National Museum. In addition to objects of ethnological interest many articles were found illustrating the ethnobotany of ancient Peru. Not only were seeds, seed-pods, dried fruits, leaves, and tubers found, but beautiful representations of many of the food plants in terra-cotta, in the form of funeral vases, were discovered in graves near the coast, especially at Chimbote and Truxillo. Among these were a number not included in Wittmack's list published in Reis and Stuebel's great work "Das Todtenfeld von Ancon." Beautiful models in terra-cotta of the tubers of *Solanum tuberosum* were found, also of the fruits of *Solanum muricatum* and *Lucuma obovata*, and most interesting of all the almond-like kernels of *Caryocar amygdaliforme* R. & P., easily distinguished by their protruding recurved embryo. Another interesting object was a terra-cotta vase representing the roots of the yahutia (*Xanthosoma* sp.). The collections include specimens of *Phaseolus vulgaris* and *Phaseolus lunatus*, a gourd full of peanuts (*Arachis hypogaea*) and models of the same on terra-cotta vases; mandioca roots and models of the latter; quantities of maize and models of the same on funeral vases; bags of coca leaves

(*Erythroxylum Coca*), and specimens of raw cotton, dark brown, light brown, and white, together with spindles with cotton yarn upon them; looms with half-woven fabrics, and textiles of beautiful and intricate designs. Among the most interesting of the funeral vases were forms representing the corn god of ancient Peru, a monster with protruding tusks, surrounded by ears of maize; and the god of agriculture, represented with a stalk of maize in one hand and a stalk of mandioca in the other, with a cluster of roots at the base very much like those of a dahlia.

This paper was illustrated by numerous slides, principally of objects collected by the speaker and now in the collection of the Field Columbian Museum.

PERLEY SPAULDING, *Corresponding Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At the 475th regular meeting of the Society, held October 21, in the Public Library, Dr. D. S. LAMB, of the Army Medical Museum, delivered an address on *Sanitation in ancient civilizations.* In the usage of the speaker the word ancient was specifically applied to the period before the fall of the Roman Empire. The beginning of the historic period for different nations, he said, varies much; for Egypt, about 11,000 B.C.; for the American nations, within the Christian era. But the character of all the beginnings was probably much the same: human necessities, life, health, food, clothing, shelter, differed but little, except as influenced by climate or geographical position. The need of sanitation was especially shown by the histories of epidemics; for instance, the black death of the fourteenth century destroyed, it is said, about 25,000,000 persons.

Pure water was one of the first necessities. Man must have availed himself at first of the use of springs, lakes, and streams; and when these were not available, he dug a well; later, to have the water still more accessible, he built a cistern. And when many families had congregated together, he built an aqueduct to bring the water to the town or city and to distribute it to the individuals. Old artesian wells are found in Asia Minor, Persia, China, Egypt, Algeria, and even the Desert of Sahara. There were aqueducts in Palestine; one was built by Hezekiah about 700 B.C. The earliest form of aqueduct in Greece was at Cos. Rome had at one time 19 aqueducts; 14 of these were large and together had a total length of 359 miles, 55 of which was on arches, sometimes 100 feet high. Some of these are still in use. Most however fell into decay or were destroyed by hostile armies. In olden times when the king of Persia travelled he had the water boiled before drinking it. Aqueducts have been found in Mexico, Guatemala, and Peru, antedating the arrival of Columbus.

As for the disposal of waste, among the Hebrews it was buried or burned. There is no account of drainage among the Greeks. The Romans built great *cloacae* or sewers, that carried the storm water and refuse into the Tiber. Several of these are still in use. At one time the sewers were cleaned out at a cost of a million dollars; it was necessary to divert the course of seven so-called rivers to do it. The disposal of the dead varied much in different nations. After a battle it was usual either to bury in large pits or trenches or to burn the bodies. The opening of such pits or trenches, as well as the opening of church vaults and old burial grounds, sometimes caused sickness and even death. The Egyptians buried the dead after embalming them. Infants, however, were often buried beneath the habitation. In India the dead were generally cremated. The Parsees placed their dead on gratings in towers, for the vultures to eat; the bones were afterwards gathered up. Among the Massagatae, says Herodotus, when a man became old, he was sacrificed and eaten. In Greece the dead were buried near the houses of the living; coffins of stone were used. The Romans cremated the dead after about 450 B.C. until the spread of Christianity, when for several centuries it was the custom to place the dead in the catacombs beneath the city of Rome. The Hebrews always buried outside the camp or city. The story of the burial of Jesus Christ is that the body was wrapped in linen with spices about 100 pounds in weight and buried in a tomb in a garden on Mount Calvary. The ancient Mexicans cremated the dead. Indian mounds in the United States contain bodies of the dead.

