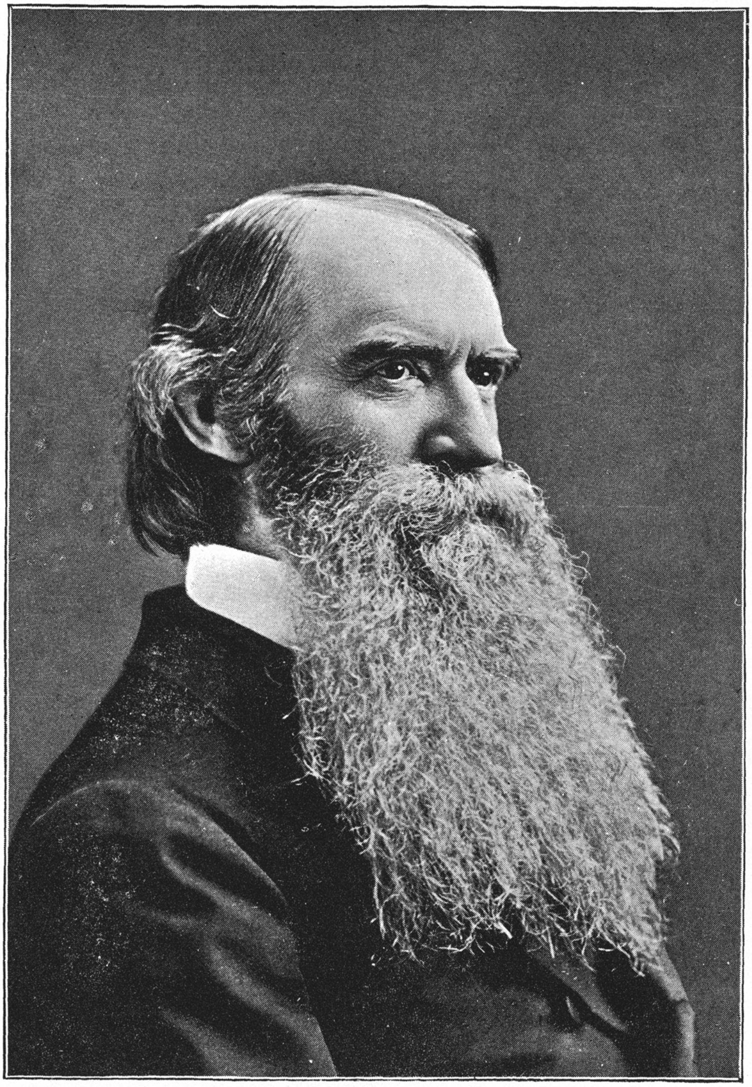

Bull. Geol. Soc. Am., Vol. 4, 1892.

BULLETIN OF THE GEOLOGICAL SOCIETY OF AMERICA
VOL. 4, PP. 371-458, FRONTISPIECE SEPTEMBER 23, 1893

PROCEEDINGS OF THE FIFTH ANNUAL MEETING, HELD AT OTTAWA, CANADA, DECEMBER 28, 29 AND 30, 1892

HERMAN LEROY FAIRCHILD, *Secretary*

CONTENTS

Session of Wednesday, December 28

The Society met in the railway committee-room of the House of Commons. President G. K. Gilbert presided during the several sessions of the meeting.

At 10.20 a m the President called the Society to order and after a word of salutation introduced His Excellency, the Governor-General of Canada, Sir Frederick Arthur Stanley, who extended a hearty welcome to the Fellows of the Society. Science, he said, was cosmopolitan and did not admit of distinctions of race, creed or national boundary; as far as science was concerned, all were one brotherhood. He assured the visitors that they would be shown every hospitality while in the city. The President made reply to the welcome of His Excellency, referring in complimentary terms to Canadian hospitality.

The Council report was read by the Secretary as follows:

REPORT OF THE COUNCIL

To the Fellows of the Geological Society of America,
in Fifth Annual Meeting, 1892:

Meetings of the Council.—During the past year the Council has held two meetings, coincident with the meetings of the Society, each with four sessions. A large amount of administrative business has been done, with earnestness and unity.

Meetings of the Society.—The records of the two meetings held during the year, at Columbus and Rochester, will be found in full in the printed proceedings of the Bulletin.

The attendance has been small, at Columbus twenty-three and at Rochester thirty-four. The prosperity and success of the Society is, however, not dependent upon the size of its meetings. The brief experience would seem to indicate that a larger attendance would be secured at the great cities of the east, but as an international society it would not be proper to localize its sessions for the sake of larger meetings.

Membership.—The Society has lost three Fellows during the year by death: Dr J. S. Newberry, Dr T. Sterry Hunt and Professor J. H. Chapin. Four names have been dropped, by application of the rules, for nonpayment of dues. The latest printed roll of membership bears the names of 209 living and 9 deceased Fellows. At the summer meeting 13 men were elected, of whom 12 have qualified, namely: A. E. Barlow, H. P. H. Brumell, M. R. Campbell, A. del Castillo, H. W. Fairbanks, L. S. Griswold, A. P. Low, V. F. Marsters, W. B Scott, C. H. Smyth, Jr.,

J. Stanley-Brown, C. L. Whittle. From the list will be taken one name by resignation and one for delinquency, leaving a total fellowship of 219. Three elections are announced at this meeting: Professor H. F. Reid, Mr. F. W. Sardeson and Mr J. F. Whiteaves.

Nine nominations are before the Council.

After long and serious consideration the Council has determined not to present any names for Correspondents at the present time.

Bulletin Publication.—Volume 3 has been distributed to all Fellows, subscribers and exchanges direct from the Secretary's office. The cost of the volume is given later in this report. The proceedings of the summer meeting, making the first two brochures of volume 4, are almost ready for distribution.

Bulletin Distribution.—The following tables show the distribution of the three volumes. In explanation it should be said that the edition of volume 1 was only five hundred copies, and that the first two volumes were sent to the Fellows directly from the printers; also that the stock of volume 3 has not been wholly unpacked. It is found more convenient to make the tables cover the whole distribution from the Secretary's office during the past two years. A comparison of last year's report with this will give the details for the past year.

Bulletin Distribution from the Secretary's Office During 1891 and 1892

BY COMPLETE VOLUMES

	Vol. 1.	Vol. 2.	Vol. 3.
In reserve	102	346	395(?)
Donated to institutions ("exchanges")	81	81	81
Held for "exchanges"	10	10	10
Sold to Libraries, etc	54	55	53
Sold to Fellows	11	9	
Sent to Fellows to supply deficiencies	2	1	
Donated by Council	3	3	1
Bound for office use	1	1	1
Sent to Fellows in brochures, as issued			209
Number of complete copies received	264	506	750(?)

BY BROCHURES

		Vol. 1.	Vol. 2.	Vol. 3.
Sent to Fellows to supply deficiencies	to 8 Fellows	39		
	to 29 Fellows		90	
	to 7 Fellows			13
Sold to Fellows		5	3	
Sold to the public		2		4
	(to 9 persons)		17	

Bulletin Sales.—As announced by the Secretary, in January, a circular letter advertising the Bulletin was sent to several hundred libraries in the United States and Canada. Subscriptions have been received from about thirty libraries, and a large number of irregular sales effected. A set of books kept by the Secretary shows the details. The financial result is given in the following tables:

Receipts from sale of Bulletin during 1892

BY SALE OF COMPLETE VOLUMES

	Vol. 1.	Vol. 2.	Vol. 3.	Total.	
From Fellows	$14 50	$19 00	$4 50	$38 00	
From libraries, etc.	170 00	175 00	142 00	487 00	
Total	$184 50	$194 00	$146 50	$525 00	
By last report (1891)	115 10	102 50		217 60	
Second total	$299 60	$296 50	$146 50		$742 60

BY SALE OF BROCHURES

	Vol. 1.	Vol. 2.	Vol. 3.	Total.	
From Fellows		$0 50		$0 50	
From the public	$1 40	60	$2 65	4 65	
Total	$1 40	$1 10	$2 65	$5 15	
By last report (1891)	3 15	4 95		8 10	
Second total	$4 55	$6 05	$2 65		$13 25

Grand total	$755 85
Received for volume 4, in advance	15 00
Receipts to date	$770 85
Amount uncollected	170 45
Bulletin sales to date	$941 30

"*Exchanges.*"—The list of institutions to which the Bulletin is donated is not materially different from that of the last report. Seventy-nine institutions have been placed on the list.

Library.—The material received in return for the Bulletin, mostly from foreign soeieties, makes about 100 volumes, entire or fractional. This is chiefly geological matter and should be useful to the Fellows as soon as it can be made accessible. The Council has not yet acted under the authority conferred at the last annual meeting, empowering it to select a depository for this accumulating material, but the matter is in the hands of a committee and such selection will probably soon be made.

The matter collected by Professor Hitchcock is as follows:

A complete set of the Reports of the Second Geological Survey of Pennsylvania, 115 volumes and several elephant folio atlases.

Reports of the Geological Surveys of other States as follows: Illinois, 8 volumes; Ohio, 8 volumes; Arkansas, 7 volumes; Texas, 2 volumes; California, 9 volumes and pamphlets.

Tenth Annual Report of the U. S. Geological Survey, and Bulletins 62–81.

Miscellaneous books, 15; pamphlets, 225, largely authors' copies, especially of the younger Fellows. Several lists of publications of individual Fellows.

A few volumes from exchanges, and about 30 duplicates.

The number of contributors, 36.

Photographs of 35 Fellows.

Two large maps of the United States, made for the Society. Crayon portrait of Alexander Winchell.

