BULLETIN OF THE GEOLOGICAL SOCIETY OF AMERICA
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PROCEEDINGS OF THE TWENTIETH ANNUAL MEETING, HELD AT ALBUQUERQUE, NEW MEXICO, DECEMBER 30 AND 31, INCLUDING PROCEEDINGS OF THE NINTH ANNUAL MEETING OF THE CORDILLERAN SECTION, HELD AT THE SAME PLACE AND TIME.

EDMUND OTIS HOVEY, *Secretary.*

CONTENTS

Session of Monday, December 30

The Society was called to order by President Charles R. Van Hise at 9.15 o'clock a m, at the University of New Mexico. A cordial address of welcome was delivered by President W. G. Tight, of the University of New Mexico, to which response was made by President Van Hise.

The report of the Council was called for, and was presented by the Secretary, in print, as follows:

REPORT OF THE COUNCIL

To the Geological Society of America,
in Twentieth Annual Meeting assembled:

The regular annual meeting of the Council was held at New York in connection with the meeting of the Society. There have been no special meetings during the year.

The details of administration for the nineteenth year of the existence of the Society are given in the following reports of the officers:

Secretary's Report

To the Council of the Geological Society of America:

Meetings.—The proceedings of the annual meeting of the Society held at New York city December 27, 28, and 29, 1906, have been recorded in the closing brochure of volume 18 of the Bulletin, which is now in press.

Membership.—During the past year the Society has lost two Fellows by death: James M. Safford and Angelo Heilprin. The resignation of one Fellow has been accepted. The names of the fourteen Fellows elected at the New York meeting have been added to the list, all of them having completed their membership according to rule. The present enrollment of the Society is 294, or 11 more than at the time of making the last annual report. Four candidates are before the Society for election and several applications are under consideration by Council.

Distribution of Bulletin.—There have now been distributed 17 brochures comprising 448 pages of volume 18, and the remaining four brochures, including the Proceedings, are in the hands of the printers in various stages of completion. By action of the Publication Committee no manuscripts were accepted by the Secretary after November 1, in an effort to finish the volume within the calendar year. Partly through the slowness of authors in sending back proofs, the result has not been accomplished. Hereafter the rule which provides that "printing shall not be delayed by reason of absence or incapacity of authors more than one week beyond the time ordinarily required for the transmission of mails" (*vide* Bull., vol. 5, p. 649) should be enforced. Authors are urged also to send in their manuscripts earlier. The irregular distribution of the Bulletin during the past year has been as follows: Complete volumes, including one complete set, sold to Fellows, 28; sold to the public, 103; sent out to supply deficiencies, 2; brochures sent out to supply deficiencies, 57; sold to Fellows, 47; sold to the public, 37. A complete set of paleontologic and stratigraphic papers has been given to the Concilium Bibliographicum of Zürich. Three copies of volume 17 have been bound for the use of officers and the library, and one complete set has been bound for the Secretary's office. This set remains the property of the Society.

Bulletin Sales.—The receipts from the sale of the Bulletin during the past year are shown in the following table:

Bulletin Sales, December 1, 1906, to November 30, 1907

	Complete volumes.			Brochures.			Grand total.
	Fellows.	Public.	Total.	Fellows.	Public.	Total.	
Volume 1	$9.00	....	$9.00	$1.15	$0.40	$1.55	$10.55
Volume 2	9.00	....	9.00	....	1.00	1.00	10.00
Volume 3	8 00	....	8.00	....	.12	.12	8.12
Volume 4	7.00	....	7.00	.20	.30	.50	7.50
Volume 5	8.00	....	8.00	.25	.57	.82	8.82
Volume 6	8.00	....	8.00	.10	....	.10	8.10
Volume 7	8.00	....	8.00	....	.60	.60	8.60
Volume 8	8.00	....	8.00	....	.30	.30	8.30
Volume 9	8.00	....	8.00	1.25	.30	1.55	9.55
Volume 10	8.00	....	8.00	.55	.80	1.35	9.35
Volume 11	9.00	....	9.00	.55	2.20	2.75	11.75
Volume 12	4.00	....	4.00	.25	3.85	4.10	8.10
Volume 13	4.50	$5.00	9.50	....	1.44	1.44	10.94
Volume 14	4.50	....	4.50	....	4.60	4.60	9.10
Volume 15	4.50	5.00	9.50	1.55	2.40	3.95	13.45
Volume 16	4.50	25 00	29.50	1.70	1.35	3.05	32.55
Volume 17	4.50	145.00	149.50	.70	4.55	5.25	154.75
Volume 18	....	305.00	305.00	....	.25	.25	305.25
Volume 19	....	30 00	30.00	....	....	....	30.00
Total	$116.50	$515.00	$631.50	$8.25	$25.03	$33.28	$664.78
Index	2.25	4.75	7.00	....	....	....	7.00
	$118.75	$519.75	$638.50	$8.25	$25.03	$33.28	$671.78

Receipts for the fiscal year		$671.78
Previously reported		9,602.34
Total receipts to date		$10,274.12
Charged, but not yet received:		
On 1906 account		80.00
On 1907 account		35.40
Total sales to date		$10,389.52

The bills for volume 18 have not been sent out to volume subscribers yet, and the table given above includes only actual payments.

The cost of publishing the Bulletin, volumes 1-17, has been $33,414.91, the average cost per volume being $1,965.58. These figures, however, do not include the expense of distribution. The number of pages and illustrations in the volumes has increased so much during the past few years that the price of subscription for libraries and foreign individuals should be raised. The present price does not cover the actual cost of publication, and is about one-third less than the price charged by other societies for volumes corresponding with our Bulletin in number and size of pages and plates and in quality of paper and printing.

Expenses.—The following table gives the cost of administration and of Bulletin distribution during the past year. The expense of moving the Secretary's office from Rochester to New York has made the outgo for "Administration" unusually high.

EXPENDITURE OF SECRETARY'S OFFICE DURING THE FISCAL YEAR ENDING NOVEMBER 30, 1907

Account of Administration

Postage and telegrams	$37.73	
Expressage and freight	14.73	
Printing (including stationery)	240.38	
Addressograph links	1.34	
Binding 3 copies volume 17	3.00	
Office furniture and storage closet	136.63	
Meetings (expenses of Cordilleran Section)	16.31	
Total		$450.12

Account of Bulletin

Postage	$138.63	
Expressage and freight	80.40	
Paper and printing	11.15	
Addressograph links	.50	
Laborers	5.50	
Storage closet	51.45	
Binding set of Bulletin	28.60	
Collection of checks	4.75	
Total		$320.98
Total expenses for the year		$771.10

As soon as possible after the New York meeting the transfer to the custody of the present incumbent of the material pertaining to the Secretary's office was finished. The Society is to be congratulated upon the care and completeness with which all its records from the beginning have been preserved, and I wish here to express my personal appreciation of the help rendered me by Professor Fairchild in starting upon the somewhat arduous though very pleasant duties of the secretaryship.

Respectfully submitted.

EDMUND OTIS HOVEY,
Secretary.

NEW YORK, *December 18, 1907.*

TREASURER'S REPORT

To the Council of the Geological Society of America:

The Treasurer herewith submits his annual report for the year ending December 1, 1907:

Three (3) Fellows, J. A. Dresser, Ida H. Ogilvie, and George I. Adams, have commuted for life during the year by the payment of one hundred dollars each, thus increasing the total Life Commutations to seventy-nine (79) at the present time.

Two (2) Fellows are delinquent for four years and three (3) Fellows for three years, and are therefore liable to be dropped from the roll for the non-payment of dues, in accordance with section 3, chapter 1, of the By-laws; eleven (11) Fellows are delinquent for two years; while thirty-one (31) Fellows, on the date of the preparation of this report, are delinquent for the present year.

The membership of the Society, including delinquents, aggregates at the present time 294, of whom 79 have commuted for life. There have been 2 deaths and 1 resignation during the past year.

The Treasurer received from his predecessor on December 1, 1906, the following securities:

	Par value
Two (2) Texas and Pacific Railroad first mortgage five per cent bonds, cost $1,976.25	$2,000.00
Three (3) U. S. Steel Corporation second mortgage five per cent bonds, cost $2,366.25	3,000.00
Ten (10) shares of the capital stock of the Iowa Apartment House Company, Washington, D. C., cost $1,000.00	1,000.00
Forty (40) shares of the capital stock of the Ontario Apartment House Company, Washington, D. C., cost $4,000.00	4,000.00
Total cost, $9,342.50; total par value	$10,000.00

These securities have been placed in a safe-deposit box in the Baltimore Trust and Guarantee Company, Baltimore, Maryland, where the funds of the Society are also deposited, and where the unexpended monthly balance draws three per cent interest.

The general financial condition of the Society is exhibited by the following tabular statement showing the receipts and disbursements for the year ending December 1, 1907:

RECEIPTS

Balance in treasury December 1, 1906		$1,997.41	
Fellowship fees 1905 (3)	$30.00		
" " 1906 (21)	210.00		
" " 1907 (168)	1,680.00		
		1,920.00	
Initiation fees (14)		140.00	
Life commutations (3)		300.00	
Interest on investments:			
Iowa Apartment House company	$60.00		
Texas and Pacific railroad bonds	100.00		
Ontario Apartment House company	220.00		
U. S. Steel Corporation bonds	150.00		
Interest on deposits to January 30, 1907, Rochester Security Trust Company	11.45		
Interest on deposits to June 30, 1907, Baltimore Trust Company	27.94		
		569.39	
Sales of publications		671.78	
			$5,598.58

EXPENDITURES

Secretary's office:			
Administration	$493.57		
Bulletin	277.53		
Allowance	500.00		
		1,271.10	
Treasurer's office:			
Postage, express, etc.	$39.05		
Clerical hire	50.00		
		89.05	
Librarian's office		8.42	
Publication of Bulletin:			
Printing	$2,042.63		
Engraving	492.73		
Editor's allowance	250.00		
		2,785.36	
Miscellaneous		10.50	
		$4,164.43	
Balance on hand December 1, 1907		1,434.15	
			$5,598.58

Respectfully submitted.

WM. BULLOCK CLARK,
Treasurer.

DECEMBER 6, 1907.

Editor's Report

To the Council of the Geological Society of America:

Before submitting the usual statement as to the progress made in the publication of the annual volume, the Editor desires to call the attention of the Council to the desirability of appointing a committee to formulate, as nearly as may be practicable, the future usage of the Society in regard to capitalization, abbreviations, and similar matters. The committee should have authority to ascertain so far as possible the wishes of each member, in order to determine the preference of the majority. This may seem a trivial matter, but it is the cause of some irritation, which should be removed by some such method as that suggested. It is certainly but fair that the members should be given a chance to express their individual views. The report of the committee would practically fix the standards in a fashion satisfactory to the members generally, relieve the present Editor and his successors from some embarrassment, and be of value in many other ways. The report should include brief suggestions as to the form in which papers should be presented, in order to lighten the Editor's labors as much as possible. It has been the experience of the present Editor that the authors of papers do not intentionally add to the Editor's burdens. It is because they have had, unless connected with institutions like the Geological Survey, no experience as to the form in which manuscripts should be prepared. If suggestions such as those indicated were included in the report, and accompanied by appropriate illustrations, it is believed they would be appreciated by members.

By reason of the decision of the Publication Committee that papers not in hand prior to November 1 should be excluded, all of volume 18 is now in type, except the proceedings of the Cordilleran Section, the manuscript of which has not been received at this date. This year's experience indicates that if it is desired that the annual volume should be issued previous to the winter meeting, the time limit of submission of papers must be still further shortened.

	Average. Vols. 1–12.	Vol. 13.	Vol. 14.	Vol. 15.	Vol. 16.	Vol. 17.	Vol. 18.
	pp. 577. pls. 43.	pp. 583. pls. 58.	pp. 609. pls. 65.	pp. 636. pls. 59.	pp. 636. pls. 94.	pp. 785. pls. 84.	pp. 717. pls. 74.
Letter-press	$1,575 14	$1,647 12	$1,657 50	$1,661 21	$1,817 03	$2,087 98	$2,015 68
Illustrations	327 62	477 27	431 21	457 76	706 97	608 68	486 22
	$1,902 66	$2,124 39	$2,088 71	$2,118 97	$2,524 00	$2,696 66	$2,501 90
Average per page	$3 30	$3 64	$3 43	$3 33	$3 96	$3 37	$3 42

Classification.

Volume.	Areal geology.	Physical geology.	Glacial geology.	Physiographic geology.	Petrographic geology.	Stratigraphic geology.	Paleontologic geology.	Economic geology.	Official matter.	Memorials.	Unclassified.	Total.
	Number of pages.											
1.......	116	137	92	18	83	44	47	.....	60	4	4	593+xii
2.......	56	110	60	111	52	168	47	9	55	1	7	662+xiv
3.......	56	41	44	41	32	158	104	.....	61	15	1	541+xii
4.......	25	134	38	74	52	52	14	.....	47	32	2	458+xii
5.......	138	135	70	54	28	51	107	.....	71	14	9	665+xii
6.......	50	111	75	39	71	99	1	.....	63	25	4	538+x
7.......	38	77	105	53	40	21	123	4	66	28	13	558+x
8.......	34	50	98	5	43	67	58	14	79	8	....	446+x
9.......	2	102	138	.....	44	28	64	16	64	12	....	460+x
10.......	35	33	96	37	59	62	68	28	84	27	17	534+xii
11.......	65	110	21	10	54	31	188	7	71	60	46	651+xii
12.......	199	39	55	53	24	98	5	5	70	2	....	538+xii
13.......	125	17	13	24	28	116	42	4	165	32	29	583+xii
14.......	48	47	48	59	183	118	22	1	80	14	1	609+xii
15.......	26	124	3	94	36	267	.....	.....	77	17	3	636+x
16.......	64	111	78	30	102	141	19	.....	67	22	15	636+xii
17.......	49	161	41	84	47	294	27	.....	71	9	2	785+xiv
18.......	16	164	141	5	29	246	5	.....	68	40	3	717+xii

It is not practicable, for the reasons indicated above, to give the exact number of pages, but there will probably be about 700. The volume will be illustrated with 67 half-tone plates and 62 text figures.

Respectfully submitted.

JOSEPH STANLEY-BROWN,
Editor.

COLD SPRING HARBOR, N. Y., *December 16, 1907.*

LIBRARIAN'S REPORT

To the Council of the Geological Society of America:

The accessions to the Library during the past year have been listed and acknowledged, and the list of these accessions for the year ending October 1 has been forwarded to the Secretary for incorporation in volume 18 of the Bulletin. The binding of complete volumes of exchanges is steadily cared for by the Case Library.

The most notable addition to the library during the year past has been the nearly complete set of the Verhandlungen des Verein der Preussischen Rheinlände, some 60 volumes, sent in exchange for a complete set of our Bulletin.

The expenses of this office for the past year are as follows:

To clerk hire	$6.00
To express	1.00
To postage	1.42
	$8.42

Respectfully submitted.

H. P. CUSHING,
Librarian.

CLEVELAND, OHIO, *December 2, 1907.*

On motion of the Secretary, it was voted to defer the consideration of the Council report to the following day.

As the Auditing Committee to examine and report upon the accounts of the Treasurer, the Society elected G. K. Gilbert, C. W. Hayes, and A. H. Purdue.

ELECTION OF OFFICERS

President Van Hise then announced the result of balloting for officers for 1908, as canvassed by the Council, and declared the following officers elected:

President:

SAMUEL CALVIN, Iowa City, Iowa.

First Vice-President:

GEORGE F. BECKER, Washington, D. C.

Second Vice-President:

A. C. LAWSON, Berkeley, California.

Secretary:

EDMUND OTIS HOVEY, New York city.

Treasurer:

WILLIAM BULLOCK CLARK, Baltimore, Md.

Editor:

JOSEPH STANLEY-BROWN, Cold Spring Harbor, N. Y.

Librarian:

H. P. CUSHING, Cleveland, Ohio.

Councilors:

H. P. CUSHING, Cleveland, Ohio.
H. B. PATTON, Golden, Colorado.

ELECTION OF FELLOWS

The Secretary stated that the candidates for fellowship had been elected by the transmitted ballots, with but few dissenting votes. The list is as follows:

CLARENCE EDWARD DUTTON, A. B. (Yale, '60), Major, U. S. A. (retired), Englewood, New Jersey.

D. P. PENHALLOW, B. S., M. S., Sc. D., Botanical Laboratories, McGill University, Montreal, Canada. Professor of Botany, McGill University.

PERCY EDWARD RAYMOND, B. A., Ph. D., Pittsburgh, Pennsylvania. Assistant Curator of Invertebrate Fossils, Carnegie Museum.

THOMAS EDMUND SAVAGE, A. B., B. S., M. S., University of Illinois, Urbana, Illinois.

NECROLOGY

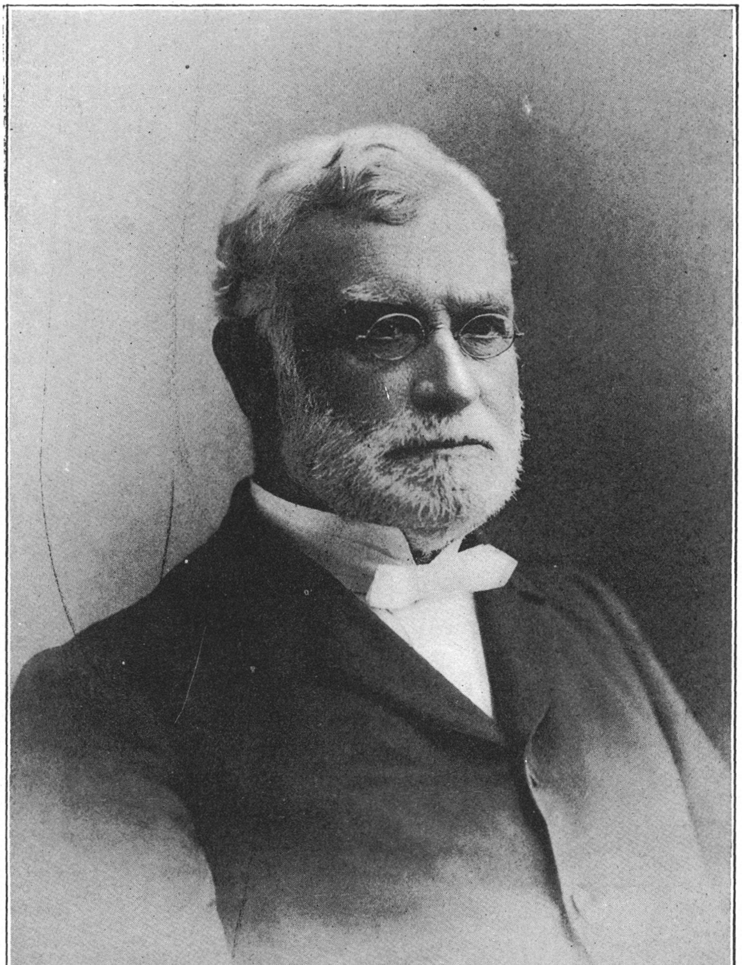
On call of the President, memorials of the Fellows who had died since the New York meeting were read as follows:

MEMOIR OF JAMES MERRILL SAFFORD

BY J. J. STEVENSON

James Merrill Safford, Ph. D., M. D., was born in Zanesville, Ohio, August 13, 1822, and died in Dallas, Texas, July 3, 1907. He was descended from sturdy New England ancestry, Thomas Safford having come from England to Massachusetts in 1630. The family was important in colonial times, and in later days counted among its members many prominent physicians. His father moved to Zanesville shortly before the birth of Professor Safford. He received his preparatory training in Zanesville and afterwards attended the Ohio University at Athens, where he was graduated in 1844. He spent two years in study at Yale, and soon after his return he was called to Cumberland University, at Lebanon, Tennessee, as professor of chemistry and natural history, where he remained until 1873, when he was chosen professor of chemistry in the medical school of the University of Nashville. Vanderbilt University was opened in 1875, and the chair of geology and natural history was assigned to him; he remained in full discharge of the duties until 1900. During much of this time he delivered the chemical lectures in the medical department, and for several years he was dean of the college of pharmacy. He was member of the State Board of Health from 1866 to 1896, and during the greater part of that period was vice-president of the board.

Professor Safford's geological work began in 1850, and his first recorded paper was published in 1851, when most of the Fellows of this



Jas M Safford

Society were not yet born. He received appointment as State Geologist of Tennessee in 1854. His first report, 164 pages, with preliminary map, was published in 1856, and was mainly a reconnaissance study of the mineral resources, but the final chapter gives a geological sketch exhibiting the formations recognized in the state. A "Biennial Report," published in 1857, was merely a brief statement of results. In 1860 the legislature ordered the preparation and publication of a final report, but the civil war followed quickly, and for a time survey work was at an end. In 1868 the state found itself in condition to reauthorize the publication. The report was completed, and it was published in 1869 as the "Geology of Tennessee," 550 pages, with map and 7 plates.

It is difficult for geologists of our day to do full justice to a work like this "Geology of Tennessee," the outcome of field studies made fifty years ago. There were no maps, for much of the state was still wilderness; mines were few; the roads were on natural grades; there was no network of railroads to give sections in critical places. Professor Safford had no instruments except a compass and a pocket level, and the appropriation was so small that he was without means to procure those aids without which a modern geologist would think himself almost helpless. Over much of the area he could not ride, and a great part of the 11,000 miles traveled during prosecution of the work was done on foot; he was compelled to live off the country and to endure the more than inconveniences inseparable from lodging in the uncomfortable houses of mountaineers. Yet in this modest volume he gave a conspectus of Tennessee geology which has borne the most exacting review. It is the outcome of twenty years of labor, carried on mostly at his own expense.

In this volume the succession of the earlier Paleozoic formations is presented in detail and numerous subdivisions are suggested, most of which have been accepted by geologists, and they bear the names given by him. Later studies in more northerly areas have led to some modifications of his grouping, but these are based on careful investigation of fossils such as was unknown in his day. The Black shale underlying the Carboniferous was recognized as Devonian, and he noted the absence of some formations which are prominent farther north in the Appalachian basin. The description of the Carboniferous is brief, counted in pages, but the sections are in such detail and are discussed so clearly that the relations of the beds are set forth sharply in all except the extreme northeast portion of the Cumberland plateau, to which he had been able to devote little attention; yet even there he had succeeded in securing a type section. He differentiated the Tertiary and Quaternary subdivisions and described and figured fourteen new species of fossils. An admirable summary of the state's economic resources closes the volume. For compactness and clearness, this work is not excelled, perhaps not equaled, by any other official report published in this country.

The office of State Geologist was restored in 1871, and Professor Safford received the appointment to the position, as well as to that of Chemist to the Board of Agriculture. No reports as State Geologist are credited to him, though he held the post until 1899; but he was coeditor of the "Introduction to the Resources of Tennessee," a stout volume of 1193 pages, published in 1874. This contains a geological sketch of each county, adding much important material to that contained in his earlier volume. He was coeditor also of a text-book on the geology of his state, intended for use in the schools, and he published many brief articles bearing on geological questions of local interest. In 1884 he contributed to the census reports a careful discussion of the physico-geography and agricultural features of Kentucky and Tennessee, and in 1888 he published a new edition of his map of the state. In 1891 he published a discussion of the geology of the state in relation to water supply, and in the same year he contributed two papers to the Bulletin of this Society.

It was a misfortune for Professor Safford and his fellow-geologists that during most of his life he was, so to say, isolated. He attended meetings of the Association and of this Society when they were within his reach, and he always contributed much of value to the discussions; but he was known in the flesh to comparatively few of his fellow-workers, so that he labored under the disadvantage of being known only by his writings, most of which belong to a period of which some are apt to think, if not to speak, disrespectfully. He was a man among men, everywhere commanding respect by his common sense, his integrity, and his manly recognition of others. The excellence and importance of his geological work became fully known to most of us only during the last decade, but throughout his life his worth was recognized by Tennessee, in which for more than forty years he was one of the foremost citizens.

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1853. Note on tooth of *Petalodus ohioensis*. *American Journal of Science*, second series, vol. 16, p. 142.

On the parallelism of the Lower Silurian groups of middle Tennessee with those of New York. *Proceedings of the American Association for the Advancement of Science*, vol. 7, pp. 153-156. *Annals of Science*, vol. 1, pp. 249-251.

1856. Remarks on the genus Tetradium, with notices on the species found in middle Tennessee. *American Journal of Science*, second series, vol. xxii, pp. 236-238.

A geological reconnaissance of the state of Tennessee; the author's first biennial report; 164 pages, with map. Nashville, 1856.

1857. Second biennial report [on the geology of Tennessee]. 11 pages, 8°. Nashville, 1857.

1858. On Tennessee geological history. *American Journal of Science*, second series, vol. 26, pp. 128-129.

1859. [Third biennial] Report of the state geologist. 8 pages, 8°. [Nashville, 1859.]

On some points in American geological history. *American Journal of Science*, second series, vol. 27, pp. 140-141.

1860. On the species of Calceola found in Tennessee: *Calceola americana*. *American Journal of Science*, second series, vol. xxix, pp. 248, 249.

1861. The Upper Silurian beds of western Tennessee, and Dr F. Roemer's monograph. *American Journal of Science*, second series, vol. xxxi, pp. 205-209.

1864. On the Cretaceous and superior formations of western Tennessee. *American Journal of Science*, second series, vol. xxxvii, pp. 360-372.

1866. [Report on the] Jackson Mining and Petroleum Company, pages 11 to 16 of the prospectus. 16 pages, 8°. Nashville, 1866.

Note on the geological position of petroleum reservoirs in southern Kentucky and in Tennessee. *American Journal of Science*, second series, vol. xlii, pp. 104-107.

Geological report on the Alabama lands of the Georgia Petroleum Company. 15 pages, 8°. Nashville, 1866.

1869. Geology of Tennessee, vol. xii, 550 pages, 8 plates, map, 8°. Nashville, 1869.

1874. Introduction to the resources of Tennessee, by J. B. Killebrew, assisted by J. M. Safford. With geological map, 1193 and xi pages. Nashville, 1874. Contains geological descriptions of all counties by J. M. Safford, who also prepared the map.