The desire to bathe is probably as old as man himself. The Lacedemonians are said to have devised the hot air bath. The Scythians took a sweat bath. Soap was mentioned by Pliny about 25 A.D. and was said to have been brought from Germany. The Hebrews were required by religious regulations to be clean in person, clothing, and houses. In Egypt, when Alexandria was taken by the Caliph Omar in 646, there were 4000 baths, and the 700,000 books of the great library were burned to heat these baths. The Romans had many public baths, free to all. The bath of Caracalla was a mile in circumference and accommodated 2000 persons. The Greeks bathed daily.

Contagious diseases afflicted the ancients even more than the moderns. The Hebrews especially attempted to get rid of leprosy by segregating the lepers. Circumcision was common among the Egyptians, the Ethiopians and peoples in the Pacific Islands, Asia Minor, Persia, Arabia, and eastern and western Africa. Among the Hebrews the custom was a religious ceremonial. The Egyptians believed that diseases usually were contracted through food and drink, and therefore they tabooed some articles of food. Among the Greeks the Pythagoreans had rules relating to what they ate or drank as well as to their exercises. The Hebrews had many rules of diet that had the force of religious injunctions; especially as to meat, the animal had to be slaughtered in a certain way and with much attention to detail.

Daniel Folkmar, *Secretary*.

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PHYSICS.—*Studies on the silver voltameter.*[1] G. A. Hulett and G. W. Vinal, Bureau of Standards.

A comparison has been made of the silver voltameters and methods employed at the Bureau of Standards with the voltameters and methods used at Princeton University. For the details of the previous work at these two institutions reference is made to the Bureau of Standards Bulletin, **9**, 151, 209, 493; **10**, 475, and the Transactions of American Electrochemical Society, **12**, 257; **22**, 367. All the experimental data recorded in this paper were obtained in the laboratory of Physical Chemistry of Princeton University.

A preliminary comparison of the voltameters, using the same electrolyte in all, showed a consistent difference of one part in ten thousand, the Bureau voltameters having the greater deposit. A systematic search for the cause of this difference showed it to be due to two factors, viz., the differences in the methods of preparing the porous cups and, second, the differences in the method of washing the deposit.

The Bureau's porous cups were kept in silver nitrate between experiments and produced little change of acidity in the electrolyte of the voltameter, but the Princeton porous cups were usually washed free from the silver nitrate after each experiment and kept in distilled water. It was found in this case that the acidity of the voltameter electrolyte increased. The fact that the Bureau's porous cups were made by a different maker than for the Princeton cups was without significance since when the

[1] Detailed paper to appear in full in the Bulletin of the Bureau of Standards.

two different kinds were kept saturated with silver nitrate they produced identical results.

The practice of nearly all observers has been to continue the washing of the deposit until the presence of silver nitrate can no longer be detected in the wash waters by chemical tests, but many have taken the further precaution of allowing distilled water to stand on the deposit for a considerable period of time. As a test on the completeness of the washing, we compared the conductivity of the water before being put in the cup with its conductivity after it has stood in the cup for various periods of time. In every case the conductivity increased with time. It was at first supposed that this increase was due to entrapped silver nitrate gradually soaking out, as we could detect the silver in the water after allowing to it stand overnight. All subsequent experiments, for which reference is made to the complete paper, showed that this is not the case, but rather that an electrolytic process was taking place by which the silver was passing into solution at the rate of about 0.006 mg. per hour from a 4 gram deposit of silver on platinum. To confirm this we were able to show by a galvanometer that a current actually passed from the silver through the water to the platinum. In washing the deposits overnight, this effect becomes appreciable. The work was closed with a final comparison of the voltameters in the light of our experiments and unusually good agreement found.

PHYSICS.—*A simple method for the accurate measurement of relative strain in glass.* FRED. E. WRIGHT, Geophysical Laboratory.