Finances.—Following is a summary of the finances of the past year, the details being given in the Treasurer's Report:

Receipts from all sources, $3,010.52, made up of the following items:

Fellowship fees	$2,180 00	
Life commutations	100 00	
Interest and investments	102 73	
Sales of Bulletin	426 85	
Repayments on cost of Bulletin	200 94	
	3,010 52	
Balance from former Treasurer	1,258 95	
Total		$4,269 47

EXPENDITURES DURING THE YEAR

Publication of Bulletin	$1,667 68	
Maps and photographs	43 83	
Administration (including Bulletin distribution)	467 91	
Investments	1,488 90	
Total	$3,668 32	
Balance in Treasury	601 15	
		$4,269 47

The cost of volumes 1, 2 and 3 of the Bulletin is shown in the following tabulation:

COST OF BULLETIN

	Vol. 1. (pp. 593; pl. 13.)		Vol. 2. (pp. 662; pl. 23.)		Vol. 3. (pp. 541; pl. 17.)	
Cost to the Society:						
Letter-press......	$1,367 77		$1,935 27		$1,439 00	
Illustrations	291 85		302 35		261 60	
Total.........		$1,659 62		$2,237 62		$1,700 60
Cost to authors:*						
Letter-press......					$79 59	
Illustrations			$161 30		121 75	
Corrections......	$38 00		27 25		5 00	
Brochure covers..	68 00		30 00		12 00	
Total.........		$106 00		$218 55		$218 34
Aggregate.....		$1,765 62		$2,456 17		$1,918 94

Respectfully submitted,

THE COUNCIL.

The Treasurer, I. C. White, read his annual report, as follows:

REPORT OF THE TREASURER

Report of the Treasurer of the Geological Society of America for the Year ending November 30, 1892

The Treasurer, in submitting his financial report, would recommend that the By-laws of the Society be amended so that the Life Commutations shall go immediately into the Publication Fund. This would simplify the accounts and save the Treasurer considerable unnecessary work.

The detailed operations of the Treasury are shown by the following financial statement to December 1, 1892:

* Including, for volume 3, donations of printing and engraving by I. C. White, $111.09, and engraving by N. H. Winchell, $9 00; an aggregate of $120.09.

Balance-sheet.

RECEIPTS.

Cash, balance received from H. S. Williams, former Treasurer		$1,258 95
Fellowship fees for 1890 (1)	$10 00	
" " 1891 (16)	160 00	
" " 1892 (186)	1,860 00	
" " 1893 (1)	10 00	
		2,040 00
Initiation fees (14)		140 00
Life commutations (E. O. Hovey)		100 00
Interest on investments:		
On bonds of Tioga township, Kansas, February 1, 1892	$35 00	
On the same, July 30, 1892	35 00	
On Cosmos Club bonds, July 30, 1892	22 50	
On bank deposit, November 30, 1892	10 23	
		102 73
Sales of Bulletin		426 85
Repayment by Fellows of partial cost of illustrations, &c.:		
A. Winslow	$3 00	
I. C. White	99 09	
C. H. Hitchcock	8 60	
Robert Hay	35 00	
T. Nelson Dale	5 00	
W. H. Hobbs	15 00	
C. W. Hall and F. W. Sardeson	12 75	
J. E. Wolff	3 00	
A. H. Cole	19 50	
		200 94
Total		$4,269 47

EXPENDITURES.

Expenses of administration.		
Treasurer's office:		
I. C. White	$25 85	
Secretary's office:		
H. L. Fairchild	299 36	
J. P. Smith Printing Co.	68 95	
Raynor & Martin	24 00	
Rochester Printing Co.	49 75	
		$467 91
Maps and photographs:		
J. S. Diller	$9 83	
D. W. Sill	34 00	
		43 83
Publication of Bulletin.		
Editor's office:		
W J McGee	$55 24	
Printing:		
Judd & Detweiler	1,250 09	
Engraving:		
Moss Eng. Co.	314 05	
Photo-Eng. Co.	33 30	
J. L. Ridgway	15 00	
		1,667 68
Investment account.		
Bond Purchases and Deposits:		
8 Cosmos Club bonds	$800 00	
1 Cosmos Club bond and accrued interest	100 35	
Bank deposit	503 05	
" "	85 50	
		1,488 90
Cash, balance November 30, 1892		601 15
Total		$4,269 47

The Society elected as a committee to audit the Treasurer's accounts Robert Bell and R. D. Salisbury.

ELECTION OF OFFICERS FOR 1893

The result of the balloting for officers for 1893, as canvassed by the Council, was declared as follows:

President:

SIR J. WILLIAM DAWSON, Montreal, Canada.

First Vice-president:

T. C. CHAMBERLIN, Chicago, Ill.

Secretary:

H. L. FAIRCHILD, Rochester, N. Y.

Treasurer:

I. C. WHITE, Morgantown, W. Va.

No candidate for the offices of Second Vice-president, Councillors and Editor having a majority of all the ballots cast, the election of such officers under the rules was made by ballot, in the meeting, from the two candidates having the greatest number of votes for the respective offices. The President named as tellers for the balloting F. D. Adams and R. W. Ells. The balloting was separately for each office, and resulted as follows:

Second Vice-president:

J. J. STEVENSON, New York city.

Councillors:

E. A. SMITH, Tuscaloosa, Ala.
C. D. WALCOTT, Washington, D. C.

Editor:

J. STANLEY-BROWN, Washington, D. C.

ELECTION OF FELLOWS

The result of the balloting for Fellows, as canvassed by the Council, was declared as follows:

FELLOWS ELECTED

HARRY FIELDING REID, Ph. D., Cleveland, Ohio, Professor of Physics in Case School of Applied Science.

FREDERICK WILLIAM SARDESON, Minneapolis, Minnesota, Post-graduate in Geology. Now engaged in paleozoic paleontology.

JOSEPH FREDERICK WHITEAVES, Ottawa, Canada. Paleontologist and Assistant Director of the Geological Survey of Canada. Working on Canadian paleontology.

A memorial of T. Sterry Hunt, in the absence of the author, was read by C. R. Van Hise.

MEMORIAL OF THOMAS STERRY HUNT

BY RAPHAEL PUMPELLY

Thomas Sterry Hunt was born in Norwich, Connecticut, September 5, 1826, and died in New York February 12, 1892. His intimate friend, James Douglass, has drawn with a loving hand a sketch of his life, from which I have taken freely the details of his early years.* He came of Puritan stock, including on his mother's side the mystic Peter Sterry and the preacher, Thomas Sterry, author of a notable tract, "The Rot among the Bishops," in 1667, in England, and Consider and John Sterry, mathematicians in New England. For a short period only he attended the public school, and then, to aid in the support of his widowed mother and her family, he worked successively, a few months in each, in a printing office, an apothecary's shop, and a bookstore, and later in a country store. Bent on studying medicine, he kept a skeleton and home-made chemical apparatus under the counter, using the stove for a furnace. Mr Douglas says that with this equipment he made investigations into the properties of hydriodic acid, anticipating to a certain extent those of Deville. During a trip to New Haven, in 1845, at the meeting of the Association of Naturalists and Geologists he acted as reporter for a New York paper. Here he attracted the attention of the elder Silliman, who facilitated his admission into Yale, made him his assistant in water analyses, and took him into his household. This was the great turning point of his life and doubtless determined his chemical and mineralogical career. Under happy auspices while at Yale, between his eighteenth and twentieth year, he contributed eighteen papers to Silliman's Journal and wrote the Organic Chemistry for Silliman's First Principles.

At twenty years of age, in 1847, he became Chemist and Mineralogist to the Geological Survey of Canada, a connection which he retained till 1872. The Canadian Survey had largely to do with a great development of crystalline rocks, and with varied mineral resources. Hunt threw his energies into the work before him and, single-handed, worked out the

* Trans. Amer. Inst. Min. Eng., 1892.

chemical and mineralogical details of the economic geology of a vast region, and supplied to a great extent the lithological basis for a classification of its rocks. At the same time he was developing a system of chemic geology based very largely on his own original investigations. Logan and Hunt soon supplemented each the other—the one an excellent geologist, with a wide and growing field experience; the other an able chemist and mineralogist, with a versatile and suggestive mind. Both profited by this combination, which contributed greatly to the successful prosecution of the Survey. During this period he also occupied the chair of chemistry at the Laval University, at Quebec, from 1856 to 1862 and at McGill University, Montreal, from 1862 to 1868.

From 1872 to 1878 he was Professor of Geology at the Massachusetts Institute of Technology. He was a juror at the Paris Expositions in 1856 and 1857, and there came into personal contact with the geologists of England and the continent. In 1859 he was elected a Fellow of the Royal Society of London, and a member of the National Academy of Sciences in 1873. In 1881 the University of Cambridge conferred on him the degree of LL. D. He was acting President of the American Association for the Advancement of Science in 1871, President in 1877 of the Institute of Mining Engineers, and the first elected President of the Royal Society of Canada. It is to his motion, made to the American Association for the Advancement of Science in 1876, that we owe the plan for an International Geological Congress, and he held office at several of the meetings of this body. In 1855 the French government made him a Chevalier of the Legion of Honor, and later an officer of the same order, and after the Bologna meeting of the Geological Congress he received the order of Saint Mauritius and of Saint Lazarus.