1876. The elementary geology of Tennessee. James M. Safford and J. B. Killebrew. 255 pages, 8°. Nashville, 1876.

1877. The topography and geology of Nashville. In report of the Board of Health of the city of Nashville for 1877, pp. 145-170.

1878. Enumeration of the geological and mineralogical collections at the International (Centennial) Exhibition, 1876. Philadelphia. Reports and Awards, group 1, pp. 353-386. Philadelphia, 1878.

1879. Geological formations of Tennessee. *Macfarlane's American Geological Railway Guide*, pp. 196-199; also same in second edition, 1890, pp. 401-405.

1880. Regions in west Tennessee of sulphur waters and chalybeate waters respectively; the lines of division between the two regions; the origin of iron ore. State Board of Health [of Tennessee] Bulletin, vol. 4, 1880, pp. 210-212.

1884. Physico-geographical and agricultural features of the states of Tennessee (and Kentucky). *Tenth Census of the United States*, vol. 5. Report on cotton production in the United States, part 1, pp. 381-464. Washington, 1884.

The natural features and resources of the South. Remarks before the Southern Immigration Association. Proceedings of session held in Nashville, March 11-13, 1884, pp. 16-25. Nashville, Tennessee, 1884.

1885. Geological and topographical features of Tennessee in relation to disease. First Report of the Tennessee State Board of Health, pp. 237-315. Nashville, 1880. Second Report, pp. 365-385. Nashville, 1885.

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1886. Report on the lands of the Union Manufacturing Company, situated in Warren and Simpson counties, Kentucky. Louisville, Kentucky, 1886. 8 pages, 1 plate, 8°.

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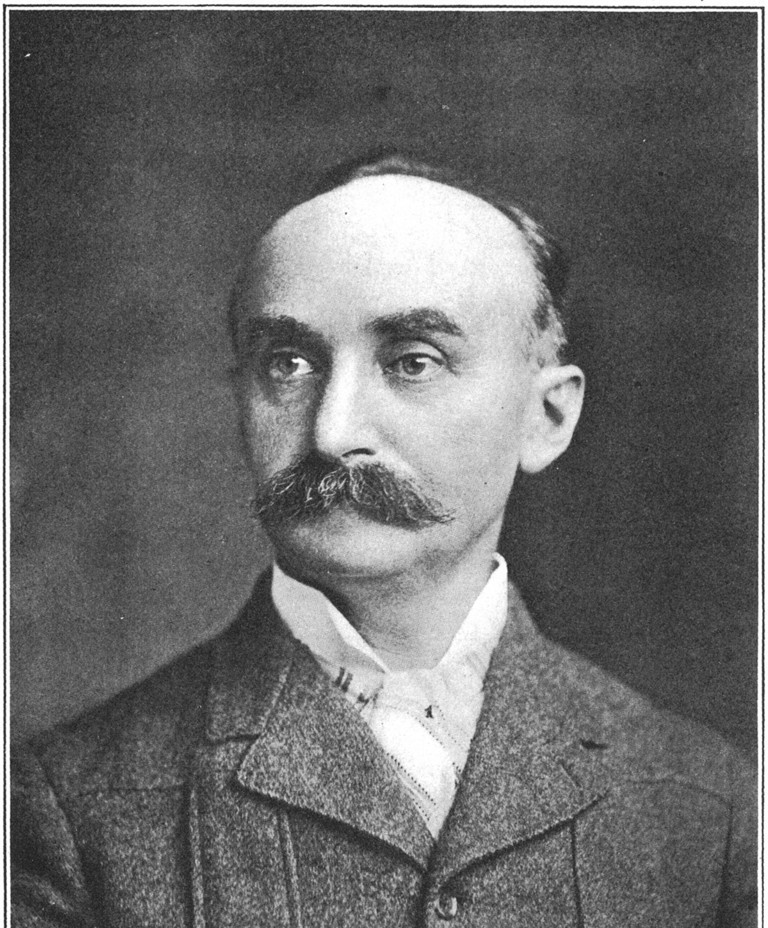

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MEMOIR OF ANGELO HEILPRIN

BY HERBERT E. GREGORY

With the death of Angelo Heilprin this Society has lost one of its prominent members, Yale University one of its ablest instructors, and geography its best known leader in America. While his work was largely geographic, his contributions to geology were many and important.

A glance at the life of Heilprin reveals an interesting career, in which inherited aptitude, increased by constancy of effort, ripened into power of an unusual sort. His grandfather, Phineas Mendel Heilprin (1801-1863), was a prominent student of Hebrew and philosophy, and his father, Michael Heilprin (1823-1888), likewise was a scholar of wide repute. Owing to persecution in Poland, Angelo Heilprin's parents escaped in 1842 and settled in Hungary, where Angelo was born, March 31, 1853. During the war for Hungarian freedom (1848-1849) the elder Heilprin was an associate of Kossuth, and, as a result of his activities in the revolution, was forced to flee, coming to America in 1856, where he later pursued a literary career.

Angelo Heilprin's early education was in the public schools of Brooklyn, but the most valuable instruction was undoubtedly that received in the home, where, with his father and brother Louis, he was constantly in an atmosphere of refinement and intellectual power. His taste for exploration and scientific study developed early. Throughout his boyhood he cared little for the ordinary light literature, but confined his reading pretty largely to stories of travel, and while yet a boy undertook tramps of considerable length in search of adventure. He early began to draw in color, and it is related that at the age of six he made a map of Greenland which was of unusual accuracy, and when this was shown to him later in life he expressed his doubt that it could be the work of a schoolboy. In the home circle he was constantly encouraged to read and to express himself in writing, as a result of which he was able when only in his twentieth year to be of much help in the preparation of articles for the American Cyclopædia, his sketch of John Tyndall in particular being a very creditable piece of work. In 1876, at the age of twenty-four, he decided to study with the famous masters of the day, and enrolled himself as a pupil in the Royal School of Mines, under the tutelage of Huxley in biology, Etheridge in paleontology, and Judd in geology. Later he studied in Paris, and in Geneva with Carl Vogt. Other European centers of culture were visited, and in each place Heilprin made the most of his opportunities, adding to his store of knowledge and developing his methods of research and instruction.

After three years of European study, Heilprin returned to America and began his connection with the Philadelphia Academy of Natural Sciences, being elected professor of invertebrate paleontology in 1880, curator in charge in 1883, and professor of geology in 1895, holding the last position till 1899. He was also associated with the Wagner Free Institute of Science, of which he became the curator. His connection with these organizations, together with writing and lecturing, constituted the chief routine of his life until 1904, when he came to Yale University as lecturer in physical geography, a position which he occupied at the time of his death.

The geographic activity of Heilprin includes exploration, investigation, and educational work. As an explorer he turned his attention to widely separated parts of the world. His first important expedition, in

1886, was to the Everglades of Florida, as the result of which he showed that the larger part of the peninsula was of Tertiary age and had not been built by recent coral activity; the existence of marine Pliocene deposits in the United States was also made known for the first time. As stated by Doctor Leidy, "The well observed facts of the report must greatly modify the opinions which have generally been held in regard to the geological construction of the peninsula of Florida."

In 1889-1890 he made his first expedition to Mexico, where a study was made of Yucatan and of the Mexican plateau, particularly with reference to the volcanoes and enormous deposits of lavas. In that year he climbed Orizaba, Popocatepetl, Nevada de Toluca, and Ixtaccihuatl, determining their heights and showing Orizaba to be the loftiest mountain at that time known in North America.

The Peary Relief Expedition of 1892 was one of the most important undertakings of Heilprin. The success of this expedition could only have been brought about by skill and bravery of the highest type, both of which qualities the leader of the expedition possessed. His book descriptive of this expedition, namely, "The Arctic Problem," is one of the most fascinating narratives in geographic literature. It is so modestly written that the reader hardly grasps the importance of the work and fails to realize that the meeting of Heilprin and Peary on the ice-cap was one of the most dramatic scenes in the history of exploration. Peary has expressed his appreciation in the following words: "My own obligations to and regard for him are particularly great. To him more than to any one else is due the activity of this country in arctic and antarctic work during the past fifteen years."

In 1896 Heilprin made an expedition into Morocco, Algeria, and Tunis. With great skill he made his way among the semi-civilized tribes in pursuit of data which led to the conclusion that the mountains of Morocco and Algeria had not been glaciated during Pleistocene times.

The year 1898 was spent on an excursion to Alaska, an account of which is given in his volume, "Alaska and the Klondike," which is full of interesting material, much of it of economic value.

In 1902, when the news of the destruction of Saint Pierre was received, Heilprin, with characteristic activity and decision, took the first steamer for Martinique, and on March 20 of that year ascended Pelée while it was still in a violent state of eruption. On this day and the days following he was in constant danger, and really took his life in his hands for the sake of studying at first hand the process of volcanic eruption. One is reminded of those earlier scientists, Empedocles at Etna, 430 B. C., and Pliny at Vesuvius, 79 A. D., both of whom paid for their scientific zeal with their lives. Fortunately Heilprin was spared, and lived to write his valuable papers dealing with the phenomena of this extraordinary expression of vulcanism.

Heilprin's excursion to British Guiana, in 1906, was designed as the first of a series of expeditions which were to be made into tropical regions. This expedition was, however, destined to be his last, for the fever contracted at this time was never fully checked, and was one of the chief causes which led to his death, on July 17, 1907.

As an educator, Professor Heilprin's influence was widespread. He was one of the first to recognize the value of photographic reproduction in the teaching of the earth sciences, and in this respect his "Principles of Geology" has set the pattern for later successful works. The great skill with which he was able to present important geological principles by the use of the most common objects is well shown in his "Town geology: the lesson of the Philadelphia rocks." Heilprin may well be called the natural teacher. His manner of presentation was very effective, and whether with the class in the field or conducting recitations, giving lectures before teachers, or public addresses, the expounder of science as well as the explorer and investigator was evident. In the experience of the writer, no teacher of geography has been more effective with classes than has Heilprin. Students readily recognized him as a master—learned and cultured, and at the same time modest, sympathetic, and democratic. As a teacher at Yale he never attempted to control his classes or to secure good work by any of the devices of pedagogues, but trusted to the value of the subject and to his method of presentation to arouse interest in the student.

Heilprin was a firm adherent to the doctrine that a knowledge of the earth and its inhabitants is an essential part of a general education having high cultural value. To him, therefore, a wide dissemination of the results of geographical study was of the first importance, and small groups of geographers devoting their attention to highly technical matters were of relatively minor importance. When the Association of American Geographers was formed—an association designed to separate the professional geographers from those merely interested in geography—Heilprin's objection was characteristic; he thought that such an association might tend to limit the distribution of geographical information.

Likewise a museum to him was a place for teaching the truths of nature, not a place for storing and protecting specimens, and his successful effort to open the museum in Philadelphia on Sundays has been imitated with advantage by other institutions.

His influence as an educator was also exerted through societies and periodicals. It is largely due to his influence that the Geographical Society of Philadelphia has become such a prominent educational factor. He was one of the founders of the Alpine Club of America. In 1893 he established the magazine "Around the World," the forerunner of the National Geographic Magazine, of which latter periodical he was one of the editors. At the time of his death he was an active member of a number of organizations and was president of the Association of American Geographers.

Professor Heilprin's versatility was one of his most marked characteristics. A scientist of the first rank, still he was widely read in literature and history. He was master of arts, too—not ordinarily associated with scientific men. Those who have had the pleasure of listening to Heilprin at the piano, as he was interpreting Hungarian folk songs, dances, or patriotic hymns, will agree that his musical ability was extraordinary. He began early to show traits of an artist. When but eleven years of age he obtained permission to copy the paintings in the capitol at Washington, and while still a young man his paintings were on exhibition in the principal cities of eastern United States. His last painting of the Pelée tower ranks among the best productions of landscape artists. They show technique which is of high order and a mastery of drawing and of color. As has been said by a well known critic, his art is "the art of a painter, not the art of a scientist." He also possessed mechanical genius, which led to the invention of several devices for which patents were secured.

As a man, Heilprin was characterized by energy, concentration, and continuous application—qualities which bring success. His modest and quiet bearing was marked, and in his associations with his fellow-men he never assumed an egotistical attitude. He preferred to be considered one of an army of fellow-workers presenting the beauties of nature to the human mind. He had a genuine zeal for scientific truths, and a foresight which led him to devote his energies to important lines of work. The writer recalls with pleasure little talks with his friend on geography, education, university ideals, and kindred topics, all of which were inspiring and in all of which Heilprin revealed himself as a modest, open-minded, yet energetic searcher after truth.

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After the reading of the memorials of the deceased Fellows the regular program of papers was taken up as follows:

OCCURRENCE OF PROUSTITE AND ARGENTITE AT THE CALIFORNIA MINE NEAR MONTEZUMA, COLORADO

BY FRANK R. VAN HORN

This paper has been published as pages 93-98 of this volume. Discussion by C. R. Van Hise, George D. Louderback, and H. E. Gregory.

MINE WATERS AND THEIR FIELD ASSAY

BY ALFRED C. LANE

This paper has been published as pages 501-512 of this volume.

The following papers were read by title:

PHOSPHATE DEPOSITS OF FLORIDA WITH RELATION TO THE UNDERGROUND WATER LEVEL

BY E. H. SELLARDS

ASBESTOS DEPOSITS OF THE GRAND CANYON, ARIZONA

BY JOSEPH HYDE PRATT

ANCIENT TECTONICS OF THE BASIN RANGES

BY CHARLES R. KEYES

ROCK-FLOOR OF INTERMONT PLAINS OF THE ARID REGION

BY CHARLES R. KEYES

Published as pages 63-92 of this volume.

The next paper read was

GLACIAL PERIODS AND THEIR BEARING ON GEOLOGICAL THEORIES

BY A. P. COLEMAN

This paper has been published as pages 347-366 of this volume. An active discussion was participated in by W. G. Tight, A. C. Lawson, I. C. White, H. M. Ami, G. K. Gilbert, H. E. Gregory, and C. R. Van Hise.

CHIEF FEATURES OF THE STRATIGRAPHY AND STRUCTURE OF MOUNT DIABLO, CALIFORNIA

BY GEORGE D. LOUDERBACK

[*Abstract*]

Mount Diablo is a distinctive feature of the central coast ranges, because it rises from low valleys on practically all sides, and is not merely a more promi-

nent peak of a continuous range. It shows a remarkably complete stratigraphic series of the characteristic Coast Range formations. Structurally it is an overturned and overthrust anticline of very late origin. There is also evidence of an earlier structural form. The geology of mount Diablo may be taken as showing a stratigraphic succession and an orogenic history characteristic of the coast ranges from the Klamath mountains to the Tehachapi.

Discussion by A. C. Lane, A. C. Lawson, and H. P. Cushing.

The following papers were then read by title:

THE EARTHQUAKE IN OWENS VALLEY, CALIFORNIA, IN 1872

BY WILLIAM HERBERT HOBBS

BEGINNING AND RECESSION OF SAINT ANTHONY FALLS

BY FREDERICK W. SARDESON

This paper was printed as pages 29-52 of this volume.

THE "NEBRASKA LOESS MAN"

BY B. SHIMEK

This paper was printed as pages 243-254 of this volume.

DISTRIBUTION OF DRUMLINS AND ITS BEARING ON THEIR ORIGIN

BY FRANK B. TAYLOR

CIRQUES AND ROCK-CUT TERRACES OF MOUNT TOBEY, MASSACHUSETTS

BY B. K. EMERSON

The next paper was

LOWER PORTION OF THE PALEOZOIC SECTION IN NORTHWESTERN NEW YORK

BY H. P. CUSHING

This paper was published as pages 155-176 of this volume. The paper was discussed by H. M. Ami.

At 12.15 o'clock the Society adjourned for luncheon in the dining-room of the university, after which President Tight led the way to the flat roof of one of the pueblo style dormitories, from which he pointed out the geological features of the surrounding country.

At 2 o'clock the afternoon session began with the reading of the annual address by the retiring President, President Charles R. Van Hise, of the University of Wisconsin, who chose as his subject "The problem of the pre-Cambrian." By request of the President, his address was thrown open to discussion, and remarks were made by A. C. Lane, A. C.

Lawson, A. P. Coleman, H. M. Ami, and C. R. Van Hise. This address was published as pages 1-28 of this volume.

The following papers were then read by title:

RED SANDSTONE FORMATION OF SOUTHEASTERN MINNESOTA

BY C. W. HALL

GEOLOGICAL HISTORY OF THE REDSTONE QUARTZITE

BY FREDERICK W. SARDESON

Published as pages 221-242 of this volume.

PALEOZOIC AND MESOZOIC OF CENTRAL WYOMING

BY N. H. DARTON

Published as pages 403-474 of this volume.

SOME FEATURES OF THE GEOLOGY OF ARIZONA AND WESTERN NEW MEXICO ALONG THE SANTA FE RAILROAD

BY N. H. DARTON

After this the Society listened to the reading of a paper on

GRENVILLE-HASTINGS UNCONFORMITY

BY WILLET G. MILLER AND CYRIL W. KNIGHT

[*Abstract*]

The crystalline limestone and associated pre-Cambrian sedimentary rocks of southeastern Ontario and the adjacent parts of the province of Quebec, to which Logan and his colleagues long ago gave the names of Grenville and Hastings series, have never been satisfactorily classified as regards their age. Recent work by the present writers has shown that much at least of what has been called the Hastings series, consisting of limestones, conglomerates, and other fragmental rocks, is much younger than, and forms a well defined unconformable series with, the typical crystalline limestones and associated fragmental rocks of what has been called the Grenville series proper. The view that the Grenville and Hastings constitute one series, the former being a more highly altered phase of the latter, is no longer tenable.

The writers find the Keewatin series of the Lake Superior region represented in southeastern Ontario by ancient rocks of like character. The Grenville limestones have been deposited on the surface of the Keewatin. The writers class the Grenville limestone as regards age with the Keewatin iron formation of lake Superior, which it has not been found possible in that region to separate from the greenstones. The pre-Cambrian conglomerate and associated sedimentary rocks overlying, uncomformably, the Grenville limestone are classed as Huronian. The conglomerate contains not only ordinary fragments of the Grenville limestone, but "eozoon"-like boulders as well, thus showing that the limestone is much older than the conglomerate. Moreover, the "pebbles of

cherty and ferruginous rocks resembling those found in the iron ranges of lake Superior" in the conglomerate of eastern Ontario are found by the writers to have been derived from layers or bands of this material in the Grenville limestone.

The paper was read by Mr. Miller and the discussion was participated in by A. P. Coleman, H. P. Cushing, C. R. Van Hise, A. C. Lane, and W. G. Miller.

The next paper was

RELATION OF THE EQUUS BEDS OF KANSAS TO REVERSED MISSISSIPPI DRAINAGE

BY W. G. TIGHT

The paper was discussed by A. P. Coleman, H. E. Gregory, A. C. Lane, and F. W. Cragin.

The following two papers were read without intermission by Dr. A. C. Lane:

NEW UPPER SILURIC FAUNA FROM SOUTHERN MICHIGAN[1]

BY W. H. SHERZER AND A. W. GRABAU

Contents

INTRODUCTORY

This fauna raises the question whether the beds from the Sylvania to the Dundee should be regarded as Silurian with precisive Devonic forms or "colonies," or whether the Sylvania should be regarded as Oriskany, and the

[1] By permission of the state geologist of Michigan.

physical conditions and fauna of the Siluric may be supposed to have lingered in Michigan longer than elsewhere.

In regard to this question entire agreement has not been reached, and there is a chance for light from new facts, but as the problem has direct bearing on certain knotty questions in New York, Canada, and Ohio, it seems well to give the ascertained paleontologic facts to help others (Lane).

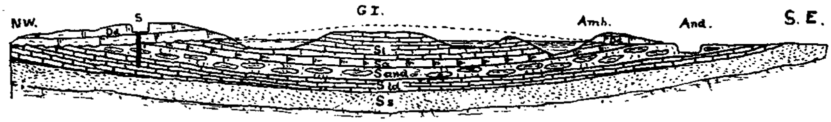

FIGURE 1.—*Section across the Detroit River*

S. Sibley quarry and bore-hole.
G. I. Grosse Isle.
Amh. Amherstburg channel.
And. Anderdon quarry.
Dd. Devonic—Dundee limestone.
Sl. Siluric—Lucas dolomite.
Sa. Siluric—Amherstburg dolomite.
Sand. Siluric—Anderdon coral limestone.
Sld. Siluric—Flat Rock dolomite.
Ss. Siluric—Sylvania sandstone.

MONROE FORMATION

SALT SHAFT EXPOSURE AND SECTION

In December, 1906, the salt shaft of the Detroit Salt Mining and Manufacturing Company penetrated a remarkable coral reef with a coral fauna of Devonic affinities deeply embedded in the Upper Siluric strata of Michigan—the Monroe formation. The existence of this reef had been suspected from the chips of the various wells drilled in this region,[2] while many years ago T. Sterry Hunt reported a similar coral horizon at a depth in the Upper Siluric beds of Goderich, Canada. Hall identified[3] the fragments obtained from the Goderich wells with corals known otherwise only from the Onondaga limestone.

The section of the salt shaft is as follows, in descending order:

(Elevation of mouth of shaft, 575 feet above tide.)	Feet	Feet
Drift	83	83
Dundee limestone, mostly a very pure calcarenite, rich in fossils, representing the lower Middle Devonic	63	146
DISCONFORMITY:[4]		
"Lucas" dolomite, a hard, very porous dolomite of a lutaceous texture, and full of cavities left by dissolved gastropods and other fossils	189	335
Intercalated limestone (*Anderdon limestone*), containing the coral fauna. The rock is a pure calcarenite (lime sand rock), in which the corals are embedded	38	373
Flat Rock dolomite, similar to the upper dolomite, but more compact, and with few fossils	47	420
DISCONFORMITY:		
Sylvania sandstone, a pure silicarenite or quartz sand rock	117	537

[2] Michigan Geological Survey, vol. v, pt. ii, pp. 27, 28, and plates of Monroe, Mount Clemens, Port Lambton, Port Huron, etc.

[3] Transactions of the American Institute of Mining Engineers, vol. v, p. 538; also Geol. Surv. of Canada, Report of Progress, 1876-7, pp. 221-243.

[4] *The hiatus* supposed to be marked by disconformity was not very apparent in the upper shaft (Lane).

	Feet	Feet
DISCONFORMITY :		
Lower Monroe dolomites to salt, as shown by preliminary well records	334	871

ANDERDON EXPOSURE

The only exposure of the intercalated coral limestone is found on the opposite side of the river in the Anderdon quarry, in Anderdon township, Essex county, Ontario, about 2 miles east of Amherstburg and 15 miles south of Detroit.[5] It is from this locality that the formation takes its name. In the quarry about 30 feet of Dundee is shown, and immediately below it lies the Anderdon, of which about 30 feet are exposed by the quarrying operations. The contact between the Dundee and Anderdon is clearly a disconformable one, as shown not only by the absence of the 189-foot Flat Rock dolomite, which in the salt shaft at Detroit intervenes between the Dundee and Anderdon, but also by pronounced erosion features on the Anderdon. The top of this bed, where freshly uncovered by the removal of the Dundee, shows sections of large gastropod and cephalopod shells (Trochonema and Trochoceras), which were partly worn away before the Dundee was deposited on the erosion surface. Furthermore, old solution fissures in the upper surface of the Anderdon were filled by the lime sands which form the basal part of the Dundee.

In one part of the quarry the Anderdon limestone is a great coral and Stromatopora reef, while in other parts it is for the most part a finely bedded, compact calcilutite (consolidated limestone mud) with conchoidal fracture and of great purity. Analyses have shown that it contains over 99 per cent $CaCO_3$, while in compactness and texture it suggests lithographic stone.

SIBLEY CORE AND OTHER EXPOSURES OF ANDERDON

About 6½ miles northwest from the Anderdon quarry in the drill cores at Sibley the Anderdon was again found to have the coral-reef facies and to underlie directly the Dundee. Between the two on Stony island and on Grosse isle a brown dolomite is shown, to which further attention is invited. Some of the best exposures formerly to be found were in the old Patrick quarry, at the south end of Grosse isle, in the Detroit river. At present the quarries at Gibraltar, 3 miles west of the Patrick quarry, furnish excellent exposures of this rock. Other good exposures are in the Woolmith quarry, near Scofield, 15 miles southwest from Gibraltar, and at Sylvania and neighboring regions in northwestern Ohio. In all these cases it lies but a short distance above the Sylvania sandstone, which indeed is shown beneath it in the Woolmith quarry and at Silica, near Sylvania, Ohio. Two divisions are generally recognizable—a lower magnesian calcarenite, with a fauna transitional between that of the Anderdon and the overlying bed, and the upper a gray dolomitic calcilutite with a gastropod fauna. This upper bed, of which from 30 to 40 feet are shown in the quarries, is the typical Lucas formation of Ohio, so named by Prosser from the outcrops in Lucas county. For convenience it may be desirable to designate the lower calcarenite by a special name, that of Amherstburg dolomite being perhaps the best available one, since this bed forms the

[5] Nattress: Ninth report of the Michigan Academy of Science, p. 177; Ontario Bureau of Mines, 1904, part ii, p. 41; also report for 1902, p. 123.

bottom of the eastern channel of the Detroit river opposite Amherstburg, Ontario. Recent dredgings have brought up the rock, and from it an extensive fauna has been collected by the Reverend Doctor Nattress, of Amherstburg. The greatest thickness of the Amherstburg dolomite is probably not over 20 or 30 feet, and a part of it is seen in the lower part of the Patrick, Gibraltar, and Woolmith quarries in Michigan and the Silica and Webster quarries in the Sylvania district of Ohio.