The phenomena attendant upon strain in glass have long interested physicists and glass-makers, and much time has been spent in the investigation of the different phases of this subject. The optical effects resulting from strain were first studied in detail by Brewster[1] at a time when only the simplest of optical apparatus was available and but little was known of double refraction. Notwithstanding this, Brewster deduced from a

[1] Philos. Trans. 1814, 1815, 1816.

series of ingenious experiments many of the fundamental laws of the optical behavior of glass strained either mechanically by differential pressure or tension, or as a result of non-uniform heating or cooling. Brewster found: that a plate of glass under load is birefracting; that the optical effect produced is sensibly proportional to the intensity of the strain; that a plate of glass under differential compression behaves optically as a uniaxial negative crystal with its principal axis in the direction of the acting load, while under differential tension it acts as an optically positive uniaxial crystal; that in a glass plate cooled quickly from a high temperature a permanent strain is imparted which is at maximum intensity next to the outer surfaces (zone of compression), and which, decreasing toward the center, reaches a neutral band and passes then into a zone of tension in the central part of the plate; that compression produces retardation, while dilatation causes acceleration of the transmitted light waves, with the result that a rapidly cooled cylindrical rod of glass with plane parallel end surfaces behaves as a negative lens (meniscus).

Following Brewster, Fresnel[2] proved definitely that two waves are transmitted through a strained glass plate; F. E. Neumann[3] gave a mathematical solution of the general problem on the basis of certain assumptions; A. Wertheim[4] verified Brewster's statement of the proportionality between optical effect and intensity of strain; Macé de Lépinay[5] found that the path difference is practically the same for all wave lengths and that, therefore, the interference colors are essentially those of Newton's color scale. J. Kerr[6] proved, by means of a Jamin interference-refractor, that in the case of compression both waves are retarded while in the case of tension both waves are accelerated; that the wave whose vibrations take place in the plane normal to the direction of the applied load is retarded most, its retardation being practically twice that of the wave vibrating along the direction of strain; that "the action of directionally strained glass, in the common

[2] Oeuvres Completes.

[3] Pogg. Ann. **54.** 1841.

[4] Comptes Rendus, **32**, **33**, **34**. 1851.

[5] Ann. d. Chim. et Phys., **19**: 1 90. 1880.

[6] J. Kerr, Phil. Mag., (5), **36**: 321. 1886.

polariscope, upon light crossing the line of strain at right angles is due exclusively to strain-generated change of velocity of the component ray which has its plane of polarization parallel to the line of strain;" that in the case of plates cut parallel with, or normal to the direction of strain, the difference of retardation for obliquely incident rays varies directly as the cosine of the angle of refraction. This relation, in particular, indicates how closely similar in its optical behavior a strained glass plate is to a uniaxial mineral. S. Czapski[7] measured the relative strain in glass rods by a dioptric method based on Brewster's observation that a cylindrical rod behaves optically as a meniscus lens. F. Pockels[8] studied, by means of a Jamin interferential refractor and a Babinet compensator, the optical effects produced in a glass plate by elastic deformation of given magnitude. He found also that a lead silicate glass high in lead shows anomalous optical behavior in that it acts under load as an optically positive substance; also that for each color of light there is a composition of lead silicate glass for which no optical effect is produced either by compression or dilatation. Recently E. Zschimmer and H. Schultz[9] have investigated, by means of a Babinet compensator in combination with an interference method based on Lummer's theory of interference curves of equal inclination, the optical behavior of glass heated and cooled under different conditions. Their method, like that of Czapski, is so applied that it furnishes an average or integration value of the relative retardation of the waves after transmission through any particular part of the plate. The method is well adapted for the purpose but the apparatus is complicated and its manipulation evidently requires a considerable degree of skill.

It is of interest to note that in practically every paper cited above a new method is proposed for measuring the optical effects observed. A careful study of these and other papers and also of the general theory of the thermal behavior of cooling glass plates indicates clearly that further progress in this interesting and technically important field depends chiefly on careful quanti-

[7] Ann. d. Phys., **42**: 319–331. 1889.

[8] Ann. d. Phys., **7**: 745–771. 1902; **9**: 220–223. 1902.

[9] Ann. d. Phys., (4), **42**: 345–396. 1913.

tative measurements and that therefore a simple method for measuring relative optical retardations accurately should be of value. The method presented below is suggested for this purpose. In this method the glass plate is examined in strong monochromatic light between crossed nicols; the path difference of the emergent light waves at any given point is measured by means of a bi-quartz compensator of special type.[10]

The most satisfactory source of monochromatic light available is the green line (546 $\mu\mu$) of a strong mercury lamp, as viewed

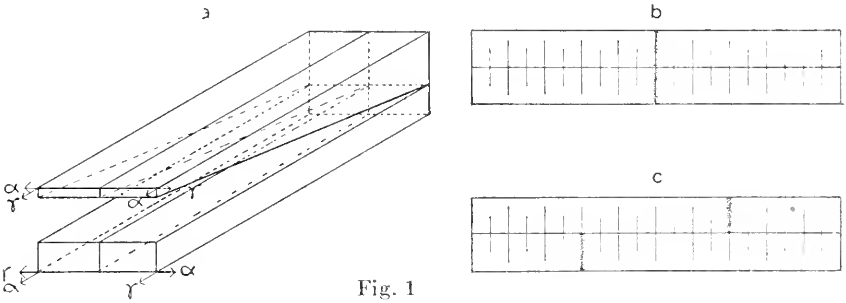

Fig. 1

through a Wratten and Wainwright special filter No. 77. The rays from the lamp are rendered parallel by means of a condenser lens before entering the polarizer. For certain purposes direct sunlight or an arc light may be used and gives results which are sufficiently accurate.