Dr Hunt was a most indefatigable worker and reader of a wide range of literature, and seems to have had a wonderfully retentive memory. In speaking, his addresses and papers were given without notes and were remarkable for their ready fluency and directness of diction, as well as for logical arrangement of ideas. The number of his published contributions to scientific literature is very large, but the more important part of his work is embodied in the few volumes which he published: "Chemical and Geological Essays," 1874 and 1878; "Azoic Rocks," 1878: "Mineral Physiology and Physiography," 1886; "A New Basis for Chemistry," 1887, and "Mineralogy according to a Natural System," 1891.

Mr Douglas informs us that Dr Hunt was a good mathematician and had an excellent acquaintance with botany, in which his interest lay more, however, on the æsthetic and economic than on the purely systematic side. He acquired such a knowledge of French as enabled him to speak it equally fluently with English. Indeed, he was a remarkable instance of self-developed genius, for he had a brief and imperfect public-school education and less than two years in Yale, where most of his time must have been spent in work as an assistant.

It is as an honored member of our Society and as a geologist that we have to speak of him on this occasion, and it is therefore fitting that we dwell particularly on those of his contributions to geology which mark his position in the history of the science and which also explain his individual attitude toward some of its more important problems.

His work in mineral chemistry and in the analyses of rocks led him naturally to the lithological side of geology. The logical and speculative nature of his mind impelled him to attempt the discovery of a general law underlying the origin of the crystalline rocks, both massive and schistose. He began in 1858 with the conception of a solid incandescent globe, which, at least in the outer layer, was an undifferentiated quartzless basic silicate, approximating dolorite in composition. At this starting point, while this mass contained all the non-volatile elements, the atmosphere still contained all the volatile elements, being densely charged with all the carbon, sulphur and chlorine, combined with oxygen or hydrogen, and containing watery vapor, nitrogen and a probable excess of oxygen. He considered that in the condensation of this atmosphere and the reaction of its powerful solvents upon the undifferentiated basic rock lay the key to the genesis of the crystalline rocks. The sulphur and chlorine of the condensing atmosphere combined with the protoxide bases of the rock and went to form the sulphates and chlorides of the ocean and to neutralize its waters. In the waters permeating the rock heated from below an active circulation was established, thus bringing to the surface the matters to be deposited.

Through this upward lixiviation the primary undifferentiated rock was separated into an upper acidic layer, chiefly of acid silicates, as feldspars with quartz, and a lower residuary basic and insoluble mass charged with iron and magnesium, the two representing the overlying granitic and the underlying basaltic layers required by many geologists. To this explanation he gave the name of Crenitic Hypothesis In the shrinkage of the great thickness, made porous by the lixiviation, he found the cause of the corrugation of the crystalline rocks and of the accompanying early extravasation of basic rocks. The lixiviation or crenitic portion of this hypothesis was not announced till 1884. In its earlier stages its author conceived the primal undifferentiated rock of the early globe to be everywhere deeply buried under its ruins—under a great thickness of fine and coarse sediments produced by the first decomposition of the rock by acid waters and by extensive subaërial decay, permeated by infiltrating waters and heated from below. Through the circulation of these waters he imagined these detrital accumulations to have been differentiated into two great divisions, the one having an excess of silica, a predominance of potash and small amounts of lime, magnesia and soda, represented by the granites and trachytes; the other, having less silica and potash, and prevalence of soda, lime and magnesia, giving rise to pyroxene and triclinic feldspars. In the metamorphism and displacement of these differentiated sediments he explained the origin of the plutonic rocks. At this period he was a believer in the metamorphic origin of the crystalline rocks, holding with Keferstein "that all the unstratified rocks from granite to lava are products of the transformation of sedimentary strata, in part very recent." But the intimate relation, required by his growing hypothesis, between this metamorphism and the chemical processes acting upon a recently solidified globe, seem to have soon caused him to reject the possibility of the formation of crystalline rocks by metamorphic processes acting upon sediments of later than pre-Cambrian age; for, in the final formulation of the crenitic hypothesis, he states that the products of subaërial decay (both of the crenitic rocks and of the basic rocks erupted from the underlying residual primary basic mass), reacted upon by the materials brought up by the crenitic processes, contributed to the formation of the transition crystalline schist, and in the transition or pre-Cambrian schists he saw only the relatively feeble and dying-out action of the crenitic processes.

It was a natural consequence of this attitude that Dr Hunt took an active part in the "Taconic Controversy" and ranged himself on the side which claimed a pre-Cambrian age for the quartzite limestone and schist series of the great Appalachian valley called Lower Taconic by Emmons and Taconian by Hunt. He had thought out a system which premises that "the laws which have presided over the differentiation of the primeval chaos and produced the various groups of rocks, * * * which have determined the progressive changes in chemical constitution from the anti-gneissic granite down to the youngest crystalline schists and the detrital sediments of later times, are * * * not less certain and definite than those which preside over astronomical and biological development." He insists that "the great successive groups of stratiform crystalline rocks mark necessary stages in the mineralogical evolution of the planet."

Acting upon this idea, he divided the crystalline-rock-making time into six periods:

I. Laurentian—granite and gneiss—during which the lixiviating process brought up acid silicates and quartz; the presence of limestones in supposed Laurentian rocks being due to a reaction of the crenitic lime silicates.

II. Norian, the formation of which was only possible after the crenitic lixiviation had exhausted a large part of the accessible primary mass of much of its silica in the forms of orthoclase albite and quartz, so that the succeeding secretions furnished the less acid silicates, as labradorite and andesite.

III. Arvonian; a stratified series of rocks including petrosilex, and quartziferous porphyry associated with beds of quartzite, micaceous schists, great beds of hematite and more rarely layers of crystalline limestone. This series he places between the Laurentian and the Huronian, stating that he is unable to fix its exact relation to the Norian.

IV. Huronian.—The shrinkage originating in the removal from the primary mass of the material to form the preceding three series caused eruptions from the underlying basic mass, so that extensive areas, both of the crenitic acid rocks and of the eruptive basic rocks, were exposed to subaërial decay.

In this decay the acid crenitic rocks gave up their alkalies, leaving residual clays, while the basic rocks yielded their lime and magnesia. The alkaline and magnesian carbonates introduced a new factor into the history of the rocks, for, reacting upon the calcium-chloride of the primeval sea, this produced lime, carbonate and alkaline and magnesian chlorides. Thus a magnesian sea was formed. The reaction of the magnesian salts of this sea upon the petrolitic matters (lime silicates) of the continued crenitic secretions brought into the sediments a vast amount of magnesian silicates, giving a distinctive character and color to the resulting schists.

V. Montalban.—The Huronian required for its formation a magnesian sea caused by the subaërial decay of both crenitic and especially of eruptive basic rocks on one hand, and by the continued addition of crenitic lime-silicate secretions contributed in an advanced stage of lixiviation on the other. The building up of the Montalban series of fine-grained gneisses, granulites, mica-schists and schists abounding in aluminous silicates of the Andalusite type presupposes the comparative absence of magnesium from the seas. Here the gneisses are of purely crenitic origin, and the schists are derived mainly from the products of subaërial decay of the older crenitic rocks, the resulting clays, still carrying a portion of their alkali, with or without the aid of crenitic secretions, yielded by diagenesis, muscovite, quartz and the simple aluminous silicates.

VI. Taconian.—This great series of quartzites, limestones, hydromica-schists and argillites, according to Dr Hunt, marks a stage of diminished energy in the process. In the schists he sees apparently the products of subaërial decay of the older crenitic rocks subjected to diagenesis, and in the presence of certain "apparently feldspathic matters forming imperfect gneisses" evidence of the still, though feebly acting, crenitic process. Traces of the still later and more feeble remnant of the crenitic process are found by Dr Hunt in the presence of rutile, tourmaline and staurolite and in the paleozoic argillites.

Having stated this order of development as an inflexible law, he assigned all the rocks generally called plutonic and metamorphic, respectively to these periods, thus forming an interdependent chronologic and lithologic canon. In this light it is easy to understand his reasons for denying the formation of crystalline schists during later periods than the pre-Cambrian, and also for rejecting a recognition of those processes which, like pseudo morphism, metasomatosis, etc, have been used in explaining local and regional metamorphism.

The so-called Taconic rocks had been by many of the most eminent geologists placed in the Paleozoic, a view which he held in common with Logan as late as 1868, and which was reiterated later by Dana after an extended and careful field study. Many of these rocks are highly crystalline and include gneisses. This touched a critical point in Dr Hunt's system at a later period of its growth, and he was naturally drawn into the Taconic controversy. The structural and other problems underlying this long and bitterly contested question were extremely complicated and such that the correctness of any interpretation could be ascertained only by exceedingly detailed surveys, made with such topographic maps as did not then exist. It should not be counted against Dr Hunt that from the limited reconnaissance field-work which he was able to do, he came out a partisan for any particular side. But, considering the various possible interpretations of the facts, his interpretation was naturally one in agreement with the requirements of his law of development of crystalline rocks. Thus in this controversy he held the view that the series called Lower Taconic by Emmons is of pre-Cambrian age. This series he named Taconian. In so far as western New England is concerned, it consists of the Stockbridge limestone with its underlying quartzite and overlying hydromica-schists, and has been recently shown by the stratigraphical studies of Dana, Wolff, Putnam, Dale, Hobbs and the writer, aided by the paleontological work of Wing, Walcott, Foerste, Wolff and Dale, to range probably in unbroken succession from the Olenellus Cambrian to the Hudson River group. At the top of this series he drew a great time-break, and placed above it Emmons' Upper Taconic, and assigned it to the Lower and Middle Cambrian.