CORRELATION OF THE BEDS

The correlation of these beds with the beds exposed in the salt shaft at Detroit is not as simple as it would at first appear. From the fact that in the quarries cited the dolomites rest directly on the Sylvania sandstone, one would be led to regard them as the equivalent of the lower or Flat Rock dolomite bed of the salt shaft, which lies between the Sylvania and the Anderdon. The fossils, however, tell a different story. There is not a single species in common between the Flat Rock dolomite of the salt shaft and the Amherstburg or Lucas beds. The Lucas, however, in all its outcrops carries a fairly abundant fauna mainly of gastropods, which is identical with that of the *upper* dolomite—189 feet thick—of the salt shaft. Moreover, the Amherstburg dolomite, which lies below the Lucas in all the quarries, contains an equal mixture of Anderdon and Lucas fossils, the former often predominating. The only possible interpretation of this seems to be that the Lucas dolomite of the quarries represents the lower part of the upper dolomite bed of the salt shaft, which therefore should be referred to as the Lucas, and that the Amherstburg dolomite lies between the Lucas and the Anderdon, forming a transitional bed. The Amherstburg bed has not been distinguished in the salt shaft, which is not surprising when the small size of the shaft is considered.

If the above interpretation is correct, some surprising facts with reference to the structural geology of southern Michigan and the adjoining areas are revealed. It is first of all shown that the Upper Monroe beds overlap southward against the Sylvania sandstone as against a basal bed. This would indicate that before the formation of the Upper Monroe beds the area involved was dry land. Studies of the authors on the Sylvania sandstone now in progress reveal facts which point to æolian or anemoclastic origin of this sandstone. Another harmonious fact is found in the thickening of the Flat Rock dolomite of the salt shaft as we go northward, as shown by well records (see diagram figure 1).

Another surprising fact is that in pre-Dundee time a number of low folds extended across southeastern Michigan, Canada, and Ohio in a direction east-northeast. A synclinal trough extended through the center of Grosse isle, past the Gibraltar, Flat Rock and Woolmith quarries, probably a little to the north of all of these. An anticlinal axis extended parallel to this through the Anderdon quarry and through the region where now are situated the Sylvania sand-pits south of Scofield. A second anticlinal axis, also parallel or approximately so to the others, extended through the region of the present Sibley quarries, or somewhat to the north. Peneplanation during Lower Devonic time truncated these low folds, so that on the deposition of the mid-Devonic Dundee the base of this formation came to rest on different members of the Upper Siluric. Thus at the Anderdon quarry the bed exposed by the truncation of the anticline was the Anderdon, and on this came to rest the Dundee (see diagram, figure 1). In the southwestward extension of this same fold the bed exposed at the top of the truncated anticline was the Sylvania, the axis of the anticline here having crossed to the south of the line of overlap—that is, the shoreline at the end of Anderdon time. At this point the Dundee came to rest directly on the Sylvania, remnants of it being still visible in intimate association with the Sylvania. This intimate association of the two caused Rominger to mistake the Sylvania for the Oriskany. South of this axis the Dundee came to rest again on the Lucas beds, as shown in several quarries in the vicinity of Sylvania, Ohio. This section formed the southern flank of the Anderdon-Tollpit anticline. Since the line of overlap of the Amherstburg over the Anderdon—that is, the shoreline at the end of Anderdon time—curves more to the south than does the axis of the anticline (extending from the Gibraltar quarry and the region south of Amherstburg through the Woolmith quarry and thence curving south to the Silica and Webster quarries near Sylvania), it is evident that the resultant outcrops will be quite varied.

POSSIBLE ECONOMIC VALUE

Incidentally it may be remarked that these anticlines may have an economic value, since all the lower strata are involved, and favorable conditions for the storage of oil and gas thus created. The fact that these anticlinals could have been located only with the help of paleontology seems, in view of what is known of the connection of oil and gas with such structures, an interesting illustration of the practical value of the study of the fossils.

Proof of the Lower Devonic Hiatus

The foregoing discussion has made clear that a hiatus of considerable magnitude exists between the Monroe beds and the overlying Dundee limestone, the approximate equivalent of the Onondaga limestone of New York. At the salt shaft this limestone rests on 189 feet of Lucas dolomite. At the Sibley and the Anderdon quarries it rests on Anderdon limestone. Between the two on Grosse isle and Stony island lower Lucas is present; at the Gibraltar and Woolmith quarries the Dundee, now removed, formerly rested on less than a hundred feet of Lucas. Three to 4 miles southeast from the latter locality the Dundee rests on the Sylvania, and fossils of the former occur in the reworked upper portion of the latter. Near the Silica and Webster quarries and at the S. K. Cooper quarry, near Sylvania, Ohio, the Dundee rests again on lower Lucas. Further southeast in Ohio the Dundee (Columbus) rests on various members of the Lower Monroe,[6] while at Buffalo, New York, the Onondaga rests on the lower 7 feet of the Bullhead or Akron limestone, the probable equivalent of the Amherstburg bed of Michigan and the Cobleskill of eastern

[6] "Relative to the lower 35 or 40 feet of the Columbus limestone, permit me to add a word: In central Ohio the dividing line between this 'brown saccharoidal magnesian limestone' and the underlying Monroe formation, with its banded compact drab limestone, is very distinct. In fact, it is an unconformity [disconformity], and at many places the lower portion of the brown limestone (Columbus) is a real basal conglomerate. From this 40 feet of brown limestone I have collected a rather scanty Columbus limestone fauna, even in the basal layers. At Sandusky and vicinity the unconformity [disconformity] is also evident. Here the upper part of the Monroe formation carries a

New York. A period of dry land is thus indicated for Michigan, Ohio, and western New York and Canada, and elsewhere as well, during which prolonged erosion occurred, preceded by a basining of the Michigan and doming of the Cincinnati regions, and the formation of the diagonal folds in southeastern Michigan and Canada. It was during this same period of dry land condition that the extensive brecciation of the Monroe beds occurred, through subærial agencies, producing the large and small angular fragments, which were subsequently, on the advent of the mid-Devonic Dundee sea, incorporated in the base of that formation, as now found at Mackinac island and Goderich, Canada, and outlined by Grabau before this Society during a former meeting.

Synopsis of the Faunas of the Monroe Beds of Michigan, Ontario, Ohio, and western New York

The Lower Monroe Faunas

In general.—In the following annotated list all the species which have so far been obtained from the Monroe formation are given. They are fully described and illustrated in a memoir of this fauna (by Grabau), now awaiting publication at the hands of the Michigan Geological Survey, and forming part of an extensive discussion of the Monroe formation by the present authors. Although the majority of species are new, and their full characterization can not be given here, it is nevertheless deemed advisable to list them, with brief suggestions of their affinities.

Although the discussion of the Lower Monroe formation does not enter into the present paper, it is nevertheless deemed desirable to include a list of the faunæ, since this will serve to emphasize the distinctness of the faunæ of the Upper Monroe beds. The subdivisions here used are those discussed in another paper by Lane, Prosser, and the present authors, and adopted in the memoir on the Monroe formation already referred to.

A. Fauna of the Greenfield dolomite.—This horizon is so far known only from Ohio, where it is exposed at Greenfield and Ballville. The fauna was originally described by Whitfield, though many of his identifications can not now be accepted. The type material is mostly in the collection of Columbia University.

Brachiopoda:

1. *Schuchertella hydraulica* (Whitfield), characterized by alternation of coarser with several finer radii; very common.
2. *Camarotœchia hydraulica* (Whitfield).

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fauna which fixes its age, while immediately above these layers comes a limestone filled with a rich Columbus fauna, thus making a clear case of it for central Ohio.

"West of Toledo, however, the dividing line is not so evident between the Lucas dolomite and the base of the Columbus limestone, as we consider it in northwestern Ohio.

"The following measurements are copied from my field book:

Columbus limestone	
Lucas dolomite	
Compact, drab dolomitic limestone, banded................	63 feet
Drab dolomitic limestone, with some gray or brown sandstone layers alternating..............................	36 feet
Sylvania sandstone	

"C. R. Stauffer, in discussion."

3. *Rhynchospira præformosa* Grabau manuscript = *Retzia formosa* Whitfield non Hall.
4. *Hindella ? whitfieldi* Grabau manuscript = *Meristella bella* Whitfield in part; common.
5. *Hindella rostralis* Grabau manuscript = *Meristella bella* Whitfield in part.
6. *Hindella ? rotundata* (Whitfield) = *Nucleospira rotundata* Whitfield.
8. *Whitfieldella subsulcata* Grabau manuscript, a rather rare form, related to *W. sulcata*.

OSTRACODA :

9. *Leperditia angulifera* Whitfield.
10. *Leperditia altoides* Grabau manuscript, larger and more robust than *L. alta*.

B. Fauna of the Put-in-bay dolomites.—This is best known from Put-in-bay island, lake Erie, but has also been found on the main land.

1. *Spirifer ohioensis* Grabau manuscript (*Sp. vanuxemi* Whitfield, a larger species than *S. vanuxemi* Hall, with fewer and coarser plications, the inner very broad; common).
2. *Goniophora dubia* (Hall), abundant.
3. *Leperditia alta* Conr., abundant.
4. *Eurypterus eriensis* Whitfield.

C. Fauna of the Raisin River beds.—These beds are partly exposed on Put-in-bay island, but more extensively in southeastern Michigan and adjoining portions of northern Ohio. Fossils are not very numerous.

1. *Whitfieldella prosseri* Grabau manuscript (*Meristella lævis* Whitfield, the most abundant and characteristic form).
2. *Pholidops* cf. *ovata* Hall; rare.
3. *Camarotœchia* sp.
4. *Meristina profunda* Grabau manuscript and mutation *sinosus* Grabau manuscript.
5. *Pterinea lanii* Grabau manuscript (*Pt. aviculoidea* Whitfield non Hall; a common species).
6. *Goniophora dubia* Hall. Very rare.
7. *Tellinomya* sp.
8. *Modiomorpha* sp.
9. *Cœlidium* ? cf. *minutum* Hall.
10. *C.* ? cf. *extenuatum* Con.
11. *Loxonema* sp.
12. *Holopea* sp. 1.
13. *Holopea* sp. 2.
14. *Holopea* sp. 3.

(12–14) Three clearly distinct species, but too poorly preserved for specific identification.

15. *Spirorbis laxus* Hall. An abundant species.
16. *Beyrichia* cf. *sussexensis* Weller. Rare.
17. Plant remains.

THE UPPER MONROE SERIES

D. Fauna of the Flat Rock dolomite of the salt shaft.—This fauna is known from the salt shaft, but some fossils have also been found in the dolomite of Flat Rock which represents this horizon.

1. *Syringopora* cf. *hisingeri* Bill. This species is doubtfully identified from the salt shaft and from Flat Rock.
2. *Syringopora cooperi* Grabau manuscript, a species with numerous short transverse processes, somewhat whorled. *S. compacta* Bill., from Anticosti, seems to be a related form.
3. *Favosites* cf. *maximus* Troost. Identified with a specimen from the Onondaga of Ohio, referred to this species.

E. Fauna of the Anderdon bed of the salt shaft (ss) and the Anderdon quarry (a.q.).—Unless specified, the species occurs in both localities.

STROMATOPOROIDS:

1. *Clathrodictyon ostiolatum* Nicholson, abundant; a Guelph and Cobleskill species.
2. *Stromatopora galtense* (Dawson), abundant; a Guelph and Cobleskill species.
3. *Stylodictyon sherzeri,* Grabau manuscript, *ss.,* the only Siluric representative of the genus known; closely related to species from the Columbus limestone and from the Traverse beds of Michigan.
4. *Clathrodictyon variolare* v. Rosen, *aq.;* a Siluric type, rather common.
5. *Cœnostroma pustulosum,* Grabau manuscript, *aq.;* an abundant form.
6. *Idiostroma nattressi,* Grabau manuscript. A small branching species, closely similar to, if not identical with those abounding in the Traverse group of Michigan.

ANTHOZOA:

7. *Helentorophyllum caliculoides* Grabau manuscript, gen. et sp. Like *Enterolasma caliculum,* of the Niagara, but with carinæ on the septa; not uncommon; *aq.*
8. *Cyathophyllum* cf. *thoraldense* Lambe; rare; *ss.*
9. *Cyathophyllum americanum,* mut. *anderdonense* Grabau manuscript. Differs from the species in its somewhat more concentrated large cysts; common; *aq.*
10. *Synaptophyllum multicaule* (Hall).
11. *Diplophyllum integumentum* Barrett. A characteristic species of the Decker ferry beds of New Jersey; common.
12. *Ceratopora tenella* (Rominger); common; *aq.*
13. *Favosites basaltica* var. *nana* Grabau manuscript; common; *ss.;* a form differing in nothing but size of corallites from the typical Columbus limestone species.
14. *Favosites rectangularis* Grabau manuscript; common; a digitate species with the corallites turning at nearly right angles. The species has squamulæ like the Devonic species.
15. *Cladopora bifurcata* Grabau manuscript; an abundant form of Siluric affinities.
16. *Favosites concava* Grabau manuscript; a common form; *aq.*
17. *Syringopora microfundulus* Grabau manuscript; not unlike *S. infundibulum* Whitfield, but very much smaller; rare; *ss.*

BRACHIOPODA:

18. *Prosserella modestoides* Grabau manuscript; gen. et sp. A genus which so far appears to be confined to the Upper Monroe; is characterized among other features by two strong but closely parallel, rarely uniting septa in the pedicle valve. Its nearest allies are found in the Middle Devonic of Europe. *P. modestoides* is common in *ss.,* is large for the genus, and non-plicate; a related form apparently occurs in the Guelph.
19. *Prosserella lucasi* Grabau manuscript; rare, but abundant in Lucas dolomite.

PELECYPODS:

20. *Conocardium monroense* Grabau manuscript; a species very closely related to *C. trigonalis* of the Schoharie grit; common.

GASTROPODS:

21. *Eotomaria galtensis* (Billings) ?; an impression referred to this species *ss.*
22. *Pleurotomaria* cf. *velaris* Whiteaves; an imperfect form of this type.

F. Fauna of the Amherstburg bed.—This is best known from the dredging in the Detroit river opposite Amherstburg, Ontario, where the Reverend Mr Nattress made an extensive collection. It is also known from the Patrick, Gibraltar, and Woolmith quarries.

STROMATOPOROIDS:

1. *Clathrodictyon ostiolatum* Nicholson; often in large, digitate masses.

ANTHOZOA:

2. *Heliophrentis alternata* Grabau manuscript, gen. et sp. A Zaphrentoid coral with carinæ in the upper part of the septa; a derivative of Siluric Zaphrenti; common. A closely related if not identical species occurs in the Schoharie.
3. Mutation *compressa* Grabau manuscript.
4. Mutation *magna* Grabau manuscript.
5. *Heliophrentis carinata* Grabau manuscript, with septa carinated throughout greater part of calyx; common.
7. *Cystiphyllum americanum* mut. *anderdonense* Grabau manuscript; rather rare.
8. *Acervularia* sp. nearest to *A. rugosa* of the Onondaga.
9. *Synaptophyllum multicaule* (Hall).
10. *Diplophyllum integumentum* Barrett; rather rare.
11. *Romingeria umbellifera* (Bill.); indistinguishable from the Devonic form.
12. *Ceratopora regularis* Grabau manuscript.
13. *Favosites tuberoides* Grabau manuscript; differs from the Devonic *F. tuberosus* only in the smaller corallites, which have well-marked squamulæ.
14. *Cladopora bifurcata* Grabau manuscript; abundant.
15. *Cladopora* cf. *cervicornis* Hall; poorly preserved, but with all the characters of that species.
16. *Syringopora microfundulus* Grabau manuscript. ?
17. *Syringopora* cf. *hisingeri* (Bill.). ?

BRYOZOA:

18. *Fenestella,* two sp.

BRACHIOPODA:

19. *Schuchertella interstriata* (Hall); common.
20. *S. amherstburgense* Grabau manuscript; rare.
21. *Stropheodonta vasculosa* Grabau manuscript; closely related to *S. patersoni-bonamica* Clarke of the Helderbergian.
22. *Stropheodonta demissa* mut. *homolostriata* Grabau manuscript; like some Onondaga forms of *S. demissa.*
23. *Stropheodonta preplicata* Grabau manuscript; closely related to *S. plicata* of the Traverse group.
24. *Stropheodonta* sp.
25. *Spirifer sulcatus* mut. *submersus* Grabau manuscript; of the type of the European *S. sulcatus.*
26. *Prosserella modestoides* Grabau manuscript.
27. *P. modestoides* mut. *depressus* Grabau manuscript; common.
28. *P. subtransversa* Grabau manuscript; possibly referable to the Lucas.
29. *Whitfieldella* sp.
30. *Meristospira michiganense* Grabau manuscript, gen. et sp. Hinge structure combining characters of *Merista* or *Whitfieldella* and *Nucleospira;* abundant in Woolmith quarry.
31. *Meristina profunda* Grabau manuscript; doubtfully identified.
32. *Atrypa reticularis* Linn.; a single fragmentary impression.
33. *Cyrtina* sp.
34. *Orthid brachiopod.*

PELECYPODA:

35. *Panenka canadensis* Whiteaves; a common form most nearly like the Schoharie type; described by Whiteaves as a mid-Devonic form.
36. *Cypricardinia canadense* Grabau manuscript.
37. *Conocardium monroense* Grabau manuscript; abundant and characteristic.

GASTROPODA:

38. *Hormotoma subcarinata* Grabau manuscript; most nearly related to Gotlandian species; most characteristic of the Lucas.
39. *Holopea antiqua* var. *pervetusta* (Conrad).
40. *Acanthonema holopiformis* Grabau manuscript, gen. et sp.; a moderately high-spired form like Orthonema, but with nodulated spirals.
41. *Strophostylus cyclostomus* Hall; rather common.
42. *Eotomaria areyi* Clarke and Ruedemann; rather common.
43. *Eotomaria* sp.
44. *Lophospira bispiralis* (Hall); rather common.
45. *Trochonema ovoides* Grabau manuscript; a large flat-spired form; nearest ally in Helderbergian.
46. *Hercynella canadense* Grabau manuscript; the first species of this characteristic Hercynian gastropod found in America; it is most nearly related to *H. fastigiata* Barrande.

CEPHALOPODA:

47. *Dawsonoceras annulatum;* a strongly annulated variety.
48. *Cyrtoceras orodes* Bill.; identical with species described by Clarke and Ruedemann from the Guelph.
49. *Poterioceras* cf. *sauriens* Clarke and Ruedemann; apparently identical with the Guelph species.
50. *Trochoceras anderdonensis* Grabau manuscript; a smooth-shelled and loose-spired form closely similar to *T. priscum* Barr. of the Bohemian Siluric.

ANNELIDA:

51. *Cornulites armatus* Conr.; a species also characteristic of the Guelph.

TRILOBITÆ:

52. *Prœtus crassimarginatus* Hall; several cephala and pygidia and a nearly entire specimen, indistinguishable from the characteristic Schoharie form.

G. Fauna of the Lucas dolomite.—This is exposed in the salt shaft and in numerous quarries of southern Michigan and Lucas county, Ohio.

ANTHOZOA:

1. *Heliophrentis carinata* Grabau manuscript; rare in this horizon.
2. *Cylindrohelium profundum* Grabau manuscript, gen. et sp.; in general like Diplophyllum, but with carinæ; calyx profound and parallel-sided. The most characteristic corals of this horizon, found also in corresponding horizon of the Saskatchewan region, upper Canada.
3. *Cylindrohelium heliophylloides* Grabau manuscript; more irregular and with shorter calyx, and with stronger carinated septa; *ss.;* an identical form figured by Clarke and Ruedemann as Heliophyllum sp. from the Guelph.
4. *Cladopora bifurcata* Grabau manuscript; not uncommon.

BRACHIOPODA:

5. *Schuchertella interstriata* (Hall); not uncommon.
6. *Camarotœchia semiplicata* (Conrad); a rather common species in the *ss.*
7. *Spirifer sulcata,* mut. *submersa* Grabau; rare in the Lucas.
8. *Sp. modestus* Hall; not uncommon in the *ss.*
9. *Prosserella lucasi* Grabau manuscript; an abundant form with pronounced fold and sinus.
10. *Prosserella subtransversa* Grabau manuscript; a transverse form with plications; common.
11. *Prosserella unilamellosus* Grabau manuscript, with the dental lamellæ united into a median septum at the base.
12. *P. planisinosus* Grabau manuscript; a large species with shallow, flat-bottomed but pronounced median depression; rare.

PELECYPODA:

13. *Pancnka canadensis* Whiteaves; rare in the Lucas.
14. *Pterinea bradti* Grabau manuscript; a low, long-winged type common in the *ss*.
15. *Goniophora* sp.
16. *Conocardium monroense* Grabau manuscript; less common than in the lower beds.
17. *Modiella* ? sp.

GASTROPODA:

18. *Hormotoma subcarinata* Grabau manuscript; abundantly represented.
19. *H. tricarinata* Grabau manuscript; a derivative of the preceding, with an additional carina.
20. *Cœlidium ? minutum* Hall; doubtfully identified.
21. *Cœlidium extenuatum* Hall; ? doubtfully identified.
22. *Loxonema parva* Grabau manuscript; a small species.
23. *Holopea subconica* Hall; common in salt shaft.
24. *Polcumita* cf. *crenulata* Clarke and Rued.; of the type of the Guelph form.
25. *Pleurotrochus bicarinatus* Grabau manuscript, gen. et sp.; type similar to the strongly spinose "Murchisonia" of the Upper Siluric of Gotland, of which several are referred to this genus.
26. *Acanthonema holopiformis* Grabau manuscript; a short, close-coiled form with two nodose spirals; common.
27. *A. holopiformis* var. *obsoleta* Grabau manuscript, with middle spiral non-nodose, obsolete.
28. *Acanthonema laxa* Grabau manuscript; longer and more loosely coiled; common.
29. *Acanthonema newberryi* (Meek) (*Orthonema newberryi* Meek), described as occurring in the Devonic.
30. *Pleuronotus subangulatus* Grabau manuscript; recalls strikingly the Devonic *P. decewi.*
31. *Euomphalus* cf. *fairchildi* Clarke and Ruedemann; rare in *ss.*
32. *Eotomaria areyi* Clarke and Ruedemann; fairly abundant.
33. *Eotomaria galtensis* (Bill.); characteristic and not uncommon.
34. *Euomphalopterus* cf. *valeria* (Bill.); a characteristic fragment from the *ss.*

CEPHALOPODS:

35. *Orthoceras* (Protokionoceras) cf. *trusitum;* several fragments showing the characteristic features of this Siluric species.

H. The fauna of the Bullhead or Akron dolomite of western New York.—This was originally described by Grabau, but some revision is necessary.[7]

ANTHOZOA:

1. *Cyathophyllum* (?) *hydraulicum* Simpson; common.
2. *Favosites* sp.

BRACHIOPODA:

3. *Schuchertella interstriata* (Hall); an abundant and characteristic form.
4. *Spirifer eriensis* Grabau.
5. *Whitfieldella sulcata* (Vanuxem).
6. *Whitfieldella subsulcata* Grabau manuscript (*Whitfieldella* cf. *levis* (Whitf.) Grabau).
7. *Whitfieldella* sp. (*Whitfieldella* cf. *rotundata* (Whit.) Grabau).
8. *A. rhynchonelloid.*

GASTROPODA:

9. *Loxonema* ? sp.
10. *Pleurotomaria* ? sp.

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[7] The name Akron dolomite is derived from its exposure in the village of Akron, in Erie county, New York. It is approximately equivalent to the Cobleskill of the East.

CEPHALOPODA:

11. *Trochoceras (Mitroceras) gebhardi* Hall.

OSTRACODA:

12. *Leperditia scalaris* Jones; common.

PLANTÆ:

13. *Nematophytum crassum* Penhallow; rare.
14. *Buthothrephis clavelloides* Grabau manuscript; rare.

Schuchertella interstriata, *Spirifer eriensis*, *Mitroceras gebhardi*, and *Leperditia scalaris* link this fauna with the Cobleskill. *Schuchertella interstriata* and the *Whitfieldellas* link it with the Amherstburg.

DISCUSSION OF THE FAUNAL DIFFERENCES

A survey of these faunas brings out the remarkable fact that there is nothing in common (a few doubtfully identified gastropods excepted) between the Lower and Upper Monroe. So distinct are the faunas that they may be considered as derived from widely separated provinces. The Lower Monroe is apparently an Atlantic fauna or series of faunas, and we are led to believe that an embayment from the Atlantic extended as far as Wisconsin in post-Salina time, and that the successive members of the Lower Monroe were deposited in this. The marine "Salina" described by Schuchert from Maryland most probably belongs here, the path of invasion being approximately across that region. There appears to be nothing in New York which corresponds to this series, that state being apparently north of the embayment. The embayment covered Ohio, Michigan, and probably a part of Indiana, and extended into Wisconsin.

Following the deposition of the Lower Monroe came a retreat of the sea and æolian deposits of quartz sands accumulated upon the limestone foundation. These are now seen in the Sylvania sandstone, the source of the material of which probably was the Saint Peter sandstone. The Upper Monroe invasion was from the northwest, and it brought with it a wholly new fauna, in which the prevailing element was of Devonic aspect. A large proportion of the species of the Anderdon and Amherstburg beds is most nearly related to the Schoharie fauna, the similarity being often so great that species have been described as Schoharie or Onondaga forms.

The following are the species more nearly related to mid-Devonic forms than to known Siluric:

STROMATOPOROIDS:

1. *Stylodictyon sherzeri* cf. *S. columnare.*
2. *Idiostroma nattressi* cf. *I. traversense* Grabau manuscript.

ANTHOZOA:

3. *Heliophrentis alternatum* cf. unidentified Schoharie form.
4. Mutation *compressa* and Mut. *magna* cf.
5. *H. carinata.*
6. *Cystiphyllum americanum*, Mut. *anderdonense* cf. *C. americanum.*
7. *Acervularia* sp. cf. *A. rugosa.*
8. *Romingeria umbillifera*, *R. umbillifera.*
9. *Ceratopora regularis.*
10. *Favosites basaltica nana* cf. *F. basaltica.*

11. *F. rectangulus.*
12. *F. tuberoides* cf. *F. tuberosus.*
13. *Cladopora* cf. *cervicornis* cf. *C. cervicornis.*
14. *Syringopora* cf. *hisingeri* cf. *S. hisingeri.*
15. *Favosites concava.*
16. *F.* cf. *maximus* cf. Devonic specimens.