The bi-quartz compensator consists of two quartz plates and two quartz wedges cut parallel to the principal axis and mounted as indicated in figure 1 a. When viewed in the diagonal position under crossed nicols this wedge presents the phenomenon of figure 1 b, namely a dark, transverse band of exact compensation, on both sides of which the interference colors rise to gray, or other color of the first or higher order depending on the pitch and length of the wedge. The wedge is so ground that graduations on the upper surface of the compensator indicate directly the path differences in $\mu\mu$ for the wave length (546 $\mu\mu$) of light employed. As indicated in figure 1 the bi-compensator is so

[10] F. E. Wright, Amer. Jour. Sci., (4), **26**: 370–371. 1908; Carnegie Institution of Washington, Publication 158: 134–135. 1911.

constructed that the optical elongations of the two halves are equal but of opposite sign, the result being that on the insertion of a birefracting plate in the diagonal position the dark band in the one-half moves to the right while in the second it moves to the left as indicated in figure 1 c. With a properly constructed bi-compensator the shift produced by a path difference of less than $1\mu\mu$ can be readily detected and measured. The sensitiveness of the combination wedge varies inversely with the pitch of the wedge. The most favorable conditions for observation are: intense illumination by parallel, monochromatic rays; long wedge with very low pitch, such that 1 scale division (0.1 mm.) is equivalent to a path difference of 1 $\mu\mu$; magnifying system for examining wedge located above analyser. This last precaution does away with the disturbing rotatory effects on the planes of vibration of the transmitted waves at the surfaces of the lens system. For most purposes, however, such precautions are not necessary and it is sufficient to use a less sensitive bi-compensator (1 scale division = $5\mu\mu$ or 10 $\mu\mu$) in the lower focal plane of a positive eyepiece in a petrographic microscope, the analyser then to be a cap-nicol.

The conversion of the optical retardations thus measured on a given piece of glass to the corresponding elastic deformation data is accomplished by direct measurements on the glass subjected to a series of mechanical loads of known magnitudes.

The above optical method for measuring relative strain in glass has been employed for several years in practical glass work and has been found to be satisfactory.[11] In certain instances details of the method require modification to meet best the special conditions of measurement, but such adaptations are readily made and the general underlying principles remain unchanged.

MINERALOGY.—*Additional notes on babingtonite from Passaic County, New Jersey.* CLARENCE N. FENNER, Geophysical Laboratory.

In the November 19th issue of this JOURNAL the writer described an occurrence of the mineral babingtonite in the deposits

[11] R. L. Frink, Eighth International Congress of Applied Chemistry, **5**: 13. 1912.

of zeolitic minerals found at various localities in the Watchung basalt sheets of northern New Jersey. Mention was made of the presence of certain remarkable cavities or casts of some mineral formerly present, which are very abundant in the deposits and which have been a source of much speculation among mineralogists for many years. It was believed that the evidence indicated that the origin of the casts was to be ascribed to babingtonite. Since the article was written certain new evidence has come to light which has an important bearing upon the subject.

Through the kindness of Dr. W. T. Schaller of the United States Geological Survey my attention has been directed to two recent discoveries. One of these was reported in an article in the New York *Times* for November 23, in which Mr. F. I. Allen of New York described the discovery of anhydrite at West Paterson and ascribed to this the rôle of the parent mineral of the casts. At about the same time or a little before, an unpublished discovery was made at McKiernan and Bergin's quarry in Paterson of pseudomorphs of quartz occupying certain of the cavities. These pseudomorphs were remarkable for the fact that they were loose in the cavities and could be easily withdrawn, but nevertheless showed sharply defined prismatic faces and less distinct terminal faces. The presence of these faces suggested that a comparison of the crystal angles with those of known species might serve to establish the identity of the original mineral.