A review of his recorded work shows that he was a brilliant and original thinker, and that his speculations in chemical geology were based on a large amount of original laboratory research and on a skillful use of that of others. Such a review brings out to light also a lack of that experience in detailed field-work, both original and critical, especially in structural geology, which is essential in building hypotheses and in testing them step by step. One cannot but feel that he was seriously limited by this deficiency, and that this limitation caused him to continue through the world's half century of progress in geology to construct a history of the early globe on a plan circumscribed by conceptions formed early in his career. Throughout his time he was the leading representative of chemical geology in America, and his works contain, both on the side of original research and of speculation, very much of the material necessary to construct the same history on lines more in accord with the present requirements. On its suggestive side Dr Hunt's work in chemical geology has ranked high in both hemispheres and its influence will long continue to be felt, and in a growing science this is perhaps the rarest and most important side.

The following bibliography indicates in the most graphic manner the enormous amount of work performed by Dr Hunt during his scientific career:

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A memorial of J. S. Newberry, in the absence of the author, was read by H. L. Fairchild.

MEMORIAL OF JOHN STRONG NEWBERRY

BY J. F. KEMP

The circle of American scientific men who, at least in the earlier periods of their work, may be most correctly described as naturalists, grows smaller year by year. The ever-widening range of facts and recorded observations with which an investigator of to-day must be familiar tends to concentrate attention upon more and more restricted lines. When, thus, one is removed who has left the stamp of his genius upon many departments of science, in all of which he was conspicuous, and when we sum up his many activities in such brief form as to grasp at once an appreciation of them, our admiration for his abilities is the more enhanced and our feeling of loss is the greater. Such a man was the late Professor John Strong Newberry.

Dr Newberry first saw the light in the little town of Windsor, Connecticut, December 22, 1822, and therefore at the time of his death, December 7, 1892, lacked about a fortnight of being seventy years of age. His ancestors were among the founders of Windsor, which they helped to settle in 1635. Dr Newberry's grandfather, Honorable Roger Newberry, was a director in the "Connecticut Company" that purchased the tract in northeastern Ohio known as the Western Reserve, and thither his father, Henry, removed in 1824, when the late professor was two years of age. The family settled at Cuyahoga Falls, south of Cleveland, and there Dr Newberry's boyhood was passed. The elder Newberry became actively engaged in opening up the coal resources of eastern Ohio and in obtaining an outlet for them to Lake Erie. His son was thus reared in the midst of mining and of that kind of mining which especially developed fossil plants. In his later years Dr Newberry took pleasure in recounting the delight which he felt while yet a boy in uncovering these delicately preserved fronds from their enclosing shale.

After preparation for college, the future professor entered the Western Reserve University at Hudson, Ohio, and was graduated in 1846. He next studied medicine in the Cleveland Medical School, and received his degree of M. D. in 1848. The attractions of European study led him shortly afterward to Paris, where he spent two years in further preparation in medicine. Interest in fossils prompted him also to seek instruction in paleontology, but as he was accustomed many years later to speak of the unsatisfactory character of his opportunities, they probably amounted to little. On returning to America he began, in 1851, the practice of medicine in Cleveland, and soon gained a wide clientele. It is a curious fact that in the same year in which Dr Newberry sought European advantages, Leo Lesquereux, his great contemporary, migrated to America.

While Dr Newberry's medical practice increased and many influences conspired to develop him into a settled and successful physician, his tastes for natural history kept making his profession more and more irksome. Friends at Washington were not slow in taking advantage of this and finally induced him to abandon Cleveland and active practice.

He became in May, 1855, assistant surgeon and geologist to the exploring party that was sent out by the War Department under Lieutenant R. S. Williamson to traverse the country between San Francisco and the Columbia river. Two years later his papers on the botany, zoölogy and geology of the region appeared in volume vi of the "Reports of Explorations and Surveys to ascertain the most practicable and economical Route for a Railroad from the Mississippi river to the Pacific ocean, made in 1853–'56, Washington, 1857."

Dr Newberry next became geologist to the Ives expedition, as it is generally known, from its commander, Lieutenant Joseph C. Ives. This party was sent to explore the Colorado river in 1857–'58.

After sailing up the river from the gulf of California in a little steamer to the mouth of the Grand canyon the party spent nearly a year in the study and exploration of the lower Colorado and the plateau lying eastward. Dr Newberry not only gained an acquaintance with the superb geologic sections and phenomena of erosion there afforded, but also with the Pueblo tribes of Indians, in whom he ever afterward took the deepest interest.

The geologic portion of the final report forms what is now its most valuable and interesting part. The full title is, "Report upon the Colorado River of the West, explored in 1857–'58," Washington, 1861.

In 1859 Dr Newberry was again in the field as naturalist of an expedition under Captain J. N. Macomb, which explored the San Juan country, in southwestern Colorado, and the adjacent parts of Utah, Arizona and New Mexico. Many observations on the coal seams and general geology of this country are recorded, to whose accuracy and importance later and fuller reports have given ample confirmation. The results of this expedition were not made public until 1876, owing in part at least to the demoralization of the war. They then appeared under the title, "Report of the Exploring Expedition from Santa Fé to the junction of the Grand and the Green Rivers," Washington, 1876.

Shortly after the trip was completed the civil war broke out. Dr Newberry was summoned to the newly organized Sanitary Commission, in which, on June 14, 1861, he took his place, although at the time attached to the War Department. But the work of the commission was imperative, and in September Dr Newberry resigned from the War Department and became secretary of the western branch of the commission, with headquarters at Louisville. All the operations in the Mississippi valley and its tributaries were under his direction. Distributing depots were quickly established at many points. At times Dr Newberry followed the army and was himself present at the battle of Chattanooga, overseeing the work of his organization. At the close of the war he made his final report. It is a volume of 543 pages and exhibits the great labors performed and the enormous sums which were expended under his administration. Dr Newberry had by this time returned to Washington and had become attached to the Smithsonian Institution. He also held a professorship in the Columbian University of Washington during 1856–1857.

In 1864 the School of Mines, Columbia College, New York, was founded, and in 1866 the chair of geology and paleontology was created, and a call was extended to Dr Newberry. He accepted and remained in the uninterrupted discharge of his duties until a stroke of paralysis, December 3, 1890, made work impossible. It was never resumed.

This long interval of twenty years is marked by incessant activity, for, in addition to instruction in the college, a vast amount of investigation and writing was carried on. Opportunities for scientific work and distinction outside of New York appeared and made possible the greatest efforts of his life. When the legislature of Ohio established a state geological survey in 1869, Dr Newberry, who had all along kept his household and home in Cleveland, was called by Governor Hayes to the directorship. Active organization was soon effected and a comprehensive scheme of work was blocked out. Three reports of progress were issued, the last extremely brief. The final reports comprised four volumes on the geology of the state, two on its paleontology, one geologic atlas and a report on the zoölogy. They all appeared between 1869 and 1882. One or two were printed in German as well as in English. A large part of the field-work was done by the director himself, and the descriptions of a number of counties are from his pen. Of course the summation is also his. In paleontology notable discoveries were made of fossil fish and fossil plants. The reports on these two groups by Dr Newberry probably attracted as much attention from scientific men as any other portions of the survey's work. Observations on the geologic history of the great lakes and their relationships to the glacial period were recorded, which have proved fruitful of later results. Not a few men began their geologic work in the survey or took part in it, who have since become leaders. G. K. Gilbert, R. D. Irving, Henry Newton, N. H. Winchell and Edward Orton, the able and courteous director of the present Ohio survey, may be mentioned. Probably an error of judgment was committed in postponing the economic work until the last, for before these reports, which always have greatest value and interest to the people at large, were reached, the legislature cut short the appropriation on the ground, as one rural member said, that too much money was devoted to clams and salamanders.

Dr Newberry also did a large amount of paleontologic work for the

Illinois survey, especially on vertebrate fossils. A still more extended undertaking was the description of the later, extinct floras in the west, materials for which had been gathered by the Hayden survey. A volume of plates was issued in 1878, but, although begun nearly fifteen years ago, the manuscript is not entirely complete, and, if published, will form a posthumous work under the editorship of the professor's old student and friend, Arthur Hollick.

In association with the New Jersey survey, Dr Newberry also undertook the description of the flora of the Amboy clays. This manuscript, with some editorial completion by Mr Hollick, will also appear as a posthumous work. The description of the fossil fishes and plants of the eastern Triassic strata was pushed to a conclusion and appeared in 1888, as Monograph XIV of the United States Geological Survey. A more elaborate work on the Paleozoic Fishes of North America came out in the following year as Monograph XVI of the same survey. Both works are extensively illustrated by plates. For the preparation of these he was appointed paleontologist on the survey in 1884.

In addition to his paleontologic papers, Dr Newberry wrote also many shorter contributions for the scientific journals on subjects connected with economic geology. In this connection it may be stated that he was one of the judges at the Centennial and was the author of the report on building stone. Several papers in Appleton's Cyclopedia are from his pen, and of Johnson's Encyclopedia he was one of the editorial staff. This sketch would be incomplete without mention of the high regard that was felt for his opinion on the value of mines, both for metals and coal. His advice was often sought, and frequent trips to the west and to Mexico widened his range of observation.

When the National Academy was founded, Dr Newberry was named by Congress as one of the incorporators and became a familiar figure at its meetings. In 1867 his alma mater honored herself and him by bestowing the degree of LL.D. In the same year he was president of the American Association for the Advancement of Science and delivered the annual address at Burlington, Vermont. Likewise in 1868, soon after his coming to New York, he was chosen president of the New York Academy of Sciences, Professor C. A. Joy, the previous incumbent, gracefully and generously retiring to give the Doctor an appropriate introduction to the scientific circles of the metropolis. For twenty-four years Dr Newberry remained president of this body, and during the last years of his life and at the time of his death was its honorary president. Dr Newberry was also president of the Torrey Botanical Club and occupied the position during the ten years between 1880 and 1890.