BRACHIOPODA:

17. *Stropheodonta vasculosa* cf. *S. patersoni* mut. *bonamica.*
18. *S. demissa homolostriata* cf. *S. demissa* var.
19. *S. preplicata* cf. *S. plicata.*
20. *Prosserella modestoides* and mutation *depressa* cf. Devonic Spirifers of the Eifel.
21. *Prosserella lucasi.*
22. *P. subtransversa.*
23. (*P. unilamellosus*) cf. Devonic Spirifers of Europe.
24. (*P. planisinosus*).

PELECYPODA:

25. *Panenka canadensis* cf. *P. dichotoma.*
26. *Conocardium monroense* cf. *C. cuneus.*

GASTROPODA:

27. *Trochonema ovoides.*
28. *Hercynella* cf. *H. fastigiata* Barr.

TRILOBITÆ:

29. *Prœtus crassimarginatus, P. crassimarginatus.*

This list of species shows that the Anderdon-Amherstburg fauna is most nearly related to the Schoharie fauna of eastern New York, and that it probably represented the stock from which that fauna was derived. Coral reef conditions existed in Michigan and Ontario at that period, the eastern extension of these conditions being first manifested in the waterlime deposits, and later in the Akron, and finally in the Cobleskill. This latter marks the period of reestablishment of connection with the Atlantic, and we find that this formation is especially characterized by an Atlantic fauna in its more eastern development (Halysites, etcetera). The faunas mingled in the neighborhood of the Schoharie region.[8]

With the opening of the Atlantic connections the late Siluric Gastropod and Cephalopod fauna entered this region and became characteristic of the succeeding Manlius-Lucas deposits, while the typical Anderdon fauna soon disappeared. A comparison of the Anderdon and the Lucas fauna shows scarcely a common species. In the Amherstburg, however, there is more or less of the commingling of the two faunas. That the junction with the Atlantic was effected while the Amherstburg beds were forming is shown by Siluric gastropod and cephalopod elements in its fauna, and their absence from the Anderdon fauna. The correlation of the Amherstburg and Cobleskill thus seems evidenced.

Considering the Anderdon fauna as a whole, we see a blending of types of the Siluric with those of Devonic affinities. Recognizing that this fauna is interpolated between two Siluric faunæ, we are forced to admit that here is an example coming perilously near satisfying the demands of Barrande's theory

[8] A. W. Grabau: Bulletin of the New York State Museum, p. 131.

of colonies. Somewhere the Siluric fauna must have developed into the Devonic, while in other regions the Siluric fauna still lingered. That this Devonic aspect is that of the mid-Devonic fauna of America rather than the lower, shows that this evolution was progressing along different lines from that of the Helderbergian fauna. This latter fauna is alien to North America, as is well known, having come to us from Europe. Somewhere in northwestern America an indigenous Lower Devonic fauna existed, which in turn gave rise to the Middle Devonic faunas of America. This indigenous American Lower Devonic must have been much like the Middle Devonic fauna, seeing that the indigenous Upper Siluric is already so far advanced as to have a decided mid-Devonic aspect.

It might, of course, be argued that the Upper Monroe is the indigenous Lower Devonic of America and that it existed contemporaneously with the Helderbergian fauna. On such an interpretation the Sylvania marks the Siluro-Devonic hiatus, and the upper hiatus representing the folding and erosion of the entire of Monroe and earlier rocks falls into the Oriskany. That period, as we know it, was scarcely long enough for the accomplishment of such extensive erosion as is implied in the pre-Onondaga hiatus, though it is known that a considerable amount was accomplished during that time. The strongest argument against such an interpretation is, however, the Siluric character of the fauna of the Lucas dolomite and the evident correspondence of the Amherstburg and Cobleskill horizons.

NOMENCLATURE AND SUBDIVISION OF THE UPPER SILURIC STRATA OF MICHIGAN, OHIO, AND WESTERN NEW YORK

BY A. C. LANE, CHARLES S. PROSSER, W. H. SHERZER, AND A. W. GRABAU

[*Abstract*]

Contents

The Monroe Formation

LOCATION AND GENERAL CHARACTERS

The highest Siluric strata of America are represented by the Monroe formation of Michigan, using this term in its limited sense for the post-Salina Siluric.

The Monroe formation is a strictly marine series succeeding the abnormal (non-marine [Grabau]) Salina. It is traceable throughout lower Michigan, westward into Wisconsin, and eastward through Ohio, Ontario, and into western New York. Where recognizable a strong dividing line separates the lower from the upper part, and in general this division is emphasized by the occurrence of the Sylvania sandstone, a rock of pure quartz grains, and representing, according to Grabau and Sherzer, an æolian deposit formed under conditions similar to those now found in the Lybian desert. According to this interpretation, the Sylvania sandstone represents a long time interval the depositional marine equivalent of which is still unknown. This long interval is further emphasized by the entire distinctness of the faunæ of the lower and upper divisions of the Monroe.

The subdivisions recognized so far in the Monroe, with their faunal characteristics (determined by Grabau), are as follows:

I. THE LOWER MONROE

Proposed name—Bass Islands series.—For this stratigraphic unit the name *Bass Islands series* is proposed, from the group of islands of that name in western Lake Erie. No other appropriate term seems to be available, though characteristic exposures of all the divisions are not found in these islands.

a. The Greenfield dolomite.—This term was proposed by Grabau in 1898, though previously used in a commercial sense, for the dolomite found about Greenfield, Highland county, Ohio, and exposed again in the regions about Ballville, in northern Ohio. The name is here accepted for this division, which is characterized by *Schuchertella hydraulica* (Whitfield); *Hindella ? whitfieldi* Grabau; *H. ? rostralis* Grabau; *Leperditia*, etcetera. The faunal zone may be called that of *Schuchertella hydraulica*. The thickness is 100 feet or more and the formation is the lowest known subdivision of the Monroe.

b. The Tymochtee shales and limestones.—This name was proposed in 1873 by N. H. Winchell for the shales and thin-bedded calcilutytes of the Monroe (Waterlime) series exposed in the creek of that name in Crawford township, Wyandot county, Ohio. The thickness there is something over a hundred feet, but the relation to the overlying and underlying formation is unknown. Its fauna likewise is unknown, and the formation must be considered a tentative division of the Lower Monroe. It is not impossible that it represents in part one or more members recognized elsewhere.

c. The Put-in-bay dolomites.—This name is proposed for the extensive fossiliferous series of waterlime exposed on Put-in-bay island, one of the Bass islands, and characterized by the fauna comprising *Spirifer ohioensis* Grabau, *Goniophora dubia* Hall, *Eurypterus eriensis* Whitfield, and Leperditia. From the abundance of the pelecypod, the paleontologic zone may be called that of *Goniophora dubia*. Something over a hundred feet of strata is exposed on Put-in-bay island, where the higher beds are in contact with the succeeding zone. The formation is also known from Marion county, Ohio. Its thickness is over 100 feet, but the base is unknown.

d. The Raisin River dolomites.—This name is proposed for the highest division of the lower Monroe exposed in Lucas and Wood counties, Ohio, and in Monroe county, Michigan, especially along the Raisin river. It is perhaps 200 feet thick and contains several oolite zones. Its known fauna comprises nearly

20 species, of which the most significant are *Whitfieldella prosseri* Grabau and *Pterinea lanii* Grabau. These are restricted to this horizon, so far as known. *Spirorbis laxus* and numerous minute gastropods, besides plant remains, further characterize this horizon. From the abundance of the brachiopod mentioned, which is everywhere found and characteristic, the faunal zone is designated as that of *Whitfieldella prosseri.*

II. THE MIDDLE MONROE

This is represented in Michigan only by the Sylvania sandstone. This is believed to represent a long interval at the end of which a new series of faunæ invaded this region upon resubmergence. The thickness of the Sylvania seldom exceeds 150 feet.

III. THE UPPER MONROE

Proposed name—Detroit River series.—For this stratigraphic unit, the group name *Detroit River series* is here proposed from the exposure of all its members along that stream. It comprises four subdivisions or faunal zones.

a. The Flat Rock dolomites.—These are exposed at Flat Rock on the Huron river, and are also found in the lower part of the salt shaft at Oakwood, near Detroit. The fauna so far obtained is meager, comprising only the corals *Syringopora cooperi* Grabau, *S.* cf. *hisingeri* Billings, and *Favosites* cf. *maximus* Troost. The first mentioned seems to be characteristic and restricted to it, and the zone is provisionally called the *Syringopora cooperi* zone. The thickness of the formation varies from 40 to 150 feet or more.

b. The Anderdon limestone.—This name, suggested by the Reverend Thomas Nattress, was adopted by Sherzer and Grabau for the coral reef limestone exposed in the Anderdon quarry, Essex county, Ontario, two miles from Amherstburg, Ontario, and in the salt shaft at Oakwood, Detroit. Its thickness is from 40 to 50 feet and its fauna a rich coral and stromatopora fauna. It varies from a pure calcilutyte to a moderately coarse calcarenyte. Six species of stromatoporoids and eleven of coral have been determined by Grabau. Among the former *Stylodictyon sherzeri* Grabau and *Idiostroma nattressi* Grabau are characteristic and restricted. From the abundance of the latter the faunal zone may be named the *Idiostroma nattressi* zone. Favosites of Devonic affinities are characteristic.

c. The Amherstburg bed.—This name is proposed by Sherzer and Grabau for the next higher stratum—a dolomite not over 20 feet thick and forming a transition zone to the overlying Lucas. This zone is rich in fossils, 52 species having been identified by Grabau, most of them being new and of Devonic affinities. The fauna unites the Anderdon and Lucas elements to a certain degree. *Panenka canadensis* Whiteaves, though not absolutely restricted to it, is its most characteristic fossil, and may serve to name the zone. The genus *Heliophrentis* Grabau is further characteristic and distinctive, while *Schuchertella interstriata* links it with the Bullhead (Akrón) dolomite of western New York, this and the Cobleskill being its eastern extension. Stropheodontas of Devonic aspect further characterize the faunæ. In common with the Anderdon, it has an abundance of *Conocardium monroense* Grabau, which is the zone fossil of the two formations combined. The Spiriferoid genus, *Prosserella* Grabau, has species in the three upper members of the Upper Monroe to which it is restricted (Prosserella horizon).

d. The Lucas dolomite.—This name was proposed by Prosser in 1903 for the upper dolomites so well exposed in Lucas county, Ohio. Here they mostly rest directly on the Sylvania, the other beds being cut out by overlap. The fauna is rich and peculiar, European types of gastropods predominating. The genus *Acanthonema* Grabau, though represented in the Amherstburg, is most characteristic, and the faunal zone may be designated the Acanthonema zone. Its thickness varies up to 200 feet or over. *Cylindrohelium profundum* is restricted to it, and may be regarded as another good zone fossil.

Proposed Classification

The proposed classification in tabular form is as follows:

Upper Monroe or Detroit River Series (L., P., S., and G.) Zone of Prosserella.	*d.* Lucas dolomite (Prosser). (Zone of *Cylindrohelium profundum* and *Acanthonema.*) *c.* Amherstburg dolomite (Sherzer and Grabau). (Zone of *Panenka canadensis.*) *b.* Anderdon limestone (Nattress). (Zone of *Idiostroma nattresii.*) *a.* Flat rock (Lane, Prosser, Sherzer, and Grabau). Zone of *Syringopora cooperi.*
....	Disconformity.
Middle Monroe	Sylvania sandstone.
....	Disconformity.
Lower Monroe or Bass Islands Series (L., P., S., and G.) Zone of Leperditia.	*d.* Raisin river dolomite (Lane, Prosser, Sherzer, and Grabau). (Zone of *Whitfieldella prosseri.*) *c.* Put-in-bay dolomite (Lane, Prosser, Sherzer, and Grabau). (Zone of *Goniophora dubia*) *b.* Tymochtee beds (N. H. Winchell). *a.* Greenfield dolomite (Grabau). (Zone of *Schuchertella hydraulica.*)

The papers were discussed by A. C. Lawson, A. P. Coleman, A. M. Miller, H. M. Ami, I. C. White, and A. C. Lane.

The concluding paper of the afternoon was

STRUCTURE AND STRATIGRAPHY OF THE OUACHITA ORDOVICIAN AREA, ARKANSAS

BY A. H. PURDUE

[*Abstract*]

The area herein considered lies in the western central part of Arkansas. It is one of two Ordovician areas within the state, the other occurring in the northern part and being the southern extension of the Cambro-Ordovician area of Missouri. Between the two areas there is a large structural trough occupied by rocks of Lower and Upper Carboniferous age, and containing the Arkansas valley.

The area is mountainous and is occupied by parallel east-west ridges. These ridges have steep, rocky slopes and inclose narrow valleys. Many of them reach from 1,800 to 2,000 feet above sea-level, or from 800 to 1,000 feet above stream level. Through them occur numerous water-gaps formed by the southward flowing streams.

The general structure is that of an anticline with an east-west axis. This

is spoken of in the geological reports of Arkansas as the Ouachita anticline. On either limb of the anticline the structure is exceedingly complicated, consisting of minor symmetrical anticlines, and overturned, closely compressed anticlines and synclines. Thrust faulting is common, parallel with the folds. Scarcely two of the ridges have the same structure, and that of any ridge is liable to change within short distances.

The rocks of the area are sandstone, shale, some limestone, chert, and novaculite. At least eight different formations are recognized. These are here tentatively named, beginning with the lowest, Collier shale, Crystal Mountain sandstone, Caddo shale, Big Fork chert, Polk Creek shale, Blaylock sandstone, Slatington shale, and Missouri Mountain formation (novaculite, sandstone, and shale).

The rocks of the area have been determined by the geological survey of Arkansas as of Ordivician age, from the graptolites that occur profusely at two horizons. There is apparently a marked unconformity at the top of the Blaylock sandstone. As the graptolite horizons noted by the present writer are below this, the possibility of the Slatington shale and the Missouri formation being of Silurian age presents itself. These formations have so far proved unproductive of fossils.

This paper was discussed by A. C. Lane and G. K. Gilbert.

Soon after 5 o'clock the Society adjourned, and at 7.30 met again in the dining-room of the Hotel Alvarado for its annual dinner, which was enjoyed by thirty-seven persons, including a few of the prominent educators of the territory.

Session of Tuesday, December 31, 1907.

The Society convened at 9.10 a. m., with President Van Hise in the chair. The report of a committee favoring the establishment of a series of stations for the study of volcanic and seismic phenomena was adopted. The consideration of an overture on the formation of a Committee on Geological Nomenclature was deferred to the end of the session. The report of the Council was accepted and ordered printed in the Proceedings, and the auditing committee was continued and given leave to report to the Council after the adjournment of the Society. The Society then proceeded with the reading of papers, the first two being presented together by Professor J. E. Wolff. They were

NOTES ON THE CRAZY MOUNTAINS, MONTANA

BY JOHN E. WOLFF

[*Abstract*]

The Crazy mountains were visited by the author in 1883 and 1889, and a paper on their geology was published in the Proceedings in 1892. Last sum-

mer, with Dr G. R. Mansfield and Mr H. E. Merwin, a review was made of their physiographic and geologic features, and some three hundred photographs were obtained, dealing with points of especial interest. One small glacier was discovered and visited, and another, not so readily accessible, was noted; the relative age of the granite-diorite stocks and of alkali-syenite was found and minor points determined. After a review of the geology of the mountains and of their special features, the results of last summer's work were described and the whole illustrated by a small selection of lantern slides. The accompanying paper, by Doctor Mansfield, was included in Professor Wolff's presentation:

GLACIATION IN THE CRAZY MOUNTAINS OF MONTANA[1]

BY GEORGE ROGERS MANSFIELD

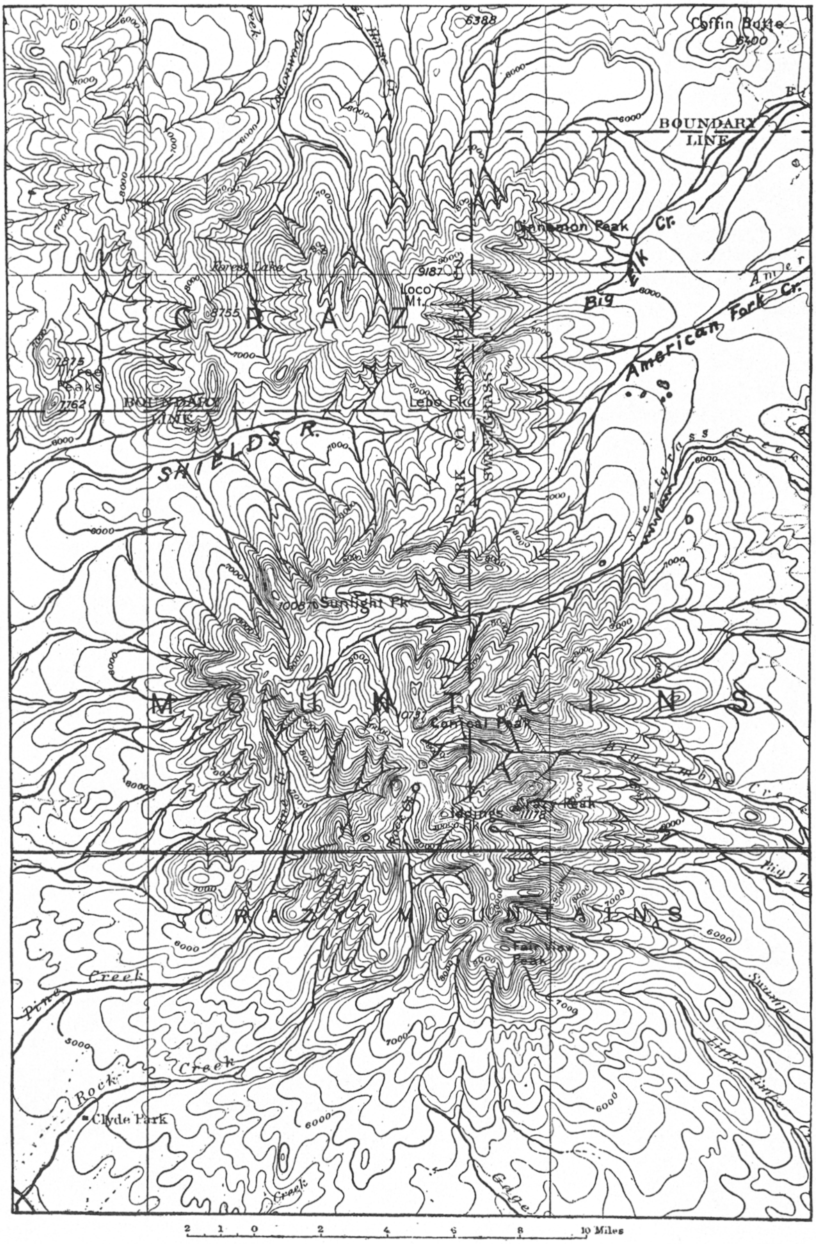
Contents

INTRODUCTION

The Crazy mountains (figure 1) occupy a somewhat oval area in central Montana, about 40 miles long from north to south, and 15 to 20 miles wide, The middle portion is approximately 46 degrees 10 minutes north latitude and 110 degrees 20 minutes west longitude. The mountains are divided by the broad basin of the Shields river into two practically separate sections—the north and the south—although there is a narrow connecting ridge along the east side. The two areas thus determined constitute distinct units, both topographically and geologically, and each has an approximately radial system of drainage. The northern section rises to a maximum altitude of about 9,200 feet, and is marked by gentle outlines in its upper slopes. The southern section, which occupies a larger territory, reaches a maximum height of 11,178 feet above the sea, and is very rugged.

In the summer of 1907 the writer, in conjunction with Professor J. E. Wolff, conducted a geological field party from the Harvard Summer School through these mountains. After the close of the school he assisted Professor Wolff in

[1] *Introduced by John E. Wolff.*



Contour Interval 200 feet
Datum is mean Sea level

FIGURE 1.—*Map of a Portion of the Crazy Mountains Area.*

From the Little Belt and Livingston quadrangles of the U. S. Geological Survey.

the latter's study and revision of the geology of the region, the completion of investigations begun some years earlier. Mr H. E. Merwin also accompanied Professor Wolff as assistant, and was associated with the writer in much of the latter's work on the glacial features of the mountains.

Previous accounts of the Crazy mountains have given little attention to the glaciation of the region. A brief general statement is made in one of Professor Wolff's papers,[1] and mention of glacial action is made in the Livingston and Little Belt Folios, United States Geological Survey, by Messrs Iddings, Weed, and Pirsson, who mapped some of the glacial deposits. Mr J. H. Ropes, who accompanied Professor Wolff on one of his earlier expeditions, studied the effects of glaciation in these mountains, but his unpublished report is not now available.

In the expedition of 1907, members of the party visited each of the main canyons and many of the smaller ones. Some of the larger branches of the main canyons were followed to their very heads, and studied in detail, but others were observed more distantly, from ridges or peaks that afforded good views into the heads of the major and minor canyons.

Character of Glaciation

The continental ice-sheets, which invaded northern Montana, did not extend to the Crazy mountains. The terminal moraine, according to recent studies,[2] passes near Great falls and along the north side of the Highwood mountains 60 or 80 miles to the north, and stretches away eastward 50 or 60 miles north of the latitude of the Crazy mountains to the border of the state. These mountains were, however, locally glaciated and contain numerous examples of the cliff and valley types, and even two or three piedmont glaciers.

Number and Dimensions of Glaciers

All the valleys that head well up in the mountains formerly supported glaciers, large or small. In many cases these were comparable in size to the Swiss glaciers of today. The largest were on the south and east sides of the mountains. Cottonwood (Pine) creek[3] on the southwest and Big Timber, Sweetgrass, American Fork, and Big Elk creeks on the southeast and east must have had glaciers approximating 10 to 18 miles in length, as indicated by the position of morainic deposits.

The glaciers of Sweetgrass and American Fork creeks on the east side of the mountains apparently combined to form a piedmont glacier that had an irregularly oval outline, approximately 7 or 8 miles in length from northwest to southeast, and 3 or 4 miles in width, according to the morainic deposits mapped by Messrs Weed and Pirsson.[4] There seems to have been also a smaller piedmont glacier produced by glaciers from the south fork of Big Tim-

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[1] The Geology of the Crazy mountains, Montana. Bulletin of the Geological Society of America, vol. 3, 1892, pp. 445-452.

[2] F. H. H. Calhoun: The Montana lobe of the Keewatin ice-sheet. *Professional Paper* no. 50, U. S. Geological Survey, 1906.

[3] Names in parentheses are those given on the topographic map, when the latter differ from those locally used.

[4] Little Belt folio, U. S. Geological Survey.

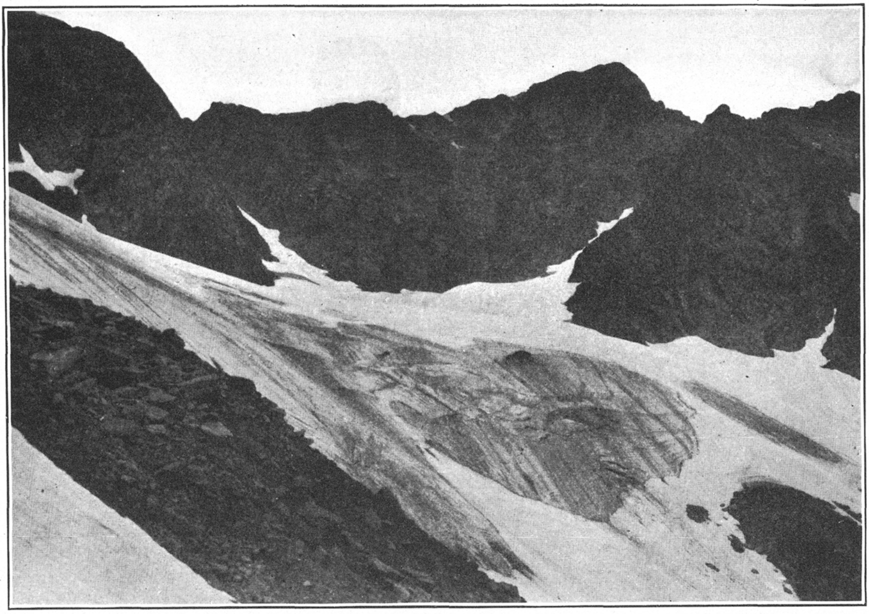

FIGURE 1.—GLACIER AT THE HEAD OF BIG TIMBER CREEK

Photograph by H. E. Merwin

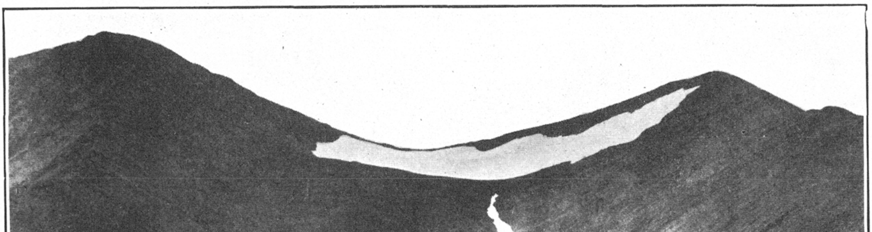

FIGURE 2.—CIRQUE AND LAKELET AT THE HEAD OF SWAMP CREEK

GLACIAL PHENOMENA IN THE CRAZY MOUNTAINS ber creek and Swamp creek, for moraines from these canyons overspread their valley sides and combine. Possibly the north fork of Big Timber may have contributed to this piedmont sheet, but the region between the two forks of Big Timber was not studied.

In his previous report on the Crazy mountains Professor Wolff estimates the elevation of striæ as 500 or even 1,000 feet above the present stream beds.[5] The observations of the present writer confirm that estimate. The elevation of striæ, the height of cliffed slopes along the edges of glacial troughs, and the altitude at which side troughs now hang above the main trough floors go to show that the main glaciers must have had a thickness of between 500 and 1,000 feet.