Since the appearance of the previous article I have received a number of inquiries regarding the occurrence of babingtonite from mineralogists who have been interested in the casts, and some question has been raised as to the quantitative importance of this mineral in the formation of the cavities. Its identification as babingtonite appears to have been accepted, but some doubt has been expressed as to whether it was present in large amount and as to whether most of the cavities should not rather be ascribed to anhydrite and a possible third mineral of unknown nature. For these reasons and on account of the importance of the new finds it seemed desirable to revisit the localities of discovery, to examine all available material, and to present a summary of the evidence which has come to view in its bearing upon the question of the identity of the original mineral or minerals of the cavities. Accordingly several days have been devoted to visits to the New Jersey localities where the minerals and casts have been found and to the collection of material for examination. Considerable new evidence has been brought to light and will be presented here.

One of the chief points upon which information was considered desirable was the question of the relative importance and abundance of the two minerals babingtonite and anhydrite. It was found that the quantity of anhydrite so far discovered was very small and that no new material had been opened up since that which Mr. Allen described. However, through the kindness of Mr. Allen and of another collector, Mr. Lovell, of Paterson, the opportunity was given to examine several specimens. The anhydrite occurs in large crystals in a quartz matrix and there seems to be no reason to doubt that it is of primary origin and does not simply fill cavities left by the removal of some other substance. In the specimens seen it occurs either in simple crystals of nearly square section or in slightly radiating or fan-like crystals produced by a spreading-out in the direction of one of the axes. Careful examination failed to show any indication of laminae of quartz projecting from the walls into the anhydrite. On the contrary the walls of the matrix appeared to be perfectly straight and smooth and differed in that respect from those of most of the rectangular casts. However, it does not seem unlikely that under certain conditions of decomposition and removal of the anhydrite such laminae might be built up along the cleavage planes. The evidence appears quite clear that anhydrite was the original mineral of some of the rectangular cavities, but the later investigation has strengthened the belief that babingtonite also was an abundant and important mineral and that certain of the casts left by its crystals are of such size and form that they present a remarkable resemblance to those due to anhydrite.

From a search among the minerals of West Paterson and Great Notch it has been found that babingtonite is less rare than had been supposed. Small remnants have been discovered on numerous specimens (about two dozen in all have been obtained) and its mode of occurrence is frequently such as to strengthen the view regarding its relationship to the casts. In many instances it is plain that the small fragments seen are survivals of larger crystals. As a general rule the babingtonite is covered with decomposition products, either the asbestos-like substance mentioned in the preceding paper, or a green material, probably of chloritic nature, or, less frequently, red hematite. In general the greater part of the crystals has been removed and only the impressions are left, but by directing a search among the terminations of the cavities, where thin laminae of other minerals projected into the original crystals, babingtonite has been found so frequently as to leave little doubt that it represents portions of the original crystals surviving because of their protected situation. In another form of occurrence the relations are such as to show that it is not of secondary deposition. Broad faces of casts have been found, on which patches of babingtonite are seen, and from other portions of the surfaces small projections of the mineral run directly into the matrix. The relations indicate that large crystals, which have been subsequently dissolved away, carried small offshoots, which have been protected by the matrix. The characteristics are those which have been observed in several crystal groups of babingtonite which are in a better state of preservation than usual.

From a study of the specimens in which these relations have been found it is possible to arrive at certain conclusions regarding the nature of the casts which are due to babingtonite.

In its simplest form the mineral has developed in small, thin blades, extending like gashes into other minerals. These may be single crystals or may form groups growing together without apparent order. At times such groups show two or three crystals of larger development, with small offshoots in various directions. With increasing size the crystals, as inferred from the cavities, have tended to assume rectangular forms, but with one dimension still much less than the other two. In places the impressions of these tabular crystals extend over a wide surface, often in a somewhat fan-like form. A specimen of pectolite showing the impression of flattened crystals of this kind, and with numerous small offshoots of babingtonite running into the matrix, gave measurements of 4 x 5 cm. On the same specimen another impression with essentially similar characteristics measured $2\frac{1}{2}$ x 5 cm. and showed a thickness of 0.5 cm. An impression on quartz, with remnants of babingtonite among the laminae, measured 7 x 1 x 0.5 cm., and another, likewise showing babingtonite, gave 7 x 3.5 x 0.3 cm. In another mode of development the width and thickness of the cavities do not differ greatly from each other and the crystals appear to have had a simple prismatic form, whose cross-section was essentially rectangular. A certain specimen which shows this type is composed of an aggregate of prehnite crystals in a finger-like form, which now surround a rectangular cavity running through the middle of the group. The original crystal is inferred to have been babingtonite because of the discovery of this material among the laminae projecting from one of the surfaces of the orifice. The dimensions of the cavity are 5 x 0.8 x 0.5 cm.