Largely in immediate recognition of his paleontologic works, the Geological Society of London conferred on Dr Newberry in 1888 the Murchison gold medal, which is awarded by the society for distinguished services in geology. In presenting the medal President Judd, and in receiving it in behalf of Dr Newberry, Sir Archibald Geikie referred in a most appreciative way to his work. When the long-pending Geological Society of America finally took form at Cleveland in 1888, Dr Newberry was present and shared in the preliminaries of organization. At the second election of officers, in New York, December 26, 1889, he was chosen first vice-president. The crowning honor of his life came, however, in 1891.

In the late seventies the subject of an International Congress of Geologists was broached in the American Association and Dr Newberry was appointed one of the committee to carry the matter through. The movement led to the organization of the congress, which has now had four meetings at intervals of three years and in several countries. The last one was in Washington in August, 1891, and chose for its presiding officer the one in whose memory these lines are penned. The honor was a fitting tribute to a long and fruitful life, but it came after its recipient was too weakened to take the chair. From his far-distant summering place on Lake Superior he was forced to send his messages of greeting to the congress.

It was in the winter of 1889–'90 that exhausting labors began to tell heavily on a constitution that had seemed so proof against fatigue that it knew not how to yield. A heavy cold and attendant weakness gave warning that certain limits must be regarded, but the professor, after a brief absence, again appeared before his classes. When the long summer vacation of 1890 came, he wrought day after day with an amanuensis on his report upon the Amboy flora. The strain was too severe and culminated the following December with a paralytic stroke, from the effects of which the honored teacher and investigator never recovered.

Dr Newberry's skillful touch has been felt in almost all lines of geologic work and in almost all departments of natural history. He was a most indefatigable collector, and the museum which he leaves at Columbia is a monument to his memory. Its wealth in fossil fish makes it unique and famous among geologic museums.

Dr Newberry had also a strong passion for music, and in his earlier career was wont to solace the long hours of western expeditions with his violin. He was likewise gifted with skill in sketching, such that many illustrations of fossils and of scenery in his reports are from his own hand. He wrote in charming and attractive literary style, and in descriptions of the grand phenomena of the west often manifested a highly artistic use of language.

In his scientific work he sometimes displayed almost the insight of a seer, and from his ability to grasp, as it were by intuition, the bearings of many widely isolated facts, he has shown a quite prophetic instinct. His determinations of strata in the west, although based on the hasty itineraries of exploring parties, have been very generally corroborated by later and more deliberate work. The same is true of his early views on the origin of petroleum, and on the buried channels that have been since discovered around nearly all the waterfalls of the central part of the country. He was withal extremely conservative on many doubtful points and before his classes was always very cautious of statement. With his students his relations were marked by great kindliness, and by them he was universally beloved.

Dr Newberry was married in Cleveland, in 1848, to Miss Sarah B. Gaylord, who, with six of their seven children, survives him.

The following bibliography contains those titles of Dr Newberry's writings which are to be regarded as broadly included under geologic science. A chronologic list of all his writings is published in the Transactions of the New York Academy of Sciences, volume xii, pages 174–185, and in the "American Geologist" for July, 1893. A list of his botanic papers, with a list of the plants named after him, is printed in the Bulletin of the Torrey Botanical Club for March, 1893.

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Dr Newberry was also one of the editors of Johnson's Encyclopædia, having charge of geology and paleontology. He wrote many articles on these subjects for its pages in 1875 and the years immediately following.

Biographic sketches of Dr Newberry have been published in all the current biographic dictionaries and cyclopedias. Portraits of him appear accompanying such sketches in Men of Progress, 1870–'71, page 317, and Contemporary Biography of New York, volume v, 1887, page 255. The Popular Science Monthly, volume ix, page 491, 1876, contains a sketch, with portrait, and in Fairchild's History of the New York Academy of Sciences there is an excellent artotype.*

A memorial of J. H. Chapin, in the absence of the author, was read by C. H. Hitchcock.

MEMORIAL OF JAMES HENRY CHAPIN

BY W. M. DAVIS

James Henry Chapin, an original member of our Society, was born in Leavenworth, Indiana, on December 31, 1832. He died in South Norwalk, Connecticut, on March 14, 1892, in his sixtieth year. He was a

*Since his death memorials have appeared, with portraits, in the Engineering and Mining Journal, December 17, 1892, page 581; the Scientific American, December 31, 1892, page 423; the School of Mines Quarterly, January, 1893, page 93, with two steel portraits, one taken in 1865 and one in 1887; the Bulletin of the Torrey Botanical Club, March, 1893, with an artotype; and in the Transactions of the New York Academy of Sciences, volume xii, March, 1893, a memoir, by Professor H. L. Fairchild, republished by the Scientific Alliance of New York, March, 1893. A memorial, by Professor J. J. Stevenson, appears in the American Geologist for July, 1893, with a revised chronologic bibliography, by J. F. Kemp.

descendant in the eighth generation of Samuel Chapin, who came from Wales to Dorchester, Massachusetts, in 1636 or 1637, moving to the outlying settlement of Springfield, Massachusetts, in 1842. His father was Gustavus W. Chapin, of Cooperstown, New York; his mother, Mary McNaughton, of Ohio. One of the family of nine children of a hard-working farmer, Dr Chapin showed a characteristic American spirit, being a self-supporting student in his youth and an active worker in varied directions during his maturity. He was graduated at Lombard college, Galesburg, Illinois, in 1857, and spent a time there in teaching mathematics and natural science; but he soon turned toward the ministry and occupied Universalist pulpits in Illinois for several years. In 1857 he married Helen M. Weaver, who died in 1871, leaving a daughter. During the later years of the rebellion he was actively and successfully engaged in California in raising funds for the Sanitary Commission.

It is not until 1871 that Dr Chapin's attention was especially directed toward geology. It had been previously a subject of general interest to him, but on accepting the chair of geology and mineralogy in the St. Lawrence University in northern New York his thoughts were more turned toward our science. Between 1873 and 1885 he also held the pastorate of the Universalist church at Meriden, Connecticut, where he resided the greater part of the time, his duties at the St. Lawrence University requiring but the smaller part of the year. In 1875 he was called to the presidency of his *alma mater* at Galesberg, Illinois, but felt unable to accept the position.

At Meriden, in 1878, he married Kate A. Lewis, daughter of Honorable Isaac C. Lewis, prominently connected with the business development of that busy city. His travels abroad and his lectures at home during the past twenty years led to the publication of several volumes of general interest. In 1889 he was elected to the Connecticut legislature, where he was active in introducing a bill for a state topographic survey similar to the surveys previously established in Massachusetts and Rhode Island. He was appointed one of the three commissioners to superintend the prosecution of the survey, and through his interest in the work he made it widely known to the people of the state. The schools of Meriden had his close attention, and the high school was his particular care. He was closely identified with the Meriden Scientific Association, an active local institution, of which he has been president. He frequently took part in its meetings and excursions, his interest being aroused in particular by the ancient volcanic phenomena of the district. His death was deeply felt by the community in which he was so actively engaged.

The following is a list of the geologic writings of Dr Chapin:

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The hanging Hills; The Trap Ridges of Meriden; Notes of Africa: *Trans. Meriden Sci. Assoc.*
The topographical Survey of Connecticut: *Trans. Meriden Sci. Assoc.*, January, 1890, p. 7.
Cycadinocarpus chapini: Trans. Meriden Sci. Assoc., January, 1891, p. 1.
Some geological Features of Meriden: *Trans. Meriden Sci. Assoc.*, January, 1891, p. 4.
Magazine articles on Science and Religion and Genises and Geology.
A Year's Progress in Science: *Meriden Daily Republican*, February 9, 1892.

The President, following the reading of the memorials, declared the morning session adjourned.

The Society reassembled at 2 o'clock p. m., and the reading of papers was declared in order.

The first paper upon the printed program was—

ON THE COALS AND PETROLEUMS OF THE CROW'S NEST PASS, ROCKY MOUNTAINS

BY A. R. C. SELWYN

Remarks were made by the President and I. C. White.

The second paper was—

ON THE GEOLOGY OF NATURAL GAS AND PETROLEUM IN SOUTHWESTERN ONTARIO

BY H. P. H. BRUMELL

Remarks were made in discussion by Dr I. C. White, who said:

That Mr Brumell's paper was confirmatory of Professor Edward Orton's conclusion that the limestone, when a repository of oil or gas, is dolomitic and porous, and that the probable reason why the Dundas anticlinal contains no gas is because the Trenton limestone there is not dolomitic.

Mr H. M. Ami said:

That the Trenton is throughout not dolomitic; that the dolomitic layers below are of the Calciferous.

Another paper by the same author:

NOTES ON THE OCCURRENCE OF PETROLEUM IN GASPÉ, QUEBEC

BY H. P. H. BRUMELL

These two papers are printed as pages 225–244 of this volume.

On account of the absence of the author the following paper was presented by title:

SOME FEATURES OF THE PHOSPHATE-BEARING ROCKS OF OTTAWA COUNTY, PROVINCE OF QUEBEC

BY ELFRIC DREW INGALL

In the absence of the author the next paper was read by F. D. Adams:

NOTE ON FOSSIL SPONGES FROM THE QUEBEC GROUP (LOWER CAMBRO-SILURIAN) AT LITTLE METIS, CANADA

BY J. WILLIAM DAWSON

[*Abstract*]

The object of this note was to introduce to the Society some specimens and a photograph in illustration of a very remarkable and interesting discovery of Lower Paleozoic sponges, made accidentally in 1887 by Dr B. G. Harrington, F. G. S., and followed up by the writer.