Living Glaciers

Glaciation in the Crazy mountains is not yet extinct. At the head of the west branch of the north fork of Big Timber creek, facing to the northeast, there is a small cliff glacier at an altitude of 9,000 to 9,500 feet. The length of the glacier, including its snow field, is probably not more than an eighth of a mile, while its width is about one-fourth of a mile, giving an area of about 20 acres. This glacierlet was discovered by the Harvard Summer School party on July 31, 1907. The failure of previous observers to note its true character was doubtless due to the fact that it is generally covered with light snow that effectually conceals its structure. The general features of the glacier are shown in plate 35, figure 1. In the midst of what appears to be an ordinary snow patch is seen a mass of dirty ice, showing distinct banding and contortion with shearing. Miniature crevasses, extending obliquely backward from near the east side, show the characteristic greenish blue color of glacier ice. The morainic material seen in the foreground of plate 35, figure 1, lies at least in part upon dirty, banded ice. The convex front of the ice changes gradually into the concave surface of the snow field, and, at the back of the latter, cracks in several places indicate the presence of the bergschrund. The walls of the enclosing cirque rise sheer 500 to 700 feet to the ridges and peaks above. The melting snow and ice drains into a lakelet on the floor of the trough below. A recent letter from Mr E. C. Russell, forest supervisor at Livingston, Montana, states that in September of this year large blocks of ice, that had broken off the glacier, had fallen into this lakelet.

Near the head of the south branch of the south fork of Sweetgrass canyon, where it heads against the east fork of Cottonwood (Pine) creek, there is a large snowfield that is believed by the writer to conceal another small glacier. This snowfield lies at an altitude of nearly 10,000 feet and faces northeast. It was not visited by the party, but, seen from a distance, it presents the same convexo-concave slope noted in the case of Big Timber glacier. Several cracks were observed at the head of the snowfield, and an obscure oblique structure running downward from west to east was noted in the snow, as if the latter only partly concealed banded ice. No other snow patches seen displayed such characteristics, save only that containing the Big Timber glacier.

A third glacierlet in the head of Rock creek is reported by Forest Assistant R. B. Wilson in an unpublished manuscript. He does not specify the position of this glacier except by general reference. The creek has two well defined

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[5] Op. cit., p. 446.

branches, the north and the east. It is probable that the latter contains the glacier, for Professor Wolff and Mr Merwin, who examined the north branch, found no evidence of it in that canyon. The east branch was not visited by the party.

Effects of Glaciation

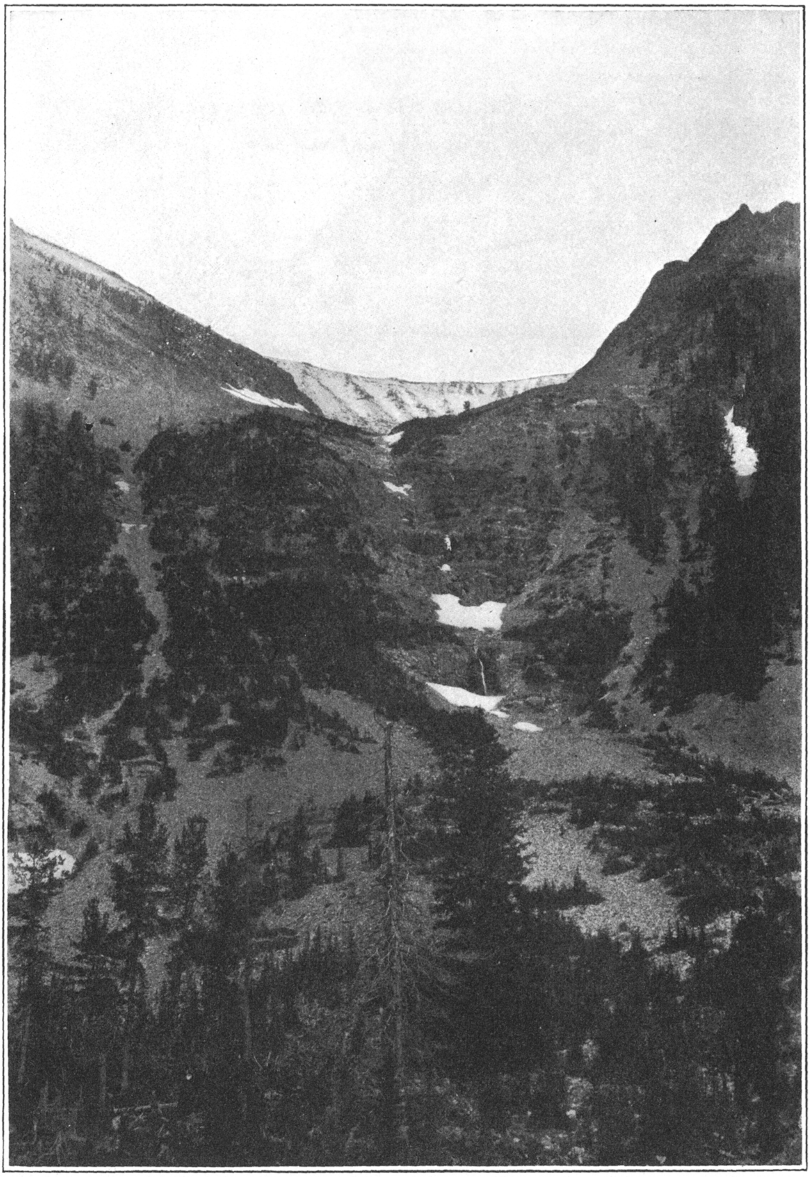
Cirques and Hanging Valleys

All the higher valleys in both sections of the mountains have cirques at their heads. The steep or precipitous walls are usually well marked, but often later accumulations of slide rock have modified to some extent the earlier outlines. In the northern section of the mountains cirques occur mainly in the region of Loco mountain, the highest summit, where they cut sharply into the gentle, ancient topography of the mountain. In the southern section cirques occur throughout the area above the foothills, and, where adjacent cirques worked backward on opposite sides of divides, sharp arrêtes have been produced. Two-story cirques occur in a number of places, fine examples having been observed near the supposed glacier in Sweetgrass canyon and in the north fork of Rock creek. Plate 35, figure 2, shows a beautiful cirque, with lakelet at the head of the north branch of the south fork of Swamp creek.

Hanging valleys may be seen on the sides of the larger canyons. Good examples occur in the canyons of Big Timber, Sweetgrass, and Rock creeks. Plates 36 and 37, figure 1, show hanging valleys in Rock canyon and Big Timber canyon respectively. In each case the upper valley hangs at least 600 feet above the main trough floor. In plate 37, figure 1, the hanging valley on the south side (left of picture) consists really of at least four shallow troughs, each separated from its neighbor by a low rock ridge, and each representing the outflow from a separate cirque. Near the rim these subordinate troughs unite, and send their drainage out through a branching stream that leaps in a double series of small cascades to the floor of the main valley below. Two other subordinate notches occur in the rim, but these contain no streams. Apparently the combined output of ice from the several cirques was insufficient in quantity, and worked for too brief a time to efface the low boundary ridges of the minor troughs, so that, while the surfaces of the contributing ice streams doubtless joined, the streams themselves were enabled to maintain their individuality almost to the very rim.

Troughs

The lower canyons have broad, flaring, trough-like cross-sections, and the trough constitutes nearly all, or, indeed, the entire valley (see plate 37, figure 2). In the upper canyons, where the hard rocky core of the high mountains is penetrated, the troughs form a much smaller proportion of the valleys, and the latter appear rather broadly V-shaped. In plate 37, figure 1, the main valley of Big Timber creek is seen to have long slopes of normal erosion above the top of the glacial trough. This relation seems to hold throughout the higher parts of the mountains. The valleys are in the main rather straight, and the spurs that would normally enter from the side have been cut back. This truncation is not, however, limited to the slopes included within the troughs, but extends as well to the upper slopes that have not been glaciated. Thus the glacial troughs seem to have been formed in valleys that had already



HANGING VALLEY OF EAST FORK OF ROCK CREEK, MONTANA

Photograph by H. E. Merwin

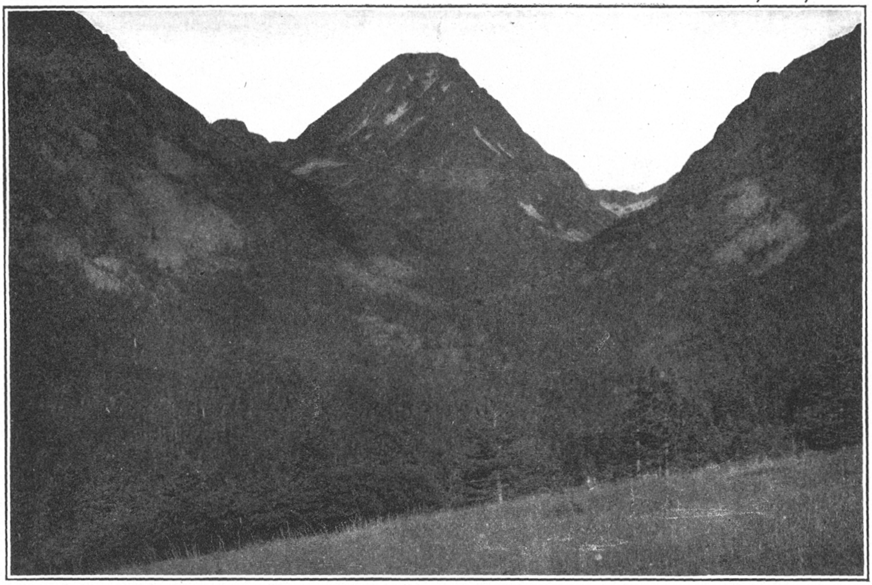


FIGURE 1.—NORTH FORK OF BIG TIMBER CANYON

View looking west from a point 5 or 6 miles east of the head and showing hanging valley and glacial trough. Photograph by J. E. Wolff

FIGURE 2.—BIG TIMBER CANYON

View eastward from a point 3 miles below the head, showing trough-like lower canyon

GLACIAL PHENOMENA IN THE CRAZY MOUNTAINS been broadly opened and straightened by normal erosion, so that ice action has not greatly modified them.

STRIÆ AND DEPTH OF CUTTING

Striæ are found only in the upper parts of the larger canyons, in the region of the hard rocks of the igneous cores and contact zones of the mountains. Elsewhere the rocks have weathered sufficiently to remove or conceal the ice markings. Even in the region where the rocks are hard, slide rock and morainic material mask the glaciated surfaces so that actual striations are not frequently seen. Well developed roches moutonées were, however, studied in Big Timber and Sweetgrass canyons and more distantly observed in other canyons. The directions of all striæ seen agreed with the general trends of the valleys in which they were found. The presence of striæ indicates that the original valleys have been deepened by the ice to some extent at least. Outside the hard rock area the canyons have doubtless been more deeply eroded, and then partly filled with glacial and fluviatile material. The general depth of the filling is not known, since most of the streams have not yet succeeded in cutting through it. In Cottonwood (Pine) canyon, however, about 3 miles below the junction of the north and east forks, the stream has reached bedrock through 10 to 15 feet of till, which thins out down stream and grades into water-worn material.

MORAINES AND WASH DEPOSITS

Moraines are found in the lower parts of the larger canyons, but are usually not well defined toward their heads. Accumulations of slide rock, which occur almost everywhere, have mingled with and obscured the morainic materials of the upper valleys. Some moraines occur on the western side of the mountains, on the benches sloping northwestward to the Shields River basin, but the heaviest deposits are those previously mentioned in connection with the ancient piedmont glaciers on the east side. Small lateral moraines occur in some of the canyons. The best examples were seen at the heads of Sweetgrass and American Fork creeks. In many of the cirques little moraine-like humps of slide rock have accumulated about the base of the back and side slopes, as if loose pieces of rock had fallen on the surfaces of the snow patches that occupy the cirques, and had been deposited in irregular heaps when the snow melted away.

Within the area visited by the party there was very little fluvio-glacial material. Doubtless most of such debris had been deposited farther down in the valleys. In one place, however, a fine section of stratified sands and clays was found, namely, in the valley of the east fork of Duck (Gage) creek, about 5 miles south-southwest of Fairview peak.

LAKELETS

Numerous lakelets occupy rock basins in the cirques and higher valleys. They are seldom more than 200 or 300 yards in diameter. Sometimes they occur in strings of three or four. They are mostly found in the canyons of streams that flow eastward and southeastward from the mountains, though a few are found in some of the west-flowing creeks. From the summit of Crazy peak one of the members of the party counted 18 of these lakelets, several of them partly or wholly ice-covered. One of the most beautiful examples is shown in plate 35, figure 2.

Other lakelets or moist hollows occur among the morainic deposits in the lower canyons or on the foot slopes of the mountains, particularly in the vicinity of Sweetgrass and American Fork creeks. A steep-sided lake of this kind near Swamp creek was estimated to be one-fourth of a mile in length.

The largest lake in the Crazy mountains, known as Cottonwood (Forest) lake, in the northern section, owes its being to an obstruction of loose porphyritic blocks, that is probably morainic, though other signs of glaciation in the valley in which it occurs are not very distinct. The linear form and fairly regular outline of the lake are favorable to this view, though the valley is not very trough-like in character, has no cirques at its head or along its sides, and has no other well defined morainic deposits.

The alternative view that the obstruction is simply a pile of fragments of a hard dike or sheet weathered *in situ* is not supported by evidence of the continuation of such dike or sheet on the sides of the valley. The porphyritic masses appear to be all of the same kind, but might have come from similar rocks up valley.

Relations to Previous Topography

Peneplanation

Reference has been made to the gentle outlines of the upper topography of the northern section of the mountains. Loco mountain, the main *massif* of that region, has a nearly flat top 3 or 4 miles long and 1 or 2 miles wide at an altitude of 9,000 feet. A small knoll rising 200 feet above the general level forms Loco peak, the highest summit. The gentle outlines here mentioned have been produced upon both sedimentary and igneous rocks, regardless of structure, and represent an ancient surface of erosion. This is now deeply cut by the later cirques and canyons, but down the main divides one may follow the older topography with moderate grade to the gentle foot slopes, remnants of which now form the beautiful benches that slope away from the mountains at an angle of about 5 degrees, 100 feet or more above the present stream valleys.

In the southern section the altitudes are greater and the general topography more rugged, but many of the ridges rise to fairly accordant levels, and here and there small remnants of a flat surface occur at an altitude of about 10,000 feet. The main divides descend to gently sloping benches as in the northern section. The truncation of widely different rocks and structures by the older topography of mountain and bench land shows that the region was formerly subjected to extended erosion, sufficient to produce an early stage of peneplanation. The superior hardness of the central cores of the mountains permitted the latter to retain subdued mountainous relief, for the summits now lie 3,000 to 4,000 feet above the upper limits of the benches.

Revival

After peneplanation the region was revived. Two well defined sets of rock benches, lower than the ones already described, show that there were at least two periods of erosion before the present one. The earlier of these appears to have reached a late mature stage, while the later one was somewhat less advanced. The present deep canyons were probably excavated and broadened and the lateral spurs cut back during these periods of erosion. The evidence of these two later cycles is less well marked within the mountains than in the bench land outside. In Sweetgrass canyon, however, just inside the contact zone, the rocks are very hard and the canyon boxes. The walls at this point are divided into four minor slopes, with noticeable breaks in grade between successive portions. The uppermost set of slopes indicates a relatively broad and open valley with gently sloping concave sides. The two next lower sets are smoothed and somewhat concaved. The lowest slopes descend steeply to the present stream bed. The uppermost set of the slopes here indicated appears to represent an earlier, broadly opened valley of the ancient topography, while the three lower sets represent respectively the two later erosion stages and the present cycle. The trough-like appearance of the head of Big Timber canyon (plate 37, figure 1) is very likely due merely to glacial modification of the valley of the second of the later cycles, while the upper slopes represent the first, the more ancient topography having been obliterated in that region.

ALTERNATIVE HYPOTHESES

The alternative hypothesis, that the benches and slopes mentioned do not represent revival, but merely differential erosion in rocks of varying hardness, does not find support in the case of the Sweetgrass locality just cited, for the slopes are cut in hard igneous rocks that have practically uniform vertical distribution. The benches, too, are very distinct in many localities rather widely separated, and differing in geological horizon and structure, yet they seem to maintain fairly constant relations to each other.

The hypothesis that the benches are merely alluvial terraces is not supported by the facts. The benches are only thinly covered by gravels. Near their tops exposures of bed rock occur in the later ravines. The forms in question are true rock benches due to revival by uplift, which must have been sufficiently extended to include the area observed.

ADVENT OF ICE

Morainic material lies on the uppermost benches, and also at lower levels within the lower canyons, but in the latter case it is not certain whether the glacial deposits rest on rock benches or simply represent morainic fillings. In the Sweetgrass gateway above described, however, the two intermediate sets of slopes have been glaciated, while the lowest is not striated and appears to be post-Glacial. Hence it seems probable that occupation by ice succeeded the second of the later cycles of erosion.

Duration of Glaciation

It has been shown that in the lower canyons the trough form includes nearly or quite the entire valley, and that in the bench lands the ice at times even overspread the valley walls. In the upper canyons, however, the troughs form much less conspicuous parts of the valleys. Slopes of normal erosion extend 2,000 to 3,000 feet above the tops of the troughs. Though the divides are generally sharp, they are more frequently the product of normal erosion than of the development of cirques. When due to the latter cause the opposing slopes of the divide become precipitous and sharp arrêtes are formed.

The hanging valleys in Big Timber canyon and elsewhere indicate a considerable amount of glacial erosion, at least locally, but the relatively narrow gateway in Sweetgrass canyon does not show much modification by ice action. The rocks both within and without the contact zone of the sediments with the eruptives are weaker than those of that zone, so that the canyons broaden both above and below that region. The contact zone would thus mark a belt of minimum deepening, which at the time of occupation by glaciers was probably the site of ice falls, as it now is of cascades. Above this zone the maximum deepening, as indicated by the hanging valley in Big Timber, may have been as much as 300 or even 500 feet. Below this zone the maximum deepening may have equalled or even exceeded that figure; the streams have not yet penetrated the glacial filling. But the additional depth of 300 or 500 feet produced by glacial action in a canyon where the sides rise 2,000 or 3,000 feet above the valley floor, cannot be regarded as a very extensive modification of pre-Glacial form.

The topographic features of the Crazy mountains thus seem to be mainly pre-Glacial. The ice remained long enough to deepen and modify the form of existing valleys and to develop the cirques and arrêtes so common in the higher mountains.

Post-glacial Erosion

At the heads of the canyons the streams are cutting new gorges for themselves beneath the old trough floors. These are still so immature that the rims of the hanging valleys are barely notched by them as they leap in cascades to the valley floors below. The glacial lakelets are for the most part unfilled and undrained. In the north branches of the east fork of Cottonwood (Pine) creek, sharply cut V-shaped gorges were observed in the fillings of the glacial valleys, but these gorges had not penetrated the filling, which was 100 feet or more in thickness, and had not reached grade. In the hard rocks of the contact zone, cascades have developed and some incision has been accomplished, while in glacial fillings below this "fall line" the streams have reached grade, without cutting through the filling, and rush along through stony flood plains. In the lower canyons of some of the larger creeks, such as Cottonwood (Pine) and Sweetgrass, the streams have cut into the bed rock and developed gorges 100 feet or more in depth. In Sweetgrass creek a beautiful meander belt has been established, for a distance of about 3 miles, in the weak rocks near the lower end of the canyon.

Within the area affected by the glaciers post-Glacial erosion has accomplished little in the way of readjustment of drainage. Indeed, the drainage may be said to be highly immature. Outside the glaciated area, however, erosion has progressed steadily from the glacial time to the present. The larger streams have developed broad flood plains, such as those of the Shields river and the Yellowstone, and many of the smaller ones have reached grade.

Summary

During the Glacial period the Crazy mountains were the seat of local glaciation. Cliff, valley, and piedmont glaciers were formed, the largest being on the southeast and east sides of the mountains, where some attained a length of 10 to 18 miles and a thickness of 500 to 1,000 feet. Glaciation is not extinct. A small cliff glacier occurs at the head of Big Timber canyon and another in Sweetgrass, while a third is reported at the head of Rock creek. Previous to glaciation the region had reached an early stage of peneplanation and had been revived in two partial cycles of erosion. Glaciation did not continue long enough greatly to modify pre-existing topography, but did produce broad, deep troughs in the weaker rocks and arrêtes in many of the sharp divides. Later stream erosion has incised the glacial deposits and, in some cases, the old trough floors.

The papers were discussed by A. C. Lawson.

The following papers were read by title:

SHALER MOUNTAINS, UNALASKA, A GRANITE CORE TO THE ALEUTIAN ISLANDS

BY T. A. JAGGAR, JR.

GROWTH AND DESTRUCTION OF METCALF CONE, BOGOSLOFF ISLAND, 1906-7

BY T. A. JAGGAR, JR.

Then was read

SANDIA MOUNTAINS

BY W. G. TIGHT

The following papers were then read by title:

GEOLOGY OF THE ALASKA RANGE

BY A. H. BROOKS

PALEOZOIC AND ASSOCIATED ROCKS OF THE UPPER YUKON BASIN

BY A. H. BROOKS AND E. M. KINDLE

GEOLOGIC RECONNAISSANCE OF THE PORCUPINE VALLEY, ALASKA

BY E. M. KINDLE

The last two papers were published as pages 255-338 of this volume.

The following paper was read by title:

DISCOVERY OF FISH REMAINS IN ORDOVICIAN OF THE BLACK HILLS, SOUTH DAKOTA

BY N. H. DARTON[1]

[*Abstract*]

Two years ago I announced to this Society the discovery of fish remains in the Ordovician (Bighorn formation) of the Bighorn mountains, and gave a résumé of our knowledge of the Ordovician of the Northwest.[2] During the

[1] Published by permission of the Director of the U. S. Geological Survey.
[2] Bulletin of the Geological Society of America, vol. 17, pp. 541-566, plates 73-79.

past summer I had occasion to extend my examination of the Ordovician of the Black Hills in South Dakota, and at one locality 15 miles northwest of Rapid I discovered fish remains similar to those previously reported from the Bighorn mountains and by Mr Walcott[3] in the region west of Canyon City, Colorado. The remains were submitted to Mr Walcott, and now await his report as to genera and species. Unfortunately it was practicable to obtain only a small mass of the fossil-bearing rock, but its stratigraphic position was evident. The precise locality was one mile north-northeast of Nemo post office, a small settlement on a branch railroad about half way between Deadwood and Rapid. It is on the northeastern slope of the general Black Hills uplift, where the rocks dip to the northeast at a low angle.

The Ordovician in the Black hills is represented by a formation which has been designated the Whitewood limestone from typical exposures on Whitewood creek about 2 miles below Deadwood. The rock is hard, massive, somewhat siliceous, and ordinarily of buff color with brownish spots or mottlings. It contains large endoceras, maclureas, and corals of Trenton age. Its thickness is 80 feet near Deadwood, but it thins rapidly to the south, and it is entirely absent in the latitude of Rapid. The location of the southern margin was not ascertained precisely, owing to talus which covers the slopes, but the limit of the main outcrop is several miles north of Nemo. The limestone lies unconformably on Deadwood formation (Middle Cambrian), and is overlain by the Englewood limestone of the Mississippian division of the Carboniferous. Above and below it are thin bodies of green shales which yield no fossils, but are included in the overlying and underlying formations. The lower shale, and possibly also the upper one, extends south beyond the margin of the Whitewood limestone, usually constituting a slope between a bench of the upper sandstone of the Deadwood and a cliff of the lowest limestone of the Carboniferous. It was on a slope of this character, northeast of Nemo, that I obtained the limestone fragment containing the fish remains. It probably represents a very thin outlier of the Whitewood limestone lying on the green shale which here is regarded as the top member of the Deadwood formation.

The next paper read was

TOPAZ-BEARING RHYOLITE OF THE THOMAS RANGE, UTAH

BY HORACE B. PATTON

The paper has been published as pages 177-192 of this volume.
The paper was discussed by G. K. Gilbert.

The next two papers were read without break.

STRATA CONTAINING THE JURASSIC FLORA OF OREGON

BY J. S. DILLER

LOCAL SILICIFICATION OF THE KNOXVILLE

BY J. S. DILLER

[3] Bulletin of the Geological Society of America, vol. 3, pp. 153-167.

The first of the two papers was published as pages 367-402 of this volume.

The second paper was discussed by A. C. Lawson.

On account of the special interest due to the excursion after the meeting to the Grand Canyon of the Colorado, the following paper was, in the absence of its author, read by C. W. Hayes:

WIND EROSION IN THE PLATEAU COUNTRY

BY WHITMAN CROSS

This paper has been published as pages 53-62 of this volume.

The next paper was read by title:

ASSOCIATION OF PEGMATITE WITH HORNBLENDIC BORDER BEDS OF GRANITE AND THE APPEARANCE OF LARGE ISOLATED MASSES OF THE TWO TOGETHER DEEP IN THE GROUND

BY B. K. EMERSON

The next paper was read by Mr. Louderback. It was

BENITOITE: ITS MINERALOGY, PARAGENESIS, AND GEOLOGICAL OCCURRENCE

BY GEORGE D. LOUDERBACK AND W. C. BLASDALE

[*Abstract*]

Benitoite and the associated minerals were briefly described and chemical analyses presented. The paragenesis and geological mode of occurrence were discussed and compared with geologically related but mineralogically different deposits in the same geologic province.

The paper was discussed by W. G. Tight.

The next papers were read by title, as follows:

IGNEOUS ROCKS OF THE ORTIZ MOUNTAINS

BY IDA H. OGILVIE

PRE-GLACIAL DRAINAGE IN CENTRAL WESTERN NEW YORK

BY AMADEUS W. GRABAU

The next paper was read by title. It was

GEOLOGIC PROCESSES AND GEOGRAPHIC PRODUCTS OF THE ARID REGION

BY CHARLES R. KEYES

[*Abstract*]

Contents

INTRODUCTORY

The Albuquerque meeting of the Geological Society is in its history the first, I believe, ever held under conditions of an arid climate. Under such circumstances attention is appropriately directed to certain features of the landscape about and to some of the peculiarities of the geologic operations producing them. In the normal humid climate some of these relief features would be ascribed to very different causes. Under conditions of aridity the geologic agencies at work modifying the facial expression of our globe operate in a manner so very different from what they do in a humid land that the effects can only be fully appreciated after long residence in a dry country.