These measurements indicate that the crystals of babingtonite attained large dimensions. Some may have been considerably larger than the measurements given, as similar cavities of larger size are not infrequent, but only those have been cited in which the presence of babingtonite has been detected.

If, in cavities of this character, babingtonite had been discovered in two or three specimens only, its presence might perhaps be explained in other ways than under the supposition that it represented the remnants of the crystals which filled the cavities, but it has been found in repeated instances in the situations where it was looked for and where it might be expected to resist for the longest time the solvent action of circulating waters, and its presence can hardly be regarded as fortuitous.

In practically all specimens in which babingtonite has been found in the cavities thin laminae, projecting from the walls and lying parallel to the widest surfaces, are a marked characteristic, and such cavities are very abundant. In certain other cavities the walls are either smooth or show ridges of somewhat different appearance from that presented by the extremely thin laminae. In still others a cell-like structure of rectangular partitions has been built across the cavities. In such types anhydrite may have been the original filling, but no trace of either mineral has been detected in them.

The formation of the laminae and ridges and partitions seems best referable to the action of solvents upon planes of easy solution in the crystal structure, with the simultaneous deposition of other minerals. Such solution-planes would most likely correspond to cleavage-planes, although not necessarily so. Anhydrite, as is well known, has three easy cleavages at right angles to each other. According to Dana and Hintze, babingtonite has but two cleavages, which are parallel to 001 and 010 and include an angle of 92° 36′, but it has been found by examination of small cleavage-fragments under the microscope that in reality four are probably present. Three of these make angles with each other which do not differ appreciably from 90°. These cleavages have been observed both in the New Jersey mineral and in National Museum specimens from Italy and Norway. Therefore it does not appear practicable at present to differentiate the casts on the basis of rectangular parting-laminae.

In these approximately rectangular cavities the babingtonite crystals appear to have been of prismatic or tabular habit, with a terminal plane cutting the other two at nearly right angles. It cannot be stated definitely which crystal-faces are represented, but, as suggested in the former paper, Dauber's *g* ($2\bar{1}0$), *h* (110), and *c* (001) appear probable forms. These are figured by Hintze as faces of prominent development in babingtonite from Arendal and Herbornseelbach and the included angles differ only slightly from 90°. Crystals bounded by these three planes are of simpler form than babingtonite ordinarily shows, but, considering the well-known variations in this respect which many species exhibit, this does not appear of serious importance.

Thus far the casts of rectangular form only have been treated in this article, and it remains to consider those of lozenge-shaped cross-section. The latter are also of frequent occurrence in the deposits and are often associated with those of rectangular development. It is rather remarkable that, whereas the rectangular casts are found in various minerals—quartz, prehnite, pectolite, datolite, albite—the lozenge-shaped casts have been observed in quartz only, and no other minerals have been noticed in close association (except possibly such as are of later origin). This naturally implies a difference in conditions of deposition in the two cases.

In the previous paper the lozenge-shaped cavities were regarded as due to babingtonite. Since then little new evidence has been found which either confirms or disproves this view, but one fact on which the conclusion was in part based has been found to have less force than had been supposed. It had been observed that cross-sections of the babingtonite crystals first discovered exhibited lozenge-shaped boundaries, and in the new material likewise this is frequently true, but careful examination raises a doubt as to whether this is not a result of the manner in which weathering has attacked the crystals. It seems probable, in fact, that, in some cases, decomposition has acted in a peculiar manner upon the crystal-surfaces and has tended to produce lozenge-shaped forms from originally rectangular crystals. Less weight, therefore, is now attached to this evidence.

On the other hand, the measurements of the angles of the cavities which were cited show very close agreement with the crystal angle between the faces *b* (010) and *g* ($2\bar{1}0$) of babingtonite.

A number of the quartz pseudomorphs from McKiernan and Bergin's quarry have been obtained and a series of new measurements has been made with a contact goniometer. Some of these specimens were kindly loaned by Professor Palache of Harvard University and by Mr. Lovell of Paterson, and others were secured from the foreman of the quarry. Although these pseudomorphs show sharp prismatic angles there was less agreement among the measurements than had been expected. The average of 56 measurements gave $61\frac{1}{3}°$, but there were variations ranging from $57\frac{1}{2}$ to $66\frac{1}{2}°$, and the two extremities of the same pseudomorph frequently showed a marked difference.