In two or three thin bands, in black shales belonging to a markedly unfruitful portion of the Quebec group, there occur a number of fossil sponges perfectly flattened and with their originally silicious skeletons replaced with pyrite. They thus form very delicate tracery on the surfaces of the shale. By careful quarrying in these beds there were discovered up to 1889 thirteen species, which were described and figured by the author and Dr Hinde, of London, in the Transactions of the Royal Society of Canada for that year. Six of these belong to the primitive genus *Protospongia* of Salter, and of most of these we have the entire forms, showing their oscula, protecting spicules and anchoring rods, details which were previously unknown. One species belongs to the genus *Cyathospongia* of Walcott, previously known in the Utica shale. Another, cylindrical and curiously hispid, has been placed by Hinde in a new genus *Acanthodictya*. Another appears to belong to genus *Hyalostelia* of the same author. Three others, which seem to have simple and not hexactinellid spicules, have been placed in the genera *Sasiothrix* and *Halichondrites*. The thirteenth has not yet been named, being imperfectly preserved.

Since 1889 the excavations have been continued, but until the present year with the result only of finding additional specimens of the species already known. Last summer, however, the author was so fortunate as to discover a very large and remarkable form, of which a photograph was exhibited, the original slab, now in

the Peter Redpath Museum of McGill University, being too fragile to admit of carriage. This new species must have been of sack-like form and as much as fourteen inches in diameter. Its walls consist of rhombic meshes about half an inch wide. These meshes are made up of delicate spicules loosely twisted together and apparently branching at the angles of the meshes. They seem to have been filled in and covered with small cruciform or simple flesh spicules which toward the sides conceal the meshes of the framework. The hair of the specimen and its anchoring rods are wanting, but on the same surface are numerous fragments of anchoring rods which would seem to have belonged to this species. They are composed of many long, slender spicules similar to those of the body, but closely twisted so as to form a rope or cord, on which are placed minute tubercles or flat projections, so as to give greater holding power. This remarkable sponge is probably the largest and most complex yet found in formations of so great age. Dr Hinde, the author of the British Museum catalogue of fossil sponges, has kindly undertaken its detailed description, and proposes to place it in a new genus, *Palawsaccus.*

It was further remarked that the discovery of so many species on what represents a single sea bottom illustrates in a remarkable manner the abundance of sponges at this early date, and shows how much may be learned by following up productive beds in the older formations, in which it often happens that great thicknesses of rock are unproductive of fossils.

The only other fossils associated with these sponges are a species of *Linnarssonia, L.* (*Obolella*) *pretiosa* of Billings, and a slender, branching fucoid (*Buthotrephis pergracilis*). In neighboring sandstone beds there are fragments of *Retiolites cusiformis* of Hall, and the curious radiating markings known as *Astiopolittion*, along with impressions of worm-burrows.

Remarks were made by H. M. Ami.

The following two papers were read by the author:

NOTES ON CAMBRIAN FOSSILS FROM THE SELKIRKS AND ROCKY MOUNTAIN REGION OF CANADA

BY HENRY M. AMI

ON THE POTSDAM AND CALCIFEROUS TERRANES OF THE OTTAWA PALEOZOIC BASIN

BY HENRY M. AMI

Remarks upon the subjects of these papers were made by C. H. Hitchcock, A. R. C. Selwyn and C. R. Van Hise.

The next communication was entitled:

NOTES ON THE DEVONIAN FORMATION OF MANITOBA AND THE NORTHWEST TERRITORIES

BY J. F. WHITEAVES

The following paper was then read .

DISTINCT GLACIAL EPOCHS AND THE CRITERIA FOR THEIR RECOGNITION

BY R. D. SALISBURY

During the animated discussion which followed the reading of this paper remarks were made by W J McGee, C. H. Hitchcock, Warren Upham, Robert Bell, B. K. Emerson and the President. The paper is published in full in The Journal of Geology, volume i, pages 61–84.

The last paper of the afternoon session was—

PLEISTOCENE PHENOMENA IN THE REGION SOUTHEAST AND EAST OF LAKE ATHABASKA, CANADA

BY J. B. TYRRELL

Remarks were made by C. H. Hitchcock, Warren Upham and Robert Bell.

Announcement of the lecture in the evening was given, and the Society adjourned.

Evening Session of Wednesday, December 28

The Society was called to order at 8 o'clock in the Normal School auditorium. A lecture was given upon the following subject:

A FOSSIL EARTHQUAKE

BY W J MCGEE

[*Abstract*]

With a single exception, the traveler by steam-packet on the lower Mississippi finds the river flanked by alluvial banks so low that during great freshets they are overflowed all the way from Cairo to the Gulf, save where protected by natural or artificial levees. The exceptional locality comprises nearly all of Lake county, Tennessee, and a considerable area in Missouri, on the opposite side of the river. This area, which is some 20 miles in mean diameter, bulges upward in the form of a low dome, 20 or 25 feet above the general level of the alluvial plain. East of it lies Reelfoot lake; west of it the "Sunk country" of southeastern Missouri and northeastern Arkansas, and through its crest the Mississippi has cut a meandering trough. When the surface of the dome is examined it is found to be scored by broad trenches like the channels of waterways; moreover, these trenches are flanked by natural levees so characteristic of the Mississippi flood-plains that they are at once recognized as bayous from which the waters have been removed. The structure of the dome is revealed in the channel of the Mississippi. It is composed of a sheet of alluvium, 10 to 30 feet thick, identical in character with the modern river deposit flooring the entire flood plain, and unconformably below lies the dense, tenacious blue or greenish Port Hudson clays, which underlie the flood plain throughout. Thus the structure is similar to that of other parts of the "Delta," save that the deposits lie 20 or 25 feet higher.

The configuration and composition of the dome indicate that it was originally a part of the broad flood plain extending from the mouth of the Ohio to the Gulf, and its exceptional altitude and general conformation suggest a localized uplift. Moreover, several of the dry bayous enter Reelfoot lake squarely or obliquely, and when this occurs there is no trace of delta-building, and both channel and natural levees may be traced for long distances in the lake; indeed, for some distances they may be traced throughout their extent and found to connect in the form of a fairly definite drainage system. This absence of deltas indicates that the uplift or deformation occurred suddenly. Furthermore, it is found that while great cypresses, sycamores and poplars, sometimes two or three centuries old, grow over the general surface of the dome, no trees older than seventy or seventy-five years grow within the unoccupied bayous; from which it may be inferred that the uplift occurred at least seventy or seventy-five years ago, and probably not much earlier.

Reelfoot lake is a shallow water-body of irregular form, perhaps five miles in average width and twenty miles in length from north to south, lying between the Lake county dome and the base of the upland scarp, a dozen to a score of miles east of the river. Its depth increases very gradually from its western margin nearly to the eastern shore, where at low water its depth is twenty or thirty feet. At high water on the Mississippi its depth is some twenty feet more, since it then becomes part of the general flood by which the Lake county uplift is transformed into a double island. The lake is not an uninterrupted sheet. Here and there, particularly toward the western side, groves of sickly cypresses spring from its bottom and half shadow the water surface with puny branches and scant foliage, and here and there throughout all portions of the water body, save in the channels of the old bayous, gaunt cypress trunks with decaying branches stand, sometimes a dozen to the acre, numbering many thousands in all. Moreover, between the decaying boles, rising a score to a hundred feet above the water, there are ten times as many stumps, commonly of lesser trees, rising barely to low-water level. Now, while the subsurface structure beneath Reelfoot lake is not revealed, the phenomena of the lake grade into the phenomena of the dome. The lake bottom is meandered by waterways whose combined channels and natural levees prove them to be bayous similar to those of the Mississippi flood-plain; along and between the bayous cypress stumps and boles are scattered just as they are distributed over much of the modern flood-plain, and dry bayous and drowned swamps alike indicate that the land beneath Reelfoot lake was depressed. Moreover the transformation of the area from land to lake without filling the old bayous by sediment indicates that the depression occurred suddenly. Furthermore the presence of the cypress stumps and trunks, particularly in the deep portions of the lake where the drowning must have been complete, indicates that the date of the subsidence was not remote.

The upland scarp overlooking the Mississippi flood plain on the east, from Baton Rouge to the mouth of the Ohio, is everywhere mantled by loess or a loam of closely related character, and the mantle, as well as the underlying rocks, is deeply scored by erosion. Accordingly the upland margin is made up of steep salients and cusps and narrow divides separating a myriad ravines. Now, on approaching the Reelfoot country from the north or the south, certain minor topographic features appear and finally culminate in that part of the scarp overlooking the lake. The narrowest divides are longitudinally cleft by trenches yards in width and often several feet in depth; the steeper outlying cusps are divided by similar trenches, and frequently the salients are cleft by such trenches cutting across their steeper slopes or radiating in three or four lines from the apex. Furthermore, along the face of the scarp opposite the lake, ancient landslips, with their characteristic deformation of the surface, are found in numbers, and over the landslips and along the sides of the trenches on the summit trees are frequently thrown out of the perpendicular. These features suggest a sudden and violent movement by which the highly unstable topographic forms of the upland scarp were in part broken down and thrown into more stable positions. On examining the inclined trees it is usually found that the great boles two or more centuries old are inclined from root to top, though the younger trees of seventy or seventy-five years usually stand upright, and that the trunks of a century to a century and a half in age are commonly inclined near the ground, but are vertical above. Thus the forest trees flanking the fissures and clothing the scarp give a trustworthy and fairly accurate date for the production of the minor topographic features—a date determined by much counting of annual rings to lie between seventy-five and eighty-five or ninety years ago.