It is a remarkable fact that the arid regions have given us our two most comprehensive and important generalizations regarding the evolution of the geographic features of our earth. The first of these is, of course, the theory of the base-level of erosion, as first propounded by Powell, after his extensive explorations of the Great Basin region of western America. The second is the hypothesis of the complete leveling of elevated continental areas without base-leveling, as urged by Passarge, for the great interior plateau of South Africa. One principle develops the geographic cycle under conditions of normal humidity; the other, not less significant, is the foundation for the recognition of a distinct geographic cycle in a dry climate.

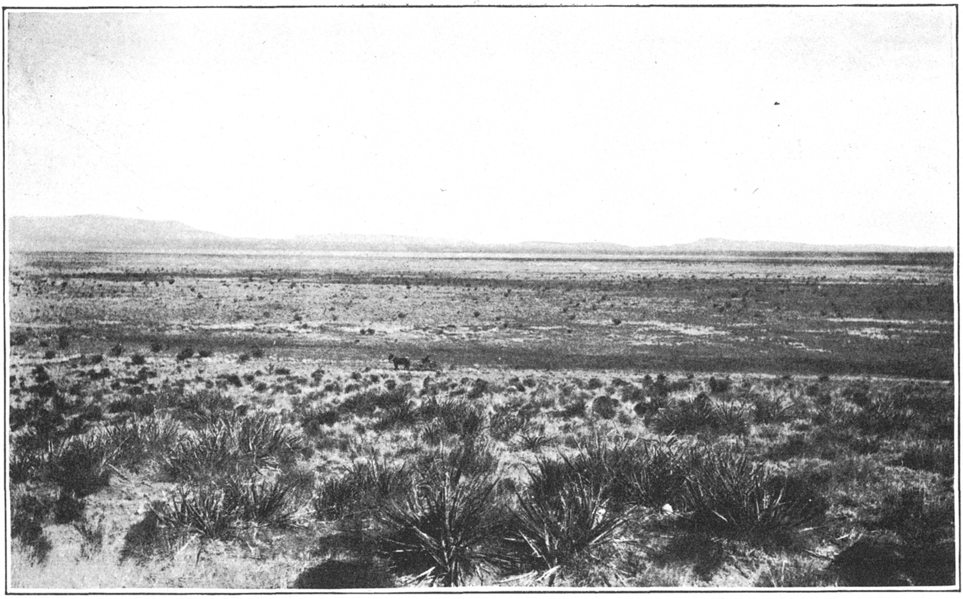


FIGURE 1.—PLAINS OF THE JORNADA DEL MUERTO, NEW MEXICO

Worn out on beveled strata; distance to rim, 30 miles

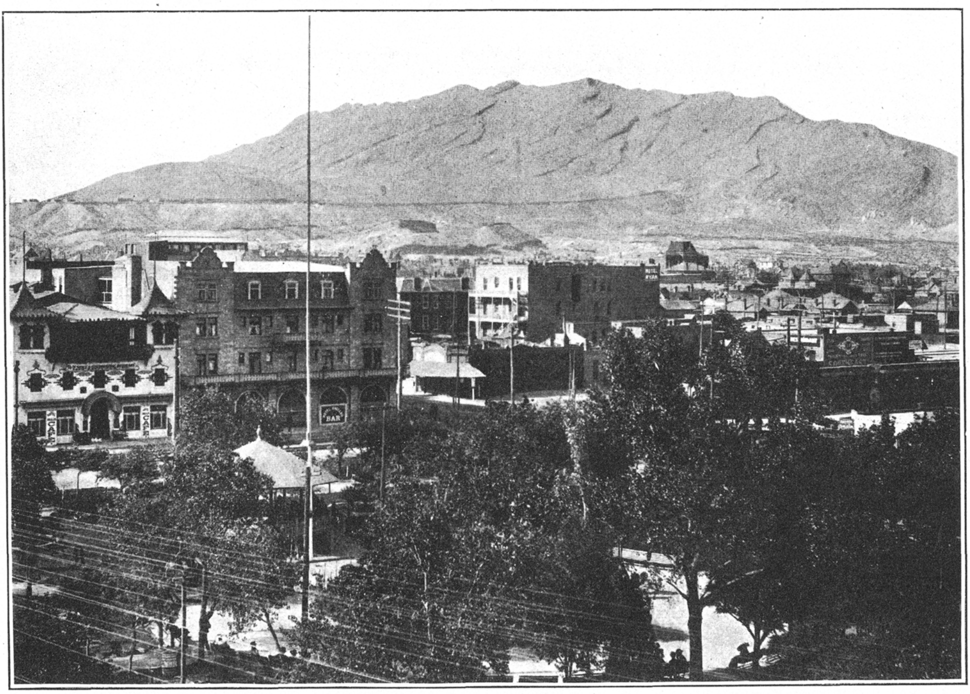


FIGURE 2.—FRANKLIN MOUNTAINS, NORTH OF EL PASO

The tilled limestone layers of the Backslope are seen even at a distance of 10 miles, as in this view

DEFLATIVE EFFECTS IN THE DESERT

Relation of New Mexico to adjacent Arid Regions

All of New Mexico is commonly regarded as forming a part of the Southwest desert. It is, however, peculiarly situated in that it lies at the meeting point of four great physiographic provinces of our continent. Their boundaries in New Mexico are outlined in the accompanying sketch-map (figure 1). These provinces are the Great plains, occupying the eastern part of the territory east of the Pecos river; (2) the Rocky mountains, reaching southward

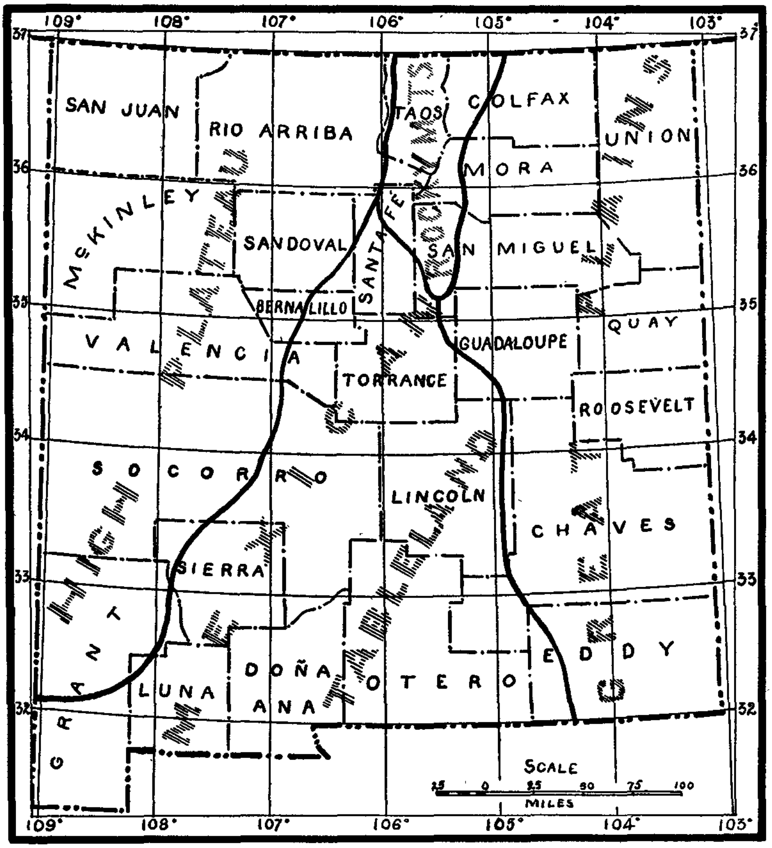


Figure 1.—*Sketch Map of New Mexico, showing Physiographic Provinces*

from Colorado in a long narrow tongue to the Glorietta pass; (3) the Mexican tableland, in the south-central part; and (4) the High Plateau province, including all of the northwest.

These four geographic provinces as represented in New Mexico differ so widely from one another in general surface relief, geologic formation, geotectonic arrangement, drainage features, climatic conditions, soil character, plant growth, economic resources, and harmonious environment for human habitation that the passage from one to another is very soon noted. In the present connection it is to be remembered that of the four provinces only the Mexican tableland and the High, or Colorado, plateau have typically arid climates; the Great Plains province represents semi-arid conditions; while the Rocky Mountains province possesses a semi-humid or humid climate.

The special workings of the geological processes to which attention is soon directed are the extent, rapidity, and vigor with which eolian erosion or deflation goes on, the feebleness and infrequency of normal water-action; and the remarkable effects of sheetflood transportation.

In the light of a distinct geographic cycle for an arid climate recently recognized, some of the most striking peculiarities of the region about us must be viewed quite differently from what they were before. Brief allusion is here made to some of the most important and also to some of the best local examples. The real significance of the commonest features now possess a new interest and their origin a new interpretation.

It may be noted in passing that the Rio Grande valley does not exhibit most of these features in typical form, for the reason that this stream is not a characteristic desert drainage-way, but a great river snow-fed and flowing through to the sea. Although it receives no perennial tributaries for a distance of a thousand miles it is a typical humid-land stream, with high gradient and great corrading powers. The old original plains-level, or bolson surface, over which it once flowed, is 500 to 1,000 feet above the present channel. Throughout its entire course of 300 miles in New Mexico it receives only sporadic and torrential waters from the lofty mountains on either side. Nevertheless, in the neighborhood of Albuquerque illustrations of all of the phenomena mentioned are well displayed, and especial attention may appropriately be called thereto.

Characteristic geographic Features

VASTNESS AND EVENNESS OF INTERMONT PLAINS

Such plains as the Estancia plains, the Hueco bolson, and the Jornada del Muerto appear to owe their leading characteristics directly to the plains-forming effects of wind-action; and to be the immediate product of local desert-leveling without base-leveling. The last mentioned plain is, perhaps, as typical as any that could be named. The view (plate 38, figure 1) shows an expanse of 30 miles in front of the highland rim in the background; the length of the plain is over 200 miles.[1]

ISOLATION OF THE MOUNTAINS

Ortiz laccolith, the Magdalena block, Sandia range, and Socorro volcano are examples. It is to be noted that this isolation is perfectly independent of mountain origin. With few exceptions, the mountains rise monadnock-like out of the even plains. The lofty and steep-sided Ortiz, Tuertos, and San Ysidro groups, to the east of Albuquerque, are separated only by five or six miles of flat valley-plains, yet preserve their characteristic isolation.[2] The Franklin block, north of El Paso, finely displays this same characteristic (plate 38, figure 2).

[1] U. S. Geological Survey, Water Survey and Irrigation Paper no. 123, 1905.

[2] Journal of Geology, vol. xvi, 1908, pp. 434-451.

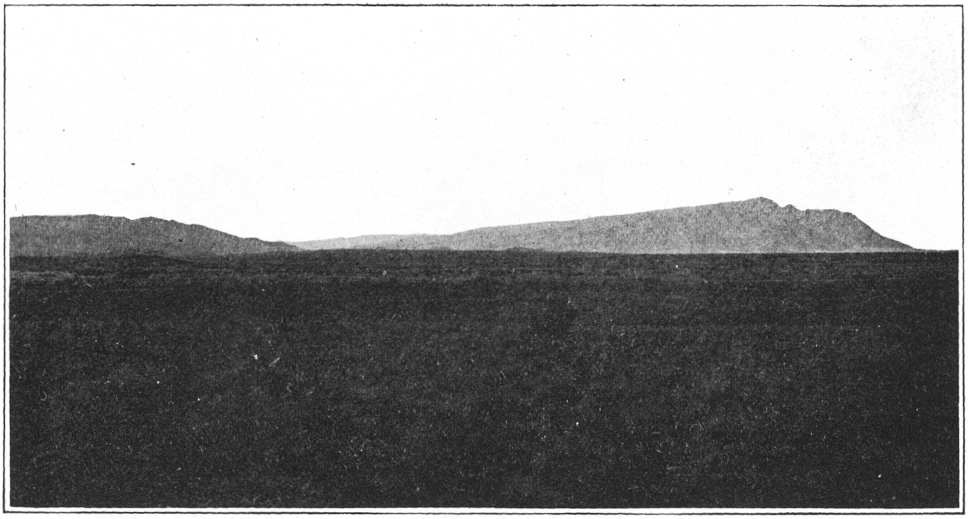


FIGURE 1.—SIERRA OSCURA, IN CENTRAL NEW MEXICO

Range rises isle-like out of sea of earth; distance, 15 miles; height, 3,000 feet

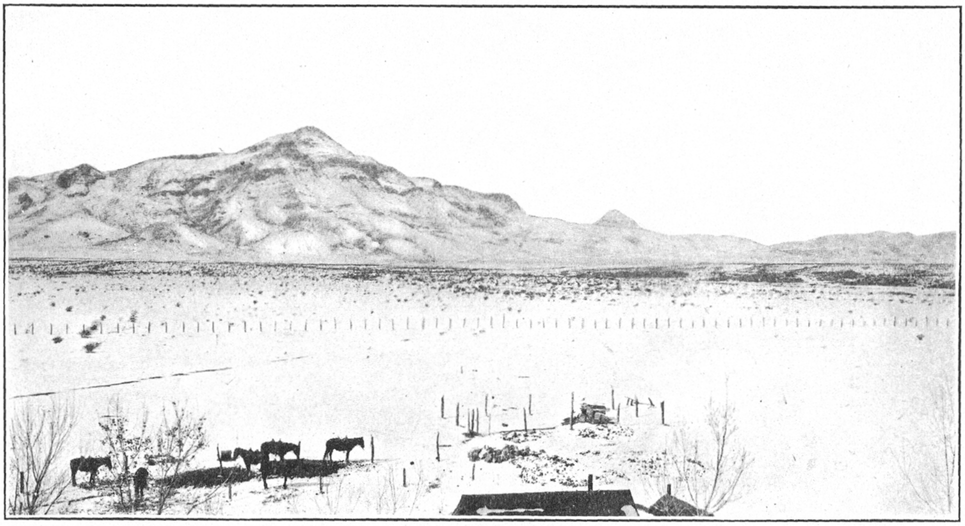


FIGURE 2.—SOCORO MOUNTAIN, NEW MEXICO

Height, 2,000 feet

ABSENCE OF FOOTHILLS IN DESERT RANGES

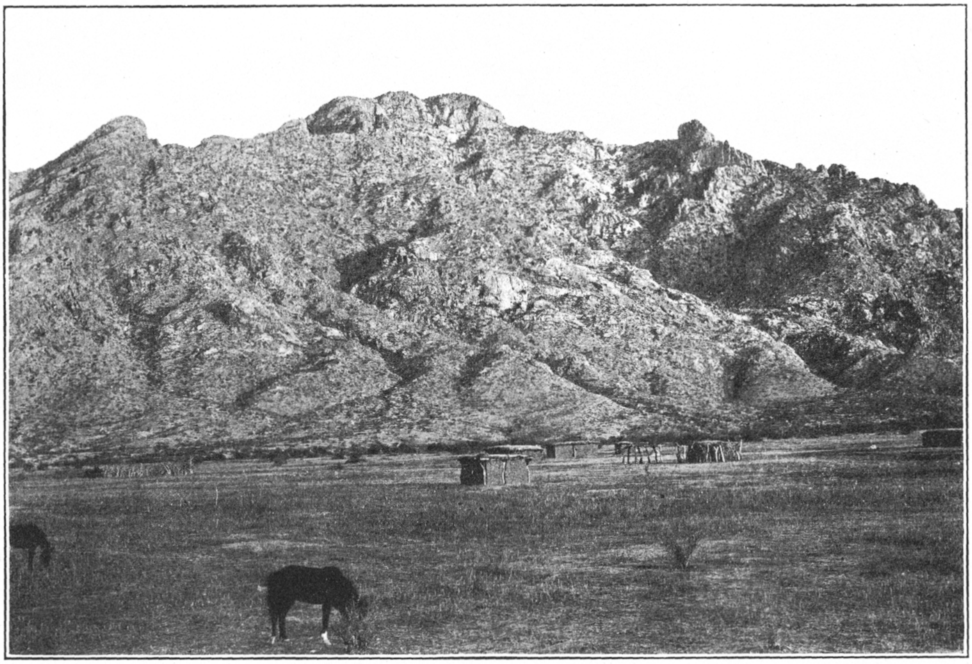


FIGURE 1.—COYOTE RANGE, SOUTHERN ARIZONA

Characteristic sharp meeting of mountain and plain

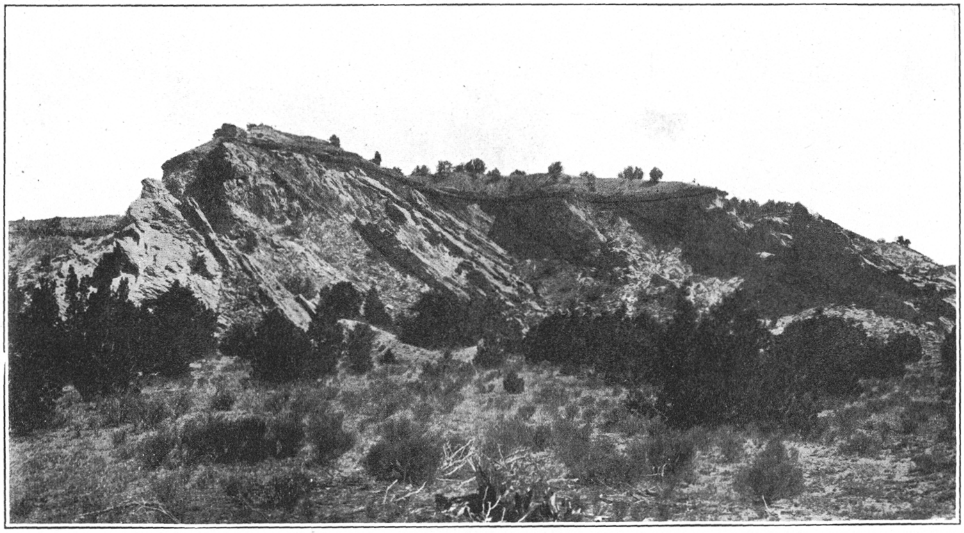


FIGURE 2.—CRETACIC SANDSTONES NEAR LOS CERRILLOS, NEW MEXICO

Plain beveling tilted strata

TWO DESTRUCTIVE DESERT FEATURES

COMPLETE ENCIRCLEMENT OF MOUNTAINS BY PLAINS

The mountains everywhere rise abruptly out of the plains, as do volcanic isles out of the sea. The Jemez, Florida, Caballos, and Oscura ranges, which finely display this feature, are only typical of the large majority of the mountains of the southwest.[3] The view of the last mentioned range is from a point on the Jornada del Muerto, 15 miles distant (plate 39, figure 1).

CHARACTERISTIC ABSENCE OF FOOTHILLS

This is one of the most surprising features of the arid region. One leaves plain and plunges by way of deep canyon at once into heart of mountain. There are no foothills about the Sandias. The Tijeras is a narrow and profound canyon until it meets the plain.[4] The Socorro mountain well illustrates this feature (plate 39, figure 2). A still more characteristic view, shown in plate 40, figure 1, is from a photograph by W J McGee of the Coyote range of southern Arizona, rising over 3,000 feet above the plain.

RESISTANT CHARACTER OF MOUNTAIN ROCKS

Independent of the origin and original rock-makeup of the mountains it is significant that it is the most resistant rocks which form them. The Sandia block is chiefly ancient crystallines and hard Carbonic limestones; the Ortiz group is mainly mica-andesite, which was originally covered by great thicknesses of Cretacic sandstones; Socorro mountain is made up of Tertiary lava flows. All of these mountains are essentially arid monadnocks rising above the plains.

SOFT SUBSTRUCTURE OF THE PLAINS

The Las Vegas plains are worn out on the soft Colorado shales; the Estancia plains have a substructure of friable Cretacic sandstones and shales; the old bolsons of the present Rio Grande valley above and below Albuquerque are floored by Early Tertiary deposits.

BEVELED ROCK-STRUCTURE OF PLAINS

In the valley of the Rio Galisteo, north and east of Albuquerque, and near the town of Los Cerrillos, the plains-surface is clearly shown in the field to bevel the rock-structure (plate 40, figure 2). The Jornada also displays the same phenomenon,[5] as does the Chupadera mesa to the east of the Jornada. The Rio Grande valley near Socorro gives many evidences of the old beveled rock-floor.

PLAINS CHARACTER OF THE ROCK-FLOOR ITSELF

In the valleys of La Jara and Arroyo San Pedro, east of the Sandia range, the surface of the rock-floor is exposed for distances of many miles. Everywhere the rock-floor is seen to be an even surface independent of the surface deposits.[6]

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[3] Journal of Geology, vol. xiii, 1905, pp. 63-70.
[4] Bulletin of the Geological Society of America, vol. 12, 1901, pp. 217-270.
[5] U. S. Geological Survey, Water Supply and Irrigation Paper no. 123, 1905.
[6] Engineering and Mining Journal, vol. lxviii, 1904, pp. 670-671.

REPRESENTATION OF FORMER PLAINS-LEVELS BY THE PLATEAU PLAINS

Mesas, or plateau plains, are one of the most characteristic features of the New Mexican arid region, and they are usually due to protective caps of old lavas which flowed out on the plains when the latter were at a higher level than at the present time. For the most part they may be, therefore, regarded as representing former levels of either general or local planation. Thus wind and water are very much alike in some of their general leveling effects (plate 41, figure 1) from photograph by U. S. Geological Survey.

NORMAL TORRENTIAL ACTION OF WATER IN THE MOUNTAINS

In the higher mountains of the arid region the torrential effects of water are not very different from what they are in the more humid regions. Whatever the effects of wind erosion there are they are largely obscured by the exceptionally heavy precipitation. The Tijeras creek and the Rio Galisteo are good examples.

FREQUENT OCCUPATION OF PLAINS BY LAKES

Intermont plains often contain somewhere within their boundaries lakes, playas, and salinas, the waters of which are quite ephemeral in character. Many, and perhaps all, of these shallow lake-basins are hollowed out of the plains-floor by the wind. Laguna del Perro, and other lakelets of the Estancia plains (plate 41, figure 2), the gypsum sands district of the Hueco bolson and the Playa de los Pinos are typical.

MARKED ABSENCE OF ROCK-WEATHERING

The extent, rapidity, and character of rock-decomposition such as takes place in the humid regions is in the arid country almost unknown. Rocks of all kinds exhibit little or no weathering. Their surfaces are characterized by their wonderful freshness. This feature is best shown in the huge igneous masses of the Cerrillos hills.

REMARKABLE THINNESS OF SURFACE MANTLE

The loam and débris covering the plains is unexpectedly thin, usually occurring only as a veneer. This is typically displayed along the Rio Galisteo and the Arroyo San Pedro east of the Sandia range. (See plate 40, figure 2, from photograph by D. W. Johnson.) The Sonoran plains, described by McGee,[7] further attest the general prevalency of the phenomenon.

TRANSPORTED NATURE OF THE SURFACE MATERIALS

All of the finer detritus is manifestly far removed from its original location. It appears to be a very rare occurrence for the surface materials of the plains to give any suggestion of the rock-composition beneath. The mesa above Albuquerque illustrates the point.

GRAVELLY CHARACTER OF SURFACE DEPOSITS LARGELY ONLY APPARENT

Predominance of gravels on the surface of the plains is illusory. The mantle is mainly loamy. It is not generally recognized that the great abundance

[7] Bulletin of the Geological Society of America, vol. 8, 1897, p. 91.

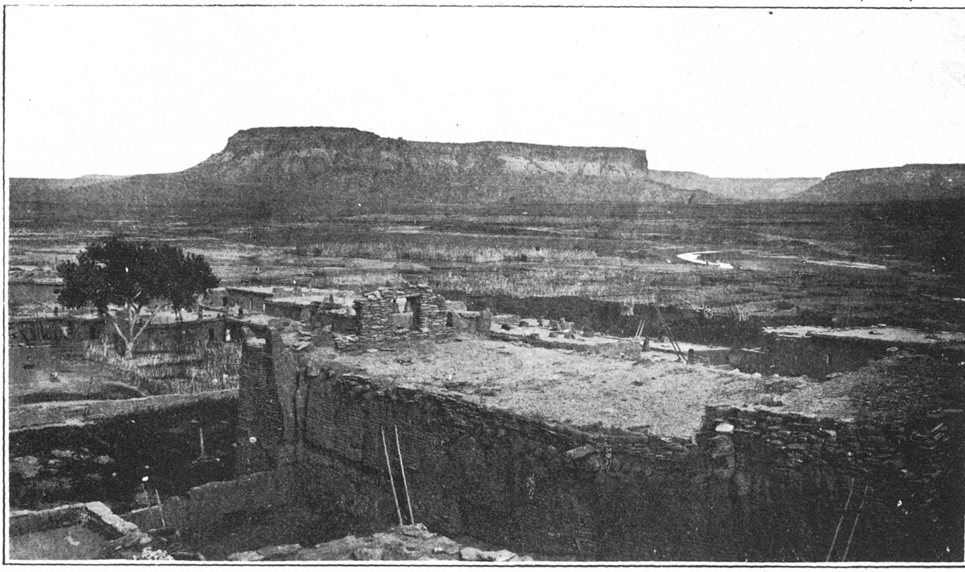

FIGURE 1.—PLATEAU PLAIN NEAR ZUÑI, NEW MEXICO

Basalt capped mesa, 600 feet above plain

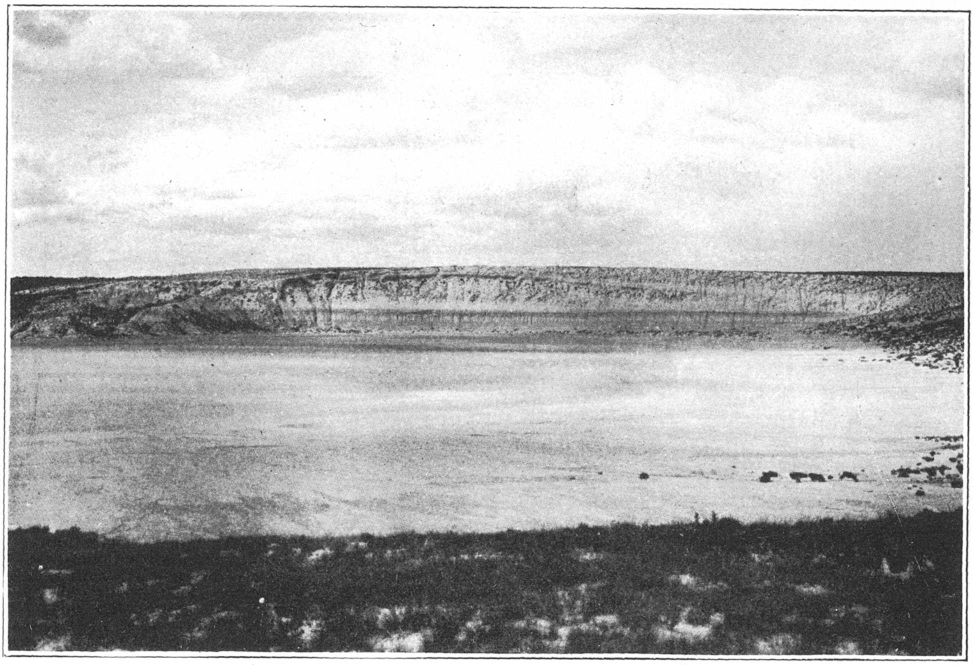

FIGURE 2.—WIND-SCOURED LAKE BASINS OF ESTANCIA PLAINS, NEW MEXICO

CONTRASTS OF DEFLATIVE EROSION

of pebbles on the surface is due principally to the fact that the wind blows away the finer materials. Most of the gravel-surfaced mesas when upturned by the plow give excellent loamy fields. The most notable examples on an extensive scale are shown in the Estancia valley.