The terminal faces of the specimens were small and much less well-defined than the prismatic faces, and the angles were not measured. They appear to indicate monoclinic or triclinic symmetry, but do not suggest the forms of babingtonite which are figured by Hintze and Dana. Differences in conditions of deposition, however, might cause much variation in this respect. Some indication of the former presence of a ferriferous mineral is afforded by the frequency with which these casts are stained red by ferric oxide or are partially occupied by a chloritic substance.

The conclusions which have been reached regarding the various forms of cavities from a study of the new material and a re-examination of all the available evidence may be summarized as follows: Both babingtonite and anhydrite were undoubtedly present in the deposits and the crystals of each attained a large size. In some instances the geometric form of the two was so similar that the nature of the original mineral cannot be decided from the casts alone. Babingtonite, however, seems to have shown a tendency to develop in a rather tabular shape, and cavities of this kind, especially when showing the projection of many thin laminae, are regarded as more probably due to the latter mineral. The rectangular cavities both of tabular and of nearly square form seem sufficiently explained by the discovery of these two minerals

The origin of the lozenge-shaped cavities is more uncertain. They may have been occupied by babingtonite deposited under different conditions from those which prevailed during the deposition of the rectangular forms and therefore developing different crystal-faces, or they may be due to some other mineral to whose nature we have little clue. It seems necessary to obtain more information before reaching a positive conclusion on this point.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOCHEMISTRY.—*Water analyses from the laboratory of the U. S. Geological Survey.* F. W. CLARKE. U. S. Geological Survey, Water-Supply Paper, 364. Pp. 40. 1914.

This paper is a compilation of 203 analyses of river, lake, spring, well and mine waters made by the chemists of the Geological Survey. Among them are included the important series of analyses of waters from the Yellowstone National Park, originally published in Bull. 47.

F. W. C.

GEOCHEMISTRY.—*Quality of the surface waters of Washington.* WALTON VAN WINKLE. U. S. Geological Survey Water-Supply Paper 339. Pp. 105. 1914. (Prepared in cooperation with the State Board of Health of Washington).

Serial analyses of water collected for a year at 17 stations on the principal rivers of Washington are reported and discussed in connection with geologic, climatic, and economic conditions. The streams are low in mineral content and excellent for general industrial use and irrigation, being comparable in quality to the extremely soft waters of New England. All the waters belong to the calcium carbonate types, the content of sulphate is not large, and chlorine is very low. The water of Columbia River was under study for two years at Cascade Locks, the lowest sampling point above tide-water. The stream ranges from 68 to 129 parts per million of dissolved solids and averages 94 parts with a hardness of 58 parts. It carries an average of only 26 parts per million of suspended matter; calculations show that it is denuding its drainage basin at a rate of 100 to 150 tons of rock material per square mile per annum.

R. B. DOLE.

GEOCHEMISTRY.—*Quality of the surface waters of Oregon.* WALTON VAN WINKLE. U. S. Geological Survey Water-Supply Paper 363. Pp. 1137 1914. (Prepared in cooperation with the state of Oregon, JOHN H. LEWIS, State Engineer.)

This document embodies the results of the first comprehensive study of the quality of the surface waters of Oregon and reports serial analyses of water from 20 stations on the principal rivers with a discussion of the analyses in relation to conditions of geology, climate, and economic development. The investigations of the composition of saline lake waters in southeastern Oregon indicate that the commercial recovery of soda salts from few of them is practicable. Most of the streams within the State drain regions of basalts and other effusives, and consequently carry relatively little mineral matter in solution.

R. B. DOLE.

GEOCHEMISTRY.—*The constitution of the natural silicates.* FRANK WIGGLESWORTH CLARKE. U. S. Geological Survey Bulletin No. 588. Pp. 128. 1914.

This bulletin is essentially a revision, brought down to date of bulletin No. 125. It gives a more complete discussion of the silicic acids, and develops more completely than in the former edition the conception that the complex alumosilicates are best formulated as substitution derivatives of normal silicates of aluminum. F. W. C.

BOTANY.—*A conspectus of North American firs, exclusive of Mexico.* W. H. LAMB. Proceedings of the Society of American Foresters, **9**. Pp. 528–538. October, 1914.

This is a dendrological monograph on North American species of *Abies*, exclusive of Mexico, designed especially for the information of forest officers.

In our native firs, generally regarded as difficult to distinguish, each specific form is here definitely separated from its nearest relative by some anatomical difference. Those characteristics which are so variant as to be valueless as a means of identification are discarded, and the form of the cone-bract, the arrangement of the leaves, the character of the upper surface of the leaves, and the position of the resin ducts in the leaf are considered as the determinative factors so far as our native firs are concerned.