While in general the flood-plain of the Mississippi is essentially alike in composition from Baton Rouge to Cairo, a minor distinction is found over the Lake county dome and in its vicinity: The flat-lying alluvium is sometimes interrupted by irregular ridges of gravel and coarse sand, sometimes by double ridges with irregular trenches between; and now and then elongated mounds of similar gravel and coarse sand occur, either isolated or in lines. When in cultivated lands, the ridges and mounds are reduced but give character to the soil throughout entire fields; but when in woodland, they affect the forest to the extent that the larger trees along their flanks are frequently thrown out of the perpendicular as are the trunks of the upland, while only young trees about seventy-five years old and less grow in the trenches.

Now it is conceivable that areas may be lifted like the Lake county dome or depressed like Reelfoot lake by gentle diastrophic action; it is conceivable even that a group of contemporaneous landslips and fissures in a hilly scarp might be developed by a variety of causes or movements coinciding fortuitously; but the gravel ridges and mounds of the flood-plain are homologous with the craterlets, sand spouts and fissures produced by earthquakes, and they are unlike phenomena produced by any other known cause. Moreover the landslips and trenches of the scarp are more perfectly and simply explained as the product of an earthquake than in any other way. Again, the depression of the land beneath Reelfoot lake is analogous to surface movements known to be produced by earthquakes; and it might be shown through the application of the principle of isostasy that the uplift in the center of the Mississippi lowland with the depression on both flanks toward the more heavily loaded uplands, is more readily explicable as an earthquake product than in any other way. Accordingly the assemblage of phenomena may be explained on the hypothesis of an earthquake of great severity, and cannot well be explained on any other hypothesis. Thus the peculiar features of Lake county, Tennessee, and contiguous territory, may justly be regarded as a physical record of a great earthquake, the date of which is fixed by attendant phenomena at from seventy-five to eighty-five years ago.

Assuming the verity of the hypothesis, one out of its many consequences may be considered. The Lake county dome lies athwart the course of the Mississippi, which is here well out in the flood-plain; so that, if the lifting was effected suddenly, the flow of the river must have been obstructed. Now the declivity of the lower Mississippi is so slight and the land so low that the back water due to any obstruction spreads over an enormous area and reaches a vast volume; moreover, under the hypothesis, the Reelfoot lake depression was formed contemporaneously and the lake must have been filled by the water of the river taken not simply above the obstruction but (by reason of geographic relations which need not be set forth in detail) from many miles above, *i. e.*, at what is now the site of Hickman. Accordingly it may be considered certain that an immediate effect of the earthquake must have been a reversal of the flow of the Mississippi about what is now the the northern extremity of Lake county, at least for many hours.

There are voluminous, though somewhat vague and little known, records of a great earthquake centering about the Spanish settlement of New Madrid, in southern Missouri, beginning near the end of 1811 and continuing with gradually diminishing intensity through the succeeding year and most of 1813. These historical records embrace a classical memoir by Dr S. L. Mitchill; an account by a kinsman of the eminent professor of geology in Harvard college; a detailed paper in the American Journal of Science, by Louis Bringier, a reputable engineer of New Orleans; detailed descriptions in the ephemeral press and in the books of the day; an elaborate description by the geographer Flint; a careful and extended statement by Sir Charles Lyell; and an unpublished circumstantial account by a grandfather of the writer, who resided in western Kentucky throughout the entire earthquake period. From these various accounts, especially that of Mitchill, it can be shown, in so far as historical records are trustworthy, that the New Madrid earthquake was one of great severity and was unparalleled in extent; it was felt from New Orleans on the south to Fort Dearborn (Chicago) and Detroit on the north, and from Washington and Charleston on the east as far westward as explorers had then penetrated, thus affecting fully one-third of the area of the United States or not less than a million square miles.

For various reasons the historical records of the New Madrid earthquake have been looked upon with distrust, and a communication has been laid before one of the leading scientific societies of the country by an eminent savant for the purpose of proving that no such earthquake ever occurred. One of the reasons for the distrust of the records was the allegation by Shaler, by Bringier, and by nearly all contemporary witnesses that the flow of the Mississippi river was changed, and that it ran upstream for hours; another reason for distrust was found in the oft-repeated allegations that during the tremor the earth opened and fountains of water flowed from the fissures, bringing up great quantities of sand and gravel (as well as "coal" and the type specimen of the now well-known *Ovibos cavifrons*), from unknown depths; but the latter allegations are in perfect accord with recent observations on earthquakes, notably, those of Charleston and Kach and Cachar, while the reversal of the flow of the Mississippi is unmistakably recorded in the present physical features of the region, for the summit of the Lake county dome is less than a score of miles from the still existing town of New Madrid.

The lecture was illustrated by lantern views. In moving and seconding a vote of thanks to the lecturer addresses were made by Sir James

Grant and Sheriff Sweetland. Following the adjournment an informal reception was given the Society.

Session of Thursday, December 29

The Society was called to order by President Gilbert at 10.30 o'clock a m.

Mr J. S. Diller read the report of the Committee on Photographs, which was accepted by consent. It was voted to continue the committee (J. F. Kemp, W. M. Davis, J. S. Diller) and to appropriate fifteen dollars ($15.00) for the use of the committee during the next year. The report is as follows:

THIRD ANNUAL REPORT OF THE COMMITTEE ON PHOTOGRAPHS

During the year 105 photographs have been presented to the Society, and the collection now numbers 740. In the register the donors' numbers are given in parentheses for the convenience of those who may wish to purchase photographs.

The collection remains with the secretary of the committee, Mr J. S. Diller, at the United States Geological Survey, Washington, D. C., where it is open to the examination of members of the Society. During the year it has been examined by a number of members and many photographs have been ordered for educational institutions.

The collection was exhibited at both the Rochester and Ottawa meetings. On this account the expenses of the committee were a little more ($11.67) than last year, but as the amount appropriated for the use of the Committee was $15.17, there remained at the close of the annual meeting a balance of $3.50.

The committee solicits contributions, such as are indicated in previous reports. Contributions may be sent to Professor J. F. Kemp, Columbia College, New York city; Professor W. M. Davis, Harvard College, Cambridge, Mass., or to Mr J. S. Diller, U. S. Geological Survey, Washington, D. C.

Register of Photographs received in 1892

Photographed and Donated by W. H. Jackson, Denver, Colorado

Numbers 640 to 650, inclusive, size, 21 x 16 inches; price, mounted, $2.50; unmounted, $2.00. Discount of 25 per cent on orders of $50.00 or over. Lantern slides from all negatives, 50 cents each. Four slides from same negative, 30 cents each.

636 (1632). Grand canyon of the Colorado. Size, 21 x 74 inches; mounted, $17.50; not mounted, $15.00.

637 (1008). Pike's peak from the Garden of the Gods. Size, 20 x 43 inches; mounted, $12.00; not mounted, $10.00.

638 (1098*p*). Yellowstone canyon and falls. Size, 19 x 44 inches; mounted, $12.00; not mounted, $10.00.

639 (1661*p*). Mammoth hot springs; Cleopatra and Jupiter terraces. Size, 17 x 38 inches; mounted, $7.50; not mounted, $6.00.
640 (1095). Yellowstone canyon.
641 (1657). Pulpit terraces; Mammoth hot springs.
642 (1105). Old Faithful; a geyser in action,
643 (1106). The "Castle" geyser and Crested spring; Yellowstone National park.
644 (1656). Index peak; Wyoming.
645 (1669). Fremont's peak and lake; Wind River mountains, Wyoming.
646 (1667). Teton range; from the east.
647 (1666). Teton range; from Jackson's lake.
648 (1653). Cloud peak; Big Horn mountains, Wyoming.
649 (1651). Matteo teepee, or Devil's tower.
650 (1344). South dome; from Glacier point.

Photographed and Presented by Professor H. F. Reid, Case School of Applied Science, Cleveland, Ohio

Size, 5½ x 8 inches. Copies of these photographs furnished to members of the Geological Society only at the following rates: Unmounted, 20 cents; mounted, 25 cents; by Frank R. Stoll, 106 Euclid avenue, Cleveland, Ohio. Orders must include Mr Reid's numbers, which are given below in parentheses.

651 (258). Glacier draining into Tidal inlet.
652 (259). Mountain near Tidal inlet.
653 (300). Muir glacier from altitude of 2,000 feet; looking eastward.
654 (303). Mount Case.
655 (305). Mount Young.
656 (310). Large iceberg discharged from Muir glacier; about 100 feet out of water.
657 (312). Muir glacier; from Caroline shoals.
658 (314). Muir glacier; from Sebree island.
659 (318). Mountains at the head of Geikie inlet.
660 (330). Mount Wright; from Sebree island.
661 (333 . Rounded limestone on Drake island.
662 (347). View over Hugh Miller inlet.
653 (348). View over Hugh Miller inlet.
664 (354). Geikie glacier; Hugh Miller inlet.
665 (362). Mountains between Tidal and Queen inlets; from across the bay, looking northeast.
666 (364). View in Hugh Miller inlet.
667 (374). First northern tributary of Muir glacier; from *V*.
668 (379). Western tributary of Muir glacier; from *V*.
669 (380). Mount Wright; from *V*.
670 (381). Muir glacier; from *V*.
671 (385). Junction of Girdled with Muir glacier.
672 (386). Junction of Girdled with Muir glacier.
673 (387). Looking down Endicott valley.
674 (389). Junction of Girdled with Muir glacier.
675 (395). Near head of Rendu inlet.
676 (398). Mount Fairweather; upper part of Glacier bay.