TENDENCY OF MANTLE TO MAKE THE PLAINS EVEN

While the rock-floor of the plains is a plain itself, there are many minor irregularities in the rock-surface. Between sheetflood transportation and wind-drifted loams and sands these depressions are quickly filled up. The soft mantle only makes the plains smoother. The nearest point where this phenomenon is clearly shown is in the vicinity of Los Cerrillos.

ABSENCE OF DISTINCT WATERWAYS ON THE PLAINS

Soon after leaving the foot of the mountains the drainage-lines entirely disappear. Although the gradients are high, no drainage-systems are developed. When channel-ways are corraded by unusual freshets in the mountains they are quickly filled up by drifting sands. In the San Pedro arroyo this vanishing of the drainage-ways is finely displayed.

RÔLE OF SHEETFLOOD ACTION

Sheetflood action is one of the most important of the plains-forming agencies. Instead of water even tending to concentrate along certain lines, as in the humid regions, heavy local rainfall in the mountains spreads out on reaching the margins of the plains. Slight inequalities tend to become obliterated by the effects of the sheetflood.

LACK OF DIRECT EVIDENCE OF FORMER HUMID CLIMATE

In the New Mexican region there are discernible no facts suggesting a climate at no distant period of much greater humidity than at present. In the Nevada region the main moulding of mountain and valley has recently been ascribed to former greater rainfall and consequent more adequate water erosion. Independent of any such change of climate the known erosional effects of the winds under conditions of an arid climate may be considered amply sufficient to account for all features of the present landscape.

The next paper read was

SHORELINE STUDIES ON LAKES ONTARIO AND ERIE

BY ALFRED W. G. WILSON

The paper has been published as pages 471-500 of this volume.

The following papers were then read by title:

FAULTS AND FOLDS OF THE GRAND CANYON DISTRICT

BY DOUGLAS WILSON JOHNSON

COON BUTTE, ARIZONA

BY JOHN B. HASTINGS

OCCURRENCE OF PETROLEUM IN THE COAST COUNTIES OF CALIFORNIA

BY RALPH ARNOLD

CONGLOMERATE FORMED BY A MINERAL-LADEN STREAM IN CALIFORNIA

BY R. ARNOLD AND R. ANDERSON

This paper has been published as pages 147-154 of this volume.

DISTRIBUTION OF GOLD IN THE SADDLE AND LEG REGION OF THE MEGUMA SERIES OF NOVA SCOTIA

BY J. EDMUND WOODMAN

PROBABLE AGE OF THE MEGUMA (GOLD-BEARING) SERIES OF NOVA SCOTIA

J. EDMUND WOODMAN

This paper was printed as pages 99-112 of this volume.

GIANT SPRINGS AT GREAT FALLS, MONTANA

BY C. A. FISHER[1]

This paper was printed as pages 339-346 of this volume.

After the end of the reading of formal papers, C. W. Hayes informally exhibited a set of photographs of the fossil woods of Arizona, together with notes on them by David White, paleobotanist to the United States Geological Survey. Then W. G. Tight exhibited and described a series of stereopticon slides illustrating glacial and other phenomena among the high Andes of Bolivia, and the scientific program was declared finished.

COMMITTEE ON GEOLOGICAL NOMENCLATURE

The question of forming a General Committee on Geological Nomenclature was thoroughly discussed by C. R. Van Hise, A. C. Lane, A. C. Lawson, A. P. Coleman, G. K. Gilbert, H. E. Gregory, R. D. George, C. W. Hayes, and W. G. Tight, and the following action was taken unanimously:

The Geological Society of America recommends to the various organizations concerned:

1. That a general Committee on Geological Nomenclature be formed; one-fifth of its members to be from the United States Geological Survey, one-fifth from the Canadian Geological Survey organizations, one-fifth

[1] Introduced by C. W. Hayes.

from Mexico, and one-fifth from geologists at large selected by the Geological Society of America.

2. That this general committee have authority to appoint special committees on nomenclature from within or without its own membership for the investigation of the particular questions referred to them, the special committees to report back their conclusions to the general committee with full reasons therefor; the different sections to report in turn to their own organizations.

3. That the fact that any subject is under discussion by this general committee be made known to the scientific public at large.

The purpose of the recommendations is to provide a source from which any geologist may on application obtain advice regarding nomenclature.

The following resolutions of thanks were presented by G. K. Gilbert, seconded by President Van Hise and heartily adopted:

The Geological Society of America acknowledges with gratitude the many and substantial courtesies extended to it by the citizens and the Commercial Club of the city of Albuquerque.

The Society also tenders its sincere and emphatic thanks to the University of New Mexico, and particularly to President W. G. Tight, for the hospitality it has enjoyed—a hospitality which included arrangements of exceptional completeness and attentions most assiduous.

Register of the Albuquerque Meeting, 1907.

The following Fellows were in attendance at the meeting:

H. M. Ami.
R. W. Brock.
Samuel Calvin.
A. P. Coleman.
George E. Collie.
F. W. Cragin.
H. P. Cushing.
J. S. Diller.
R. D. George.
G. K. Gilbert.
Herbert E. Gregory.
G. D. Harris.
C. W. Hayes.
E. O. Hovey.
Alfred C. Lane.
Andrew C. Lawson.
George D. Louderback.
Arthur M. Miller.
W. G. Miller.
H. B. Patton.
A. H. Purdue.
W. G. Tight.
Charles R. Van Hise.
Frank R. Van Horn.
T. L. Walker.
I. C. White.
A. W. G. Wilson.
John E. Wolff.

There were in addition at least five visiting geologists, not members of the Society, besides students and casual visitors.

Session of the Cordilleran Section, Tuesday, December 31, 1907.

The Cordilleran Section met with the general Society. On Tuesday, December 31, the section held a business session, at which Andrew C. Lawson and George D. Louderback were reëlected chairman and secretary respectively.

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By H. P. Cushing, *Librarian*

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3300. Travaux de Musée Géologique Pierre le Grand, vol. i, livr. 1-5.

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3250. Region aurifère de l'Amour, livr. 6.
2264. Region aurifère de Lena, livr. 4.

3039. Memoirs, nouvelle serie, no. 21.
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3214. Verhandlungen, zweite serie, band xliv.

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2711, 2992. Sveriges Geol. Undersökning, series Aa, nos. 123, 134, 137-140, with maps.
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3165. Neues Jahrbuch, 1907, band ii.
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KAISERLICH-KÖNIGLICHE GEOLOGISCHE REICHANSTALT, VIENNA

3228. Jahrbuch, band lvii.

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3149. Annalen, band xxi, 1906.

GEOLOGISCHES INSTITUT DER K. K. UNIVERSITÄT, VIENNA

3273. Beiträge zur Paleontologie und Geologie österreich-Ungarns und des Orients, band xx.

(c) *ASIA*

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BUREAU OF SCIENCE, MANILA

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(d) *AUSTRALASIA*

GEOLOGICAL DEPARTMENT OF SOUTH AUSTRALIA, ADELAIDE

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3319. Record of the Mines, 4th edition.
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3166. Records of the Geological Survey, vol. ii.
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3237. Journal and Proceedings, vol. xl, 1906.

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3210. Bulletin, new series, nos. 3-4.

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2788. Cape Breton, Guelph, South Saskatchewan, South Alberta, and Grand Trunk Pacific topographic maps.
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(*C*) From Scientific Societies and Institutions

(*a*) *AMERICA*

UNIVERSITY OF TEXAS, AUSTIN

3384. Bulletin no. 93; Scientific series no. II.

BROOKLYN INSTITUTE OF ARTS AND SCIENCES, BROOKLYN

2553. Science Bulletin, vol. i, nos. 12-14.

COLORADO COLLEGE, COLORADO SPRINGS

3385. Colorado College Publications, Science series, vol. xii, nos. 1-5.
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CARNEGIE INSTITUTION, PITTSBURGH

3387. Memorial of the Celebration of the Carnegie Institution at Pittsburgh.

AUGUSTANA LIBRARY, ROCK ISLAND

3388. Publication no. 6.

(*b*) *EUROPE*

SCHLESISCHE GESELLSCHAFT FÜR VATERLÄNDISCHE CULTUR, BRESLAU

3231. Eighty-fourth Jahresbericht, 1905.

OBSERVATOIRE ROYAL DE BELGIQUE, BRUSSELS

3389. Annuaire Astronomique, 1907.
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INSTITUTUL GEOLOGIE AL ROUMANIEI, BUCHAREST

3232. Anuarul, vol. i, fasc. 1-2.
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DANSK GEOLOGISK FORENING, COPENHAGEN

2783. Meddelelser, nr. 13.

SENCKENBERGISCHEN NATURFORSCHENDEN GESELLSCHAFT, FRANKFURT AM MAIN

3390. Bericht, 1907.

MUSÉE TEYLER, HAARLEM

3391. Archives, serie ii, vol. xi, part 1.

LA SOCIÉTÉ PORTUGAISE DE SCIENCES NATURELLES, LISBON

3392. Bulletin, vol. i, fasc. 1-3.

ACADEMIE POLYTECHNICA, PORTO

3182. Annaes Scientificos, vol. ii, no. 4.
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CORPO REALE DELLE MINIERE, ROME

3354. Carta geologica delle Alpi Occidentali.

INSTITUT DES MINES DE L'IMPERATRICE CATHERINE II, SAINT PETERSBURG

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(c) *ASIA*

TOKYO GEOGRAPHICAL SOCIETY, TOKYO

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IMPERIAL UNIVERSITY OF TOKYO, TOKYO

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(*D*) From Fellows of the Geological Society of America (Personal Publications)

CROOK, A. R.

3393. A History of the Illinois State Museum of Natural History.

FAIRCHILD, H. L.

3394. Gilbert Gulf (Marine Waters in Ontario Basin).
3395. Drumlin Structure and Origin.

WALCOTT, CHARLES D.

3396. Cambrian Geology and Paleontology, nos. 3-4.

(*E*) From Miscellaneous Sources

HEIM, ALBRECHT

3397. Der Bau der Schweizeralpen.

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CLEVELAND ABBE, JR., Ph. D., Mount Weather, Va. August, 1899.

FRANK DAWSON ADAMS, Ph. D., Montreal, Canada; Professor of Geology in McGill University. December, 1889.

GEORGE I. ADAMS, Sc. D., Bureau of Mines, Manila, P. I. December, 1902.

JOSÉ GUADALUPE AGUILERA, City of Mexico, Mexico; Director del Instituto Geologico de Mexico. August, 1896.

TRUMAN H. ALDRICH, M. E., 1739 P St. N. W., Washington, D. C. May, 1889.

HENRY M. AMI, A. M., Montreal, Canada; Assistant Paleontologist on Geological and Natural History Survey of Canada. December, 1889.

FRANK M. ANDERSON, B. A., M. S., 2604 Ætna Street, Berkeley, Cal. California State Mining Bureau. June, 1902.

PHILIP ARGALL, 728 Majestic Building, Denver, Colo. August, 1896.

RALPH ARNOLD, Ph. D., Washington, D. C.; Geologic Aid, U. S. Geological Survey. December, 1904.

GEORGE HALL ASHLEY, M. E., Ph. D., Washington, D. C.; U. S. Geological Survey. August, 1895.

RUFUS MATHER BAGG, JR., Ph. D., 1048 Riverdale St., West Springfield, Mass. December, 1896.

HARRY FOSTER BAIN, M. S., Champaign, Ill.; State Geologist. December, 1895.

S. PRENTISS BALDWIN, 736 Prospect St., Cleveland, Ohio. August, 1895.

SYDNEY H. BALL, A. B., Washington, D. C.; Assistant Geologist, U. S. Geological Survey. December, 1905.

ERWIN HINCKLEY BARBOUR, Ph. D., Lincoln, Neb.; Professor of Geology, University of Nebraska, and Acting State Geologist. December, 1896.

ALFRED ERNEST BARLOW, B. A., M. A., D. Sc., Ottawa, Canada. December, 1906.

JOSEPH BARRELL, Ph. D., New Haven, Conn.; Professor of Structural Geology, Yale University. December, 1902.

GEORGE H. BARTON, B. S., Boston, Mass.; Curator, Boston Society of Natural History. August, 1890.

FLORENCE BASCOM, Ph. D., Bryn Mawr, Pa.; Professor of Geology, Bryn Mawr College. August, 1894.

RAY SMITH BASSLER, B. A., M. S., Ph. D., Washington, D. C.; U. S. National Museum. December, 1906.

WILLIAM S. BAYLEY, Ph. D., Urbana, Ill.; Assistant Professor of Geology, University of Illinois. December, 1888.

*GEORGE F. BECKER, Ph. D., Washington, D. C.; U. S. Geological Survey.

JOSHUA W. BEEDE, Ph. D., Bloomington, Ind.; Instructor in Geology, Indiana University. December, 1902.

ROBERT BELL, I. S. O., Sc. D., M. D., LL. D., F. R. S., Ottawa, Canada; Chief Geologist, Geological Survey, Department of Mines. May, 1889.

CHARLES P. BERKEY, Ph. D., New York city; Columbia University. August, 1901.

SAMUEL WALKER BEYER, Ph. D., Ames, Iowa; Assistant Professor in Geology, Iowa Agricultural College. December, 1896.

ARTHUR B. BIBBINS, Ph. B., Baltimore, Md.; Instructor in Geology, Woman's College. December, 1903.

ALBERT S. BICKMORE, Ph. D., New York city; Curator emeritus, Department of Public Instruction, American Museum of Natural History. December, 1889.

IRVING P. BISHOP, 109 Norwood Ave., Buffalo, N. Y.; Professor of Natural Science, State Normal and Training School. December, 1899.

JOHN M. BOUTWELL, M. S., Washington, D. C.; Assistant Geologist, U. S. Geological Survey. December, 1905.

JOHN ADAMS BOWNOCKER, D. Sc., Columbus, Ohio.; Professor of Inorganic Geology, Ohio State University. December, 1904.

*JOHN C. BRANNER, Ph. D., Stanford University, Cal.;. Professor of Geology in Leland Stanford, Jr., University.

ALBERT PERRY BRIGHAM, A. B., A. M., Hamilton, N. Y.; Professor of Geology and Natural History, Colgate University. December, 1893.

REGINALD W. BROCK, M. A., Ottawa, Canada; Acting Director, Geological Survey, Department of Mines. December, 1904.

ALFRED HULSE BROOKS, B. S., Washington, D. C.; Assistant Geologist, U. S. Geological Survey. August, 1899.

AMOS P. BROWN, Ph. D., Philadelphia, Pa.; Professor of Mineralogy and Geology, University of Pennsylvania. December, 1905.

ERNEST ROBERTSON BUCKLEY, Ph. D., Flat River, Mo. June, 1902.

*SAMUEL CALVIN, Iowa City, Iowa; Professor of Geology and Zoology in the State University of Iowa.

HENRY DONALD CAMPBELL, Ph. D., Lexington, Va.; Professor of Geology and Biology in Washington and Lee University. May, 1889.

MARIUS R. CAMPBELL, Washington, D. C.: U. S. Geological Survey. Aug., 1892.

FRANKLIN R. CARPENTER, Ph. D., 1420 Josephine St., Denver, Colo. May, 1889.

ERMINE C. CASE, Ph. D., Ann Arbor, Mich.; Department of Geology, University of Michigan. December, 1901.

*T. C. CHAMBERLIN, LL. D., Chicago, Ill.; Head Professor of Geology, University of Chicago.

CLARENCE RAYMOND CLAGHORN, B. S., M. E., Tacoma, Wash. August, 1891.

FREDERICK G. CLAPP, S. B., 610 Fitzsimons Building, Pittsburgh, Pa. Dec., 1905.

*WILLIAM BULLOCK CLARK, Ph. D., Baltimore, Md.; Professor of Geology in Johns Hopkins University; State Geologist.

JOHN MASON CLARKE, A. M., Albany, N. Y.; State Paleontologist. December, 1897.

HERDMAN F. CLELAND, Ph. D., Williamstown, Mass.; Professor of Geology, Williams College. December, 1905.

J. MORGAN CLEMENTS, Ph. D., 15 William St., New York city. December, 1894.

COLLIER COBB, A. B., A. M., Chapel Hill, N. C.; Professor of Geology in University of North Carolina. December, 1894.

ARTHUR P. COLEMAN, Ph. D., Toronto, Canada; Professor of Geology, Toronto University, and Geologist of Bureau of Mines of Ontario. December, 1896.

GEORGE L. COLLIE, Ph. D., Beloit, Wis.; Professor of Geology in Beloit College. December, 1897.

ARTHUR J. COLLIER, A. M., S. B., Brownfield, Me.; Assistant Geologist, U. S. Geological Survey. June, 1902.

*THEODORE B. COMSTOCK, Sc. D., Los Angeles, Cal.

EUGENE COSTE, B. ès-Sc., E. M., Toronto, Canada. December, 1906.

*FRANCIS W. CRAGIN, Ph. D., Colorado Springs, Colo.; Professor of Geology in Colorado College.

ALJA ROBINSON CROOK, Ph. D., Springfield, Ill.; State Museum of Natural History. December, 1898.

*WILLIAM O. CROSBY, B. S., Boston, Mass.; Professor of Geology in Massachusetts Institute of Technology.

WHITMAN CROSS, Ph. D., Washington, D. C.; U. S. Geological Survey. May, 1889.

GARRY E. CULVER, A. M., 1104 Wisconsin St., Stevens Point, Wis. December, 1891.

EDGAR R. CUMINGS, Ph. D., Bloomington, Ind.; Assistant Professor of Geology, Indiana University. August, 1901.

*HENRY P. CUSHING, M. S., Adelbert College, Cleveland, Ohio; Professor of Geology, Western Reserve University.

REGINALD A. DALY, Ph. D., Boston, Mass.; Massachusetts Institute of Technology. December, 1905.

*NELSON H. DARTON, Washington, D. C.; U. S. Geological Survey.

*WILLIAM M. DAVIS, S. B., M. E., Cambridge, Mass.; Sturgis-Hooper Professor of Geology in Harvard University.

DAVID T. DAY, Ph. D., Washington, D. C.; U. S. Geological Survey. Aug., 1891.

ORVILLE A. DERBY, M. S., No. 80 Rua Visconde do Rio Branco, Sao Paulo, Brazil. December, 1890.

*JOSEPH S. DILLER, B. S., Washington, D. C.; U. S. Geological Survey.

EDWARD V. D'INVILLIERS, E. M., 506 Walnut St., Philadelphia, Pa. Dec., 1888.

RICHARD E. DODGE, A. M., New York city; Professor of Geography in the Teachers' College. August, 1897.

NOAH FIELDS DRAKE, Ph. D., Tientsin, China; Professor of Geology in Imperial Tientsin University. December, 1898.

JOHN ALEXANDER DRESSER, B. A., M. A., Montreal, Canada; Department of Geology, McGill University. December, 1906.

CHARLES R. DRYER, M. A., M. D., Terre Haute, Ind.; Professor of Geography, Indiana State Normal School. August, 1897.

*EDWIN T. DUMBLE, 1306 Main St., Houston, Texas.

CLARENCE EDWARD DUTTON, A. B., Englewood, N. J.; Major, U. S. A. (Retired). December, 1907.

ARTHUR S. EAKLE, Ph. D., Berkeley, Cal.; Instructor in Mineralogy, University of California. December, 1899.

CHARLES R. EASTMAN, A. M., Ph. D., Cambridge, Mass.; In Charge of Vetebrate Paleontology, Museum of Comparative Zoology, Harvard University. December, 1895.

EDWIN C. ECKEL, B. S., C. E., Munsey Building, Washington, D. C. Dec., 1905.

ARTHUR H. ELFTMAN, Ph. D., 706 Globe Building, Minneapolis, Minn. December, 1898.

*BENJAMIN K. EMERSON, Ph. D., Amherst, Mass.; Professor in Amherst College.

*SAMUEL F. EMMONS, A. M., E. M., Washington, D. C.; U. S. Geological Survey.

JOHN EYERMAN, F. Z. S., Oakhurst, Easton, Pa. August, 1891.

HAROLD W. FAIRBANKS, B. S., Berkeley, Cal.; Geologist State Mining Bureau. August, 1892.

*HERMAN L. FAIRCHILD, B. S., Rochester, N. Y.; Professor of Geology in University of Rochester.

J. C. FALES, Danville, Ky.; Professor in Centre College. December, 1888.

OLIVER C. FARRINGTON, Ph. D., Chicago, Ill.; Curator of Geology, Field Museum of Natural History. December, 1895.

NEVIN M. FENNEMAN, Ph. D., Cincinnati, Ohio; Professor of Geology, University of Cincinnati. December, 1904.

AUGUST F. FOERSTE, Ph. D., 417 Grand Ave., Dayton, Ohio; Teacher of Sciences, Steele High School. December, 1899.

WILLIAM M. FONTAINE, A. M., Charlottesville, Va.; Professor of Natural History and Geology in University of Virginia. December, 1888.

*PERSIFOR FRAZER, D. ès-Sc. Nat., 1082 Drexel Building, Philadelphia, Pa.; Professor of Chemistry in Horticultural Society of Pennsylvania.

Myron Leslie Fuller, S. B., 104 Belmont Ave., Brockton, Mass. Dec., 1898.

Henry Stewart Gane, Ph. D., Santa Barbara, Cal. December, 1896.

Henry Gannett, S. B., A. Met. B., Washington, D. C.; U. S. Geological Survey. December, 1891.

Russell D. George, A. B., A. M., Boulder, Colo.; Professor of Geology, University of Colorado. December, 1906.

*Grove K. Gilbert, A. M., LL. D., Washington, D. C.; U. S. Geological Survey.

Adam Capen Gill, Ph. D., Ithaca, N. Y.; Assistant Professor of Mineralogy and Petrography in Cornell University. December, 1888.

L. C. Glenn, Ph. D., Nashville, Tenn.; Professor of Geology in Vanderbilt University. June, 1900.

Charles H. Gordon, Ph. D., Knoxville, Tenn.; Professor of Geology and Mineralogy in the University of Tennessee. August, 1893.

Charles Newton Gould, A. M., Norman, Okla.; Professor of Geology, University of Oklahoma. December, 1904.

Amadeus W. Grabau, S. M., S. D., New York city; Professor of Paleontology, Columbia University. December, 1898.

Ulysses Sherman Grant, Ph. D., Evanston, Ill.; Professor of Geology, Northwestern University. December, 1890.

Herbert E. Gregory, Ph. D., New Haven, Conn.; Silliman Professor of Geology, Yale University. August, 1901.

George P. Grimsley, Ph. D., Morgantown, W. Va.; Assistant State Geologist. Geological Survey of West Virginia. August, 1895.

Leon S. Griswold, A. B., Rolla, Missouri. August, 1902.

Frederic P. Gulliver, Ph. D., Norwichtown, Conn. August, 1895.

Arnold Hague, Ph. B., Washington, D. C.; U. S. Geological Survey. May, 1889.

*Christopher W. Hall, A. M., 803 University Ave., Minneapolis, Minn.; Professor of Geology and Mineralogy in University of Minnesota.

Gilbert D. Harris, Ph. B., Ithaca, N. Y.; Assistant Professor of Paleontology and Stratigraphic Geology, Cornell University. December, 1903.

John Burchmore Harrison, M. A., F. I. C., F. G. S., Georgetown, British Guiana; Government Geologist. June, 1902.

John B. Hastings, M. E., 1480 High St., Denver, Colo. May, 1889.

*Erasmus Haworth, Ph. D., Lawrence, Kans.; Professor of Geology, University of Kansas.

C. Willard Hayes, Ph. D., Washington, D. C.; U. S. Geological Survey. May, 1889.

Richard R. Hice, B. S., Beaver, Pa. December, 1903.

*Eugene W. Hilgard, Ph. D., LL. D., Berkeley, Cal.; Professor of Agriculture in University of California.

Frank A. Hill, Roanoke, Va. May, 1889.