The firs, as far as they can be distinguished from foliage alone, are outlined in a key based entirely upon leaf differences, and a complete key to North American species follows in which every distinguishing characteristic is illustrated in accompanying plate and text figures. A brief botanical description and statement of geographical distribution is given for each species. On account of the large number of trees which are mentioned in botanical literature under the name *Abies*, an index of nomenclature is included in which the name now used by the Forest Service is followed by its most commonly accepted English equivalent.

The paper is concluded with a brief bibliography. W. H. L.

ORNITHOLOGY.—*A monograph of the genus Chordeiles* Swainson, *type of a new family of goatsuckers.* HARRY C. OBERHOLSER. Bulletin of the United States National Museum, 86. Pp. viii + 123, pls. 1–6. 1914.

The genus Chordeiles is of South American origin, though at present occupying large areas in Central and North America. It has commonly been placed in the family Caprimulgidae, but its schizognathous palate and other characters, chiefly osteological, show that it should be separated as a new family, Chordeilidae. With it should be associated the genera Nannochordeiles and Nyctiprogne, also possibly Lurocalis and Podager. Incidentally, the monotypic genus Antrostomus (type, *Antrostomus carolinensis*) is, as shown by its cranial and other characters, very distinct from the Old World Caprimulgus, and also from the American whip-poor-wills, which latter should constitute a new genus Setochalcis (type, *Caprimulgus vociferus* Wilson).

The members of the genus Chordeiles are remarkable among other things for their great individual variation, amounting in some cases to distinct color phases, and to very considerable external structural differences. The genus comprises three specific groups—*Chordeiles virginianus*, *Chordeiles acutipennis*, and *Chordeiles rupestris*. The first mentioned is divisible into nine geographic races, i.e.: *C. v. virginianus*, from eastern and northwestern North America; *C. v. hesperis*, Pacific Coast and northwestern United States; *C. v. sennetti*, northern Great Plains; *C. v. howelli*, subsp. nov., central portion of western United States; *C. v. henryi*, Arizona and New Mexico; *C. v. aserriensis*, subsp. restit., southern Texas; *C. v. chapmani*, Florida and Gulf coast to eastern Texas; *C. v. vicinus*, Bahama Islands; and *C. v. minor*, Greater Antilles. Of *Chordeiles acutipennis* there are five subspecies: *C. a. acutipennis*, from central and northern South America; *C. a. exilis* (= *pruinosus* Auct.), coast of Peru and northern Chile; *C. a. micro-*

meris, subsp. nov., southern Mexico; *C. a. texensis*, central and northern Mexico and southwestern United States; and *C. a. inferior*, subsp. nov., Lower California. The South American *Chordeiles rupestris* has three forms: *C. r. rupestris*, from middle and northern Brazil and eastern Bolivia; *C. r. xyostictus*, subsp. nov., central Colombia; and *C. r. zaleucus*, subsp. nov., eastern and central Peru. H. C. O.

ZOOLOGY.—*Une étude philosophique de la relation entre les crinoïdes actuels et la température de leur habitat.* AUSTIN H. CLARK. Bulletin de l'Institut Océanographique, Monaco, No. 294. 1914.

Of the two suborders of recent unstalked crinoids (comatulids) one, Macrophreata, is chiefly developed in the colder waters while the other, Oligophreata, occurs chiefly in the warmer seas.

In the Macrophreata the maximum number of families is found between the temperatures of 50° and 66° Fahrenheit, from which point the number gradually decreases as the temperature becomes less, and abruptly decreases as the temperature increases; in the Oligophreata the maximum number of families is found between 60° and 65° Fahrenheit, from which point the number gradually decreases as the temperature increases, and abruptly decreases as the temperature becomes less.

Considering all the comatulid families together, the greatest representation is between 55° and 65°, with the emphasis as 60°–65°; the few families of stalked crinoids of which we have adequate knowledge also occur at these temperatures.

Thus it would appear that the temperature range between 55° and 65° Fahrenheit (12°.78 and 18°.33 Centigrade) represents the optimum temperature for the recent crinoids as a whole.

The species occurring between these temperatures represent very conservative types, all of the more aberrant types being developed in warmer or colder water. Furthermore, it is within these temperatures that the fossil crinoids find their closest living representatives. Hence it is suggested that it was possibly within these temperatures, between 55° and 65° Fahrenheit (12°.78 and 18°.33 Centigrade) that the post-palæozoic crinoid fauna was chiefly developed. A. H. C.

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