*Robert T. Hill, B. S., 25 Broad St., New York city.

Richard C. Hills, Denver, Colo. August, 1894.

*Charles H. Hitchcock, Ph. D., LL. D., Honolulu, Hawaiian Islands; Professor Emeritus of Geology in Dartmouth College, Hanover, N. H.

William Herbert Hobbs, Ph. D., Ann Arbor, Mich.; Professor of Geology, University of Michigan; Assistant Geologist, U. S. Geological Survey. August, 1891.

*Levi Holbrook, A. M., P. O. Box 536, New York city.

Arthur Hollick, Ph. B., Bronx Park, New York; Assistant Curator, Department of Fossil Botany, New York Botanical Garden. August, 1893.

*Joseph A. Holmes, Washington, D. C.; in charge of investigation of fuels and structural materials, U. S. Geological Survey.

THOMAS C. HOPKINS, Ph. D., Syracuse, N. Y.; Professor of Geology, Syracuse University. December, 1894.

*EDMUND OTIS HOVEY, Ph. D., New York city; Associate Curator of Geology, American Museum of Natural History.

*HORACE C. HOVEY, D. D., Newburyport, Mass.

ERNEST HOWE, Ph. D., Newport, R. I.; Assistant Geologist, U. S. Geological Survey. December, 1903.

*EDWIN E. HOWELL, A. M., 612 Seventeenth St. N. W., Washington, D. C.

LUCIUS L. HUBBARD, Ph. D., LL. D., Houghton, Mich. December, 1894.

ELLSWORTH HUNTINGTON, A. B., A. M., Milton, Mass. December, 1906.

JOSEPH P. IDDINGS, Ph. B., Chicago, Ill.; Professor of Petrographic Geology, University of Chicago. May, 1889.

JOHN D. IRVING, Ph. D., New Haven, Conn.; Professor of Economic Geology, Yale University. December, 1905.

A. WENDELL JACKSON, Ph. B., 432 Saint Nicholas Ave., New York city. December, 1888.

ROBERT T. JACKSON, S. D., 9 Fayerweather St., Cambridge, Mass.; Assistant Professor in Paleontology in Harvard University. August, 1894.

THOMAS M. JACKSON, C. E., S. D., Clarksburg, W. Va. May, 1889.

THOMAS AUGUSTUS JAGGAR, JR., A. B., A. M., Ph. D., Boston, Mass.; Professor of Geology, Massachusetts Institute of Technology. December, 1906.

MARK S. W. JEFFERSON, A. M., Ypsilanti, Mich.; Professor of Geography, Michigan State Normal College. December, 1904.

DOUGLAS WILSON JOHNSON, B. S., Ph. D., Cambridge, Mass.; Assistant Professor of Physiography, Harvard University. December, 1906.

ALEXIS A. JULIEN, Ph. D., New York city; Curator in Geology in Columbia University. May, 1889.

ARTHUR KEITH, A. M., Washington, D. C.; U. S. Geological Survey. May, 1889.

*JAMES F. KEMP, A. B., E. M., New York city; Professor of Geology in Columbia University.

CHARLES ROLLIN KEYES, Ph. D., 944 Fifth St., Des Moines, Iowa. August, 1890.

EDWARD M. KINDLE, Ph. D., Washington, D. C.; Assistant Geologist, U. S. Geological Survey. December, 1905.

FRANK H. KNOWLTON, M. S., Washington, D. C.; Assistant Paleontologist, U. S. Geological Survey. May, 1889.

EDWARD HENRY KRAUS, Ph. D., Ann Arbor, Mich.; Junior Professor of Mineralogy, University of Michigan. June, 1902.

HENRY B. KUMMEL, Ph. D., Trenton, N. J.; State Geologist. December, 1895.

*GEORGE F. KUNZ, A. M. (Hon.), Ph. D. (Hon.), care of Tiffany & Co., Fifth avenue, at 37th street, New York city.

GEORGE EDGAR LADD, Ph. D., Rolla, Mo.; Director School of Mines. August, 1891.

J. C. K. LAFLAMME, M. A., D. D., Quebec, Canada; Professor of Mineralogy and Geology in Laval University, Quebec. August, 1890.

ALFRED C. LANE, Ph. D., Lansing, Mich.; State Geologist. December, 1889.

DANIEL W. LANGTON, Ph. D., Fuller Building, New York city. December, 1889.

ANDREW C. LAWSON, Ph. D., Berkeley, Cal.; Professor of Geology and Miner alogy in the University of California. May, 1889.

WILLIS THOMAS LEE, M. S., Washington, D. C.; Assistant Geologist, U. S. Geological Survey. December, 1903.

CHARLES K. LEITH, Ph. D., Madison, Wis.; Professor of Geology, University of Wisconsin; Assistant Geologist, U. S. Geological Survey. December, 1902.

ARTHUR G. LEONARD, Ph. D., Grand Forks, N. Dak.; Professor of Geology and State Geologist, State University of North Dakota. December, 1901.

FRANK LEVERETT, B. S., Ann Arbor, Mich.; Geologist, U. S. Geological Survey. August, 1890.

JOSEPH VOLNEY LEWIS, B. E., S. B., New Brunswick, N. J.; Professor of Geology, Rutgers College. December, 1906.

WILLIAM LIBBEY, Sc. D., Princeton, N. J.; Professor of Physical Geography in Princeton University. August, 1899.

WALDEMAR LINDGREN, M. E., Washington, D. C.; U. S. Geological Survey. August, 1890.

GEORGE DAVIS LOUDERBACK, Ph. D., Berkeley, Cal.; Associate Professor of Geology, University of California. June, 1902.

ROBERT H. LOUGHRIDGE, Ph. D., Berkeley, Cal.; Assistant Professor of Agricultural Chemistry in University of California. May, 1889.

ALBERT P. LOW, B. A. Sc., LL. D., Ottawa, Canada; Deputy Minister, Department of Mines. December, 1905.

THOMAS H. MACBRIDE, A. M., Iowa City, Iowa; Professor of Botany in the State University of Iowa. May, 1889.

HIRAM DEYER MCCASKEY, B. S., Washington, D. C.; U. S. Geological Survey. December, 1904.

RICHARD G. MCCONNELL, A. B., Ottawa, Canada; Geologist on Geological and Natural History Survey of Canada. May, 1889.

JAMES RIEMAN MACFARLANE, A. B., 100 Diamond St., Pittsburg, Pa. August 1891.

*W J MCGEE, LL. D., Washington, D. C.; Inland Waterways Commission.

WILLIAM MCINNES, A. B., Ottawa, Canada; Geologist, Geological and Natural History Survey of Canada. May, 1889.

PETER MCKELLAR, Fort William, Ontario, Canada. August, 1890.

CURTIS F. MARBUT, A. M., Columbia, Mo.; Instructor in Geology in State University and Assistant on Missouri Geological Survey. August, 1897.

VERNON F. MARSTERS, A. M., Apartado 856, Lima, Peru. August, 1892.

GEORGE CURTIS MARTIN, Ph. D., Washington, D. C.; U. S. Geological Survey. June, 1902.

EDWARD B. MATHEWS, Ph. D., Baltimore, Md.; Professor of Mineralogy and Petrography in Johns Hopkins University. August, 1895.

W. D. MATTHEW, Ph. D., New York city; Associate Curator of Vertebrate Paleontology, American Museum of Natural History. December, 1903.

P. H. MELL, M. E., Ph. D., Clemson College, S. C.; President of Clemson College. December, 1888.

WALTER C. MENDENHALL, B. S., Washington, D. C.; Geologist, U. S. Geological Survey. June, 1902.

JOHN C. MERRIAM, Ph. D., Berkeley, Cal.; Instructor in Paleontology in University of California. August, 1895.

*FREDERICK J. H. MERRILL, Ph. D., New Rochelle, N. Y.

GEORGE P. MERRILL, Ph. D., Washington, D. C.; Curator of Department of Lithology and Physical Geology in U. S. National Museum. Dec., 1888.

ARTHUR M. MILLER, A. M., Lexington, Ky.; Professor of Geology, State University of Kentucky. December, 1897.

BENJAMIN L. MILLER, Ph. D., South Bethlehem, Pa.; Professor of Geology, Lehigh University. December, 1904.

WILLET G. MILLER, M. A., Toronto, Canada; Provincial Geologist of Ontario. December, 1902.

HENRY MONTGOMERY, Ph. D., Toronto, Canada; Curator of Museum, University of Toronto. December, 1904.

*FRANK L. NASON, A. B., West Haven, Conn.

DAVID HALE NEWLAND, B. A., Albany, N. Y.; Assistant State Geologist. December, 1906.

JOHN F. NEWSOM, Ph. D., Stanford University, Cal.; Associate Professor of Mining in Leland Stanford, Jr., University. December, 1899.

WILLIAM H. NILES, Ph. B., M. A., Boston, Mass.; Professor Emeritus of Geology, Massachusetts Institute of Technology; Professor of Geology, Wellesley College. August, 1891.

WILLIAM H. NORTON, M. A., Mount Vernon, Iowa; Professor of Geology in Cornell College. December, 1895.

CHARLES J. NORWOOD, Lexington, Ky.; Professor of Mining, State University of Kentucky. August, 1894.

IDA HELEN OGILVIE, A. B., Ph. D., New York city; Tutor in Geology, Barnard College, Columbia University. December, 1906.

CLEOPHAS C. O'HARRA, Ph. D., Rapid City, S. Dak.; Professor of Mineralogy and Geology, South Dakota School of Mines. December, 1904.

EZEQUIEL ORDONEZ, 2 a General Prine, Mexico, D. F., Mex. August, 1896.

*AMOS O. OSBORN, Waterville, Oneida county, N. Y.

HENRY F. OSBORN, Sc. D., New York city; President of the American Museum of Natural History. August, 1894.

CHARLES PALACHE, B. S., Cambridge, Mass.; Instructor in Mineralogy, Harvard University. August, 1897.

WILLIAM A. PARKS, B. A., Ph. D., Toronto, Canada; Associate Professor of Geology, University of Toronto. December, 1906.

*HORACE B. PATTON, Ph. D., Golden, Colo.; Professor of Geology and Mineralogy in Colorado School of Mines.

FREDERICK B. PECK, Ph. D., Easton, Pa.; Professor of Geology and Mineralogy, Lafayette College. August, 1901.

RICHARD A. F. PENROSE, JR., Ph. D., 460 Bullitt Building, Philadelphia, Pa. May, 1889.

DAVID PEARCE PENHALLOW, B. S., M. S., Sc. D., Montreal, Canada; Professor of Botany in McGill University. December, 1907.

GEORGE H. PERKINS, Ph. D., Burlington, Vt.; State Geologist; Professor of Geology, University of Vermont. June, 1902.

JOSEPH H. PERRY, 276 Highland St., Worcester, Mass. December, 1888.

LOUIS V. PIRSSON, Ph. D., New Haven, Conn.; Professor of Physical Geology, Sheffield Scientific School of Yale University. August, 1894.

*JULIUS POHLMAN, M. D., University of Buffalo, Buffalo, N. Y.

JOSEPH HYDE PRATT, Ph. D., Chapel Hill, N. C.; Mineralogist, North Carolina Geological Survey. December, 1898.

*CHARLES S. PROSSER, M. S., Columbus, Ohio; Professor of Geology in Ohio State University.

*RAPHAEL PUMPELLY, Newport, R. I.

ALBERT HOMER PURDUE, B. A., Fayetteville, Ark.; Professor of Geology, University of Arkansas. December, 1904.

FREDERICK LESLIE RANSOME, Ph. D., Washington, D. C.; Geologist, U. S. Geological Survey. August, 1895.

PERCY EDWARD RAYMOND, B. A., Ph. D., Pittsburgh, Pa.; Assistant Curator of Invertebrate Fossils in the Carnegie Museum. December, 1907.

HARRY FIELDING REID, Ph. D., Baltimore, Md.; Professor of Geological Physics, Johns Hopkins University. December, 1892.

WILLIAM NORTH RICE, Ph. D., LL. D., Middletown, Conn.; Professor of Geology in Wesleyan University. August, 1890.

CHARLES H. RICHARDSON, Ph. D., Syracuse, N. Y.; Assistant Professor of Geology and Mineralogy, Syracuse University. December, 1899.

HEINRICH RIES, Ph. D., Ithaca, N. Y.; Professor of Economic Geology in Cornell University. December, 1893.

RUDOLPH RUEDEMANN, Ph. D., Albany, N. Y.; Assistant State Paleontologist. December, 1905.

ORESTES H. ST. JOHN, 1318 West 6th St., Topeka, Kansas. May, 1889.

*ROLLIN D. SALISBURY, A. M., Chicago, Ill.; Professor of General and Geographic Geology in University of Chicago.

FREDERICK W. SARDESON, Ph. D., Minneapolis, Minn.; Assistant Professor of Geology, University of Minnesota. December, 1892.

THOMAS EDMUND SAVAGE, A. B., B. S., M. S., Urbana, Ill.; Department of Geology, University of Illinois. December, 1907.

FRANK C. SCHRADER, M. S., A. M., Washington, D. C.; U. S. Geological Survey. August, 1901.

CHARLES SCHUCHERT, New Haven, Conn.; Professor of Paleontology, Yale University. August, 1895.

WILLIAM B. SCOTT, Ph. D., 56 Bayard Ave., Princeton, N. J.; Blair Professor of Geology in Princeton University. August, 1892.

ARTHUR EDMUND SEAMAN, B. S., Houghton, Mich.; Professor of Mineralogy and Geology, Michigan College of Mines. December, 1904.

HENRY M. SEELY, M. D., Middlebury, Vt.; Professor of Geology in Middlebury College. May, 1899.

ELIAS H. SELLARDS, Ph. D., Tallahassee, Fla.; State Geologist. December, 1905.

GEORGE BURBANK SHATTUCK, Ph. D., Poughkeepsie, N. Y.; Professor of Geology in Vassar College. August, 1899.

SOLON SHEDD, A. B., Pullman, Wash.; Professor of Geology and Mineralogy, Washington Agricultural College. December, 1904.

EDWARD M. SHEPARD, Sc. D., Springfield, Mo.; Professor of Geology, Drury College. August, 1901.

WILL H. SHERZER, M. S., Ypsilanti, Mich.; Professor in State Normal School. December, 1890.

BOHUMIL SHIMEK, C. E., M. S., Iowa City, Iowa; Professor of Physiological Botany, University of Iowa. December, 1904.

*FREDERICK W. SIMONDS, Ph. D., Austin, Texas; Professor of Geology in University of Texas.

WILLIAM JOHN SINCLAIR, B. S., Ph. D., Princeton, N. J.; Instructor in Princeton University. December, 1906.

*EUGENE A. SMITH, Ph. D., University, Tuscaloosa county, Ala.; State Geologist and Professor of Chemistry and Geology in University of Alabama.

FRANK CLEMES SMITH, E. M., Richland Center, Wis. December, 1898.

GEORGE OTIS SMITH, Ph. D., Washington, D. C.; Director, U. S. Geological Survey. August, 1897.

WILLIAM S. T. SMITH, Ph. D., 839 Lake St., Reno, Nev.; Associate Professor of Geology and Mineralogy, University of Nevada. June, 1902.

*JOHN C. SMOCK, Ph. D., Trenton, N. J.

CHARLES H. SMYTH, JR., Ph. D., Princeton, N. J.; Professor of Geology in Princeton University. August, 1892.

HENRY L. SMYTH, A. B., Cambridge, Mass.; Professor of Mining and Metallurgy in Harvard University. August, 1894.

ARTHUR COE SPENCER, B. S., Ph. D., Washington, D. C.; Assistant Geologist, U. S. Geological Survey. December, 1896.

*J. W. SPENCER, Ph. D., 2019 Hillyer Place, Washington, D. C.

JOSIAH E. SPURR, A. B., A. M., 165 Broadway, New York, N. Y. Dec., 1894.

JOSEPH STANLEY-BROWN, Cold Spring Harbor, Long Island, N. Y. August, 1892.

TIMOTHY WILLIAM STANTON, B. S., U. S. National Museum, Washington, D. C.; Assistant Paleontologist, U. S. Geological Survey. August, 1891.

*JOHN J. STEVENSON, Ph. D., LL. D., 568 West End avenue, New York, N. Y.

WILLIAM J. SUTTON, B. S., E. M., Victoria, B. C.; Geologist to E. and N. Railway Co. August, 1901.

JOSEPH A. TAFF, B. S., Washington, D. C.; Assistant Geologist, U. S. Geological Survey. August, 1895.

JAMES E. TALMAGE, Ph. D., Salt Lake City, Utah; Professor of Geology in University of Utah. December, 1897.

RALPH S. TARR, Ithaca, N. Y.; Professor of Dynamic Geology and Physical Geography in Cornell University. August, 1890.

FRANK B. TAYLOR, Fort Wayne, Ind. December, 1895.

WILLIAM G. TIGHT, M. S., Albuquerque, N. Mex.; President and Professor of Geology, University of New Mexico. August, 1897.

*JAMES E. TODD, A. M., 113 Park St., Lawrence, Kas.; Assistant Geologist, U. S. Geological Survey.

*HENRY W. TURNER, B. S., Room 709, Mills Building, San Francisco, Cal.

JOSEPH B. TYRRELL, M. A., B. Sc., 9 Toronto St., Toronto, Canada. May, 1889.

JOHAN A. UDDEN, A. M., Rock Island, Ill.; Professor of Geology and Natural History in Augustana College. August, 1897.

EDWARD O. ULRICH, D. Sc., Washington, D. C.; Assistant Geologist, U. S. Geological Survey. December, 1903.

*WARREN UPHAM, A. M., Saint Paul, Minn.; Librarian Minnesota Historical Society.

*CHARLES R. VAN HISE, M. S., Ph. D., Madison, Wis.; President University of Wisconsin; Geologist, U. S. Geological Survey.

FRANK ROBERTSON VAN HORN, Ph. D., Cleveland, Ohio; Professor of Geology and Mineralogy, Case School of Applied Science. December, 1898.

GILBERT VAN INGEN, Princeton, N. J.; Curator of Invertebrate Paleontology and Assistant in Geology, Princeton University. December, 1904.

THOMAS WAYLAND VAUGHN, B. S., A. M., Washington, D. C.; Assistant Geologist, U. S. Geological Survey. August, 1896.

ARTHUR CLIFFORD VEACH, Washington, D. C.; Geologist, U. S. Geological Survey. December, 1906.

*ANTHONY W. VOGDES, 2425 First St., San Diego, Cal.; Brigadier General, U. S. A. (Retired).

*M. EDWARD WADSWORTH, Ph. D., Pittsburgh, Pa.; Dean of the School of Mines in the University of Pittsburgh.

*CHARLES D. WALCOTT, LL. D., Washington, D. C.; Secretary Smithsonian Institution.

THOMAS L. WALKER, Ph. D., Toronto, Canada; Professor of Mineralogy and Petrography, University of Toronto. December, 1903.

CHARLES H. WARREN, Ph. D., Boston, Mass.; Instructor in Geology, Massachusetts Institute of Technology. December, 1901.

HENRY STEPHENS WASHINGTON, Ph. D., Locust, Monmouth Co., N. J.; August, 1896.

THOMAS L. WATSON, Ph. D., Charlottesville, Va.; Professor of Geology in University of Virginia. June, 1900.

WALTER H. WEED, E. M., Norwalk, Conn. May, 1889.

FRED. BOUGHTON WEEKS, Washington, D. C.; Assistant Geologist, U. S. Geological Survey. December, 1903.

SAMUEL WEIDMAN. Ph. D., Madison, Wis.; Geologist, Wisconsin Geological and Natural History Survey. December, 1903.

STUART WELLER, B. S., Chicago, Ill.; Associate Professor of Paleontologic Geology, University of Chicago. June, 1900.

LEWIS G. WESTGATE, Ph. D., Delaware, Ohio; Professor of Geology, Ohio Wesleyan University.

THOMAS C. WESTON, care of A. Patton, Levis, Quebec, Canada. August, 1893.

DAVID WHITE, B. S., U. S. National Museum, Washington, D. C.; Geologist, U. S. Geological Survey. May, 1889.

*ISRAEL C. WHITE, Ph. D., Morgantown, W. Va.

*ROBERT P. WHITFIELD, A. M., New York city; Curator of Geology and Paleontology, American Museum of Natural History.

FRANK A. WILDER, Ph. D., North Holston, Smyth Co., Va. December, 1905.

*EDWARD H. WILLIAMS, JR., A. C., E. M., Andover, Mass.

*HENRY S. WILLIAMS, Ph. D., Ithaca, N. Y.; Professor of Geology and Head of Geological Department, Cornell University.

IRA A. WILLIAMS, M. Sc., Ames, Iowa; Teacher Iowa State College. December, 1905.

BAILEY WILLIS, Washington, D. C.; U. S. Geological Survey. December, 1889.

SAMUEL W. WILLISTON, Ph. D., M. D., Chicago, Ill.; Professor of Paleontology, University of Chicago. December, 1889.

ARTHUR B. WILLMOTT, M. A., Sault Ste. Marie, Ontario, Canada. December, 1899.

ALFRED W. G. WILSON, Ph. D., 197 Park Ave., Montreal, Ontario, Canada. June, 1902.

ALEXANDER N. WINCHELL, Doct. U. Paris, Madison, Wis.; Professor of Geology and Mineralogy, University of Wisconsin. August, 1901.

*HORACE VAUGHN WINCHELL, 505 Palace Building, Minneapolis, Minn.

*NEWTON H. WINCHELL, A. M., Minneapolis, Minn.

*ARTHUR WINSLOW, B. S., 131 State St., Boston, Mass.

JOHN E. WOLFF, Ph. D., Cambridge, Mass.; Professor of Petrography and Mineralogy in Harvard University and Curator of the Mineralogical Museum. December, 1889.

JOSEPH E. WOODMAN, S. D., Halifax, N. S.; Assistant Professor of Geology and Mineralogy, Dalhousie University. December, 1905.

ROBERT S. WOODWARD, C. E., Washington, D. C.; President of the Carnegie Institution of Washington. May, 1889.

JAY B. WOODWORTH, B. S., 24 Langdon St., Cambridge, Mass.; Assistant Professor of Geology, Harvard University. December, 1895.

FREDERIC E. WRIGHT, Ph. D., Washington, D. C.; Geo-physical Laboratory, Carnegie Institution. December, 1903.

*G. FREDERICK WRIGHT, D. D., Oberlin, Ohio; Professor in Oberlin Theological Seminary.

GEORGE A. YOUNG, Ph. D., Ottawa, Canada; Geologist, Geological Survey of Canada. December, 1905.

FELLOWS DECEASED

*Indicates Original Fellow (see article III of Constitution)

*CHARLES A. ASHBURNER, M. S., C. E. Died December 24, 1889.

CHARLES E. BEECHER, Ph. D. Died February 14, 1904.

AMOS BOWMAN. Died June 18, 1894.

*J. H. CHAPIN, Ph. D. Died March 14, 1892.

*EDWARD W. CLAYPOLE, D. Sc. Died August 17, 1901.

GEORGE H. COOK, Ph. D., LL. D. Died September 22, 1889.

*EDWARD D. COPE, Ph. D. Died April 12, 1897.

ANTONIO DEL CASTILLO. Died October 28, 1895.

*JAMES D. DANA, LL. D. Died April 14, 1895.

George M. Dawson, D. Sc. Died March 2, 1901.
Sir J. William Dawson, LL. D. Died November 19, 1899.
*William B. Dwight, Ph. B. Died August 29, 1906.
*George H. Eldridge, A. B. Died June 29, 1905.
*Albert E. Foote. Died October 10, 1895.
*Homer T. Fuller. Died August 14, 1908.
N. J. Giroux, C. E. Died November 30, 1890.
*James Hall, LL. D. Died August 7, 1898.
John B. Hatcher, Ph. B. Died July 3, 1904.
*Robert Hay. Died December 14, 1895.
*Angelo Heilprin. Died July 17, 1907.
David Honeyman, D. C. L. Died October 17, 1889.
Thomas Sterry Hunt, D. Sc., LL. D. Died February 12, 1892.
*Alpheus Hyatt, B. S. Died January 15, 1902.
*Joseph F. James, M. S. Died March 29, 1897.
Wilbur C. Knight, B. S., A. M. Died July 28, 1903.
Ralph D. Lacoe. Died February 5, 1901.
*Joseph Le Conte, M. D., LL. D. Died July 6, 1901.
*J. Peter Lesley, LL. D. Died June 2, 1903.
Henry McCalley, A. M., C. E. Died November 20, 1904.
Oliver Margy, LL. D. Died March 19, 1899.
Othniel C. Marsh, Ph. D., LL. D. Died March 18, 1899.
James E. Mills, B. S. Died July 25, 1901.
*Henry B. Nason, M. D., Ph. D., LL. D. Died January 17, 1895.
*Peter Neff, M. A. Died May 11, 1903.
*John S. Newberry, M. D., LL. D. Died December 7, 1892.
*Edward Orton, Ph. D., LL. D. Died October 16, 1899.
*Richard Owen, LL. D. Died March 24, 1890.
Samuel L. Penfield. Died August 14, 1906.
*Franklin Platt. Died July 24, 1900.
William H. Pettee, A. M. Died May 26, 1904.
*John Wesley Powell, LL. D. Died September 23, 1902.
*Israel C. Russell, LL. D. Died May 1, 1906.
*James M. Safford, M. D., LL. D. Died July 3, 1907.
*Charles Schaeffer, M. D. Died November 23, 1903.
*Nathaniel S. Shaler, LL. D. Died April 10, 1906.
Charles Wachsmuth. Died February 7, 1896.
Theodore G. White, Ph. D. Died July 7, 1901.
*George H. Williams, Ph. D. Died July 12, 1894.
*J. Francis Williams, Ph. D. Died November 9, 1891.
*Alexander Winchell, LL. D. Died February 19, 1891.
Albert A. Wright, Ph. D. Died April 2, 1905.
William S. Yeates. Died February 19, 1908.

Summary

Original Fellows	59
Elected Fellows	239
Membership	298
Deceased Fellows	52