677 (400). Upper part of Glacier bay.
678 (407). Looking up Rendu inlet; from Halfbreed island.
679 (409). Carroll glacier.
680 (410). Carroll glacier.
681 (413). Glacial scratches at the north end of Sebree island.
682 (414). Muir glacier and Mount Case; looking eastward.
683 (418). Stream terraces at end of Muir glacier.
684 (420). Ice front of Muir glacier.
685 (434). Top of Mount Verstova; near Sitka.

Photographed and Presented by Professor C. W. Hall, Minneapolis, Minn.

Size, 4½ x 7¾ inches.

686 (1). Quarry in gneiss; Morton, Minn.
687 (2). Glaciated surface of gneissic rocks; Morton, Minn.
688 (3). Exposure of quartzite conglomerate; near New Ulm, Minn.
689 (4). The Dalles of the Saint Croix; Taylor's Falls, Minn.
690 (5). Columnar structure of diabase; Grand Marais, Minn.
691 (6). "Basal conglomerate;" Taylor's Falls, Minn.
692 (7). The Potsdam sandstone; Osceola Mills, Wis.
693 (8). Fault in the Magnesian series; near Hastings, Minn.
694 (9). Contact of Trenton limestone and Saint Peter limestone; Minneapolis, Minn.
695 (10). Displaced Trenton limestone; Saint Paul, Minn.

Photographed and Presented by Mr J. Stanley-Brown, Washington, D. C.

Views on the Seal islands, Bering sea. Size, 7¼ x 9½ inches

696. Miak; near Bogoslov, Saint Paul island.
697. Miak; near Bogoslov, Saint Paul island.

Photographed and Presented by Mr H. G. Bryant, Philadelphia, Pa

Kodak views of the Grand river and falls of Labrador. Size, 4½ x 3¾ inches

698. Rapids above the falls.
699. Brink of the falls.
700. The Grand falls of Labrador.
701. Looking up stream above the falls.
702. Canyon below the falls.
703 (1). Cockle's Head; near St. John's, Newfoundland.
704 (2). Outlet of Grand lake, Labrador.
705 (3). Mountaineer Indian lodge on Grand lake.
706 (4). View looking down Grand river from lower falls.
707 (5). Part of lower falls of Grand river.

708 (6). "Dinner time."
709 (7). Rocky headland; Lake Wanakobou.
710 (8). Portaging around the Ninipi rapids.
711 (9). Camp at the head of navigation.
712 (10). View on Lake Wa-na-ko-bou.
713 (11). Cascade near Grand river above Mouni rapids.
714 (12). View on interior plateau of Labrador, showing glacial bowlders.
715 (13). Typical bowlder of the interior plateau.

Presented by U. S. Geological Survey

Photographed by W. P. Jenney

716. The anticlinal at the termination of the Ozark uplift in the northeastern corner of Indian Territory on Spring river about six miles south of Baxter, Kansas; panoramic view of four 6 x 8 inch photographs.

Photographed and presented by Ben Haines, New Albany, Ind

Size 8 x 10 inches; price, 50 cents each

24 views of Mammoth cave and vicinity

717 (04). First saltpeter vats.
718 (05). Old saltpeter pipes.
719 (08). Standing rocks.
720 (013). Stone cottage.
721 (014). Giant's coffin.
722 (017). Bottomless pit.
723 (022). The post-oak pillar.
724 (029). The arm-chair.
725 (030). The elephants' heads.
726 (036). The Egyptian temple.
727 (037). Bacon chamber.
728 (055). Stalactites in Croghan's hall.
729 (056). End of the cave.
730 057). Star chamber.
731 (060). An alcove in Gothic avenue.
732 (065). Head of Echo river.
733 (0101). White's cave; Humbolt's pillar.
734 (0106). White's cave; the royal canopy.
735 (0124). Mammoth Cave hotel.
736 (218). Wyandotte cave; the throne.
737 (220). Wyandotte cave; Monument mountain and Wallace's grand dome.
738 (235). Wyandotte cave; Niagara falls (No. 1).
739 (524). Marengo cave; "Cupid's net."
740 (529). Marengo cave; Washington's plume.

The scientific program was declared in order, and the first paper was:

NOTES ON THE GLACIAL GEOLOGY OF WESTERN LABRADOR AND NORTHERN QUEBEC *

BY A. P. LOW

Contents.

Glacial Phenomena of the Region.—As may be supposed, there is no marked difference between the glacial phenomena of the interior of Labrador and those of more southern Canada—they all point to a great mass of ice in motion. As the central divide of the interior has not yet been visited the conditions of the surface there are unknown, but it will probably be found to differ but little from the portions already explored. The watershed between the rivers flowing into the gulf of Saint Lawrence and those of Hudson bay acted as a dividing line to the direction of the later ice movement. This height of land is a marked feature in the region for over fifty miles to the north and south of Lake Mistassini, where it runs roughly north-northeast and south-southwest, or parallel to the longer axis of that lake. The country to the southeast of the divide is from 200 feet to 400 feet higher than that to the north, the descent from the one to the other being quite sharp. Near the summit of the slope toward the Saint Lawrence the finer material of the till is abundant and the surface rock is not deeply grooved or striated. As the slope is descended the striæ are more deeply marked and their course is very persistent, being nearly due north and south to beyond Lake Saint John, where the highlands of the Saint Lawrence border appear to have formed an obstruction to the bottom of the moving ice and caused it to change its course locally, so as to pour out into the Saint Lawrence valley through any convenient pass between the hills.

North of the divide all rock exposures are deeply scratched and grooved, the direction of the striation being from N. 30° E. to S. 30° W., or parallel to the steep escarpment of the watershed. Here the glacial action appears to have been much more intense than on the southern slope; all the finer material being removed, leaving only an innumerable number of bowlders to partly cover the deeply grooved rock. The only place where quantities of the finer drift material remain is along the foot and sides of the escarpment, and this may be the remains of a lateral moraine, but cannot be stated to be such, as no detailed examination of it has been made.

The great lakes Mistassini and Mistassinis and the other large lakes strung out in line with them to the southwest lie parallel to the direction of the striæ and owe their origin to the action of the ice, which has scooped their deep basins out of the comparatively soft, flat-bedded limestones of Mistassini and the altered hornblende and chlorite slates of the lakes to the southwest, leaving the granites, gneisses and diorites to form the higher lands surrounding them.

Northward from Mistassini toward the East Main river the striæ have every-

* Published by permission of the Director of the Geological Survey of Canada.

where a N. 30° E. direction, but when that river is reached these are found to be partly obliterated by a newer set coming from N. 50° E. This direction of the newer set changes slowly to N. 60° E. as the river is descended, the older set being seen from time to time on favorably protected rock surfaces. A remarkable feature of the country to the northward of Lake Mistassini is the number of low hills made up wholly of rounded bowlders. These lie parallel to the direction of the striæ and culminate in sharp, narrow ridges that slope at high angles on either side. These bowlder ridges are at times connected with rocky hills, but more often stand up independently.

On the Big, Great Whale and Clearwater rivers a similar condition of glaciation is found, the direction of the striæ following the general slope of the country. Along the Big river it is from N. 70° E.; on the Great Whale from S. 70° E., and along the Clearwater from nearly due east.

On the coast of Hudson bay the striæ do not run in any one direction, but conform with local slopes. Here as many as four sets of striæ have been observed on the rocks; any or all of these may mark the direction of local glaciers found toward the close of the period on the rocky highlands facing the bay.

The composition of the drift is largely local, but bowlders from known localities are at times found transported from fifty to one hundred miles from their original sources. The limestones of Mistassini are found over sixty miles to the south-southwest of the nearest known bed. Bowlders of this limestone, along with others of Huronian rocks, are not uncommon in the drift of the southern slope to within a few miles of Lake Saint John. As no areas of these rocks are known to exist in the region south of the watershed, at some time, probably during the period of greatest accumulation, the ice-cap must have moved up over the height of land, carrying with it fragments of the rocks on the north side and scattered them over the southern slope, where they are now found, over one hundred miles from their known source.

On a hill some 300 feet above Clearwater lake a bowlder of Silurian limestone was found. This tends to prove the previously supposed presence of a basin of rocks of this age in the level country south of Ungava bay, as the striæ show that the bowlder must have come from that direction. A chain of islands extends up the eastern third of James bay. These are undoubtedly of glacial origin and are the remains of a terminal moraine. Although they have been submerged at or subsequent to their formation they still preserve all the characteristics of such an origin, and the action during submergence has only slightly altered their external structure. They rise in their highest parts from 150 to 200 feet above the present sea-level and are wholly composed of unstratified till. Their surface is uneven, being dotted with small rounded lakes and ponds, while the hummocks of bowlders have been flattened out and settled into compact masses by the later wave action. Their faces are cut into terraces, but there are no stratified deposits anywhere. This moraine marked the limit of the glacier at a halt during the period of retrocession and was not the limit during the time of greatest glaciation. Then the ice pushed down from the interior of Labrador, crossed Hudson bay, and passed up over the low country on the western and southwestern side, and probably crossed the watershed and descended into Lake Superior. Of this we have evidence, in the direction of the striæ and the presence of Silurian and Devonian limestone bowlders in the drifts, to show that this was the direction of the ice-flow, along the rivers falling into the southern and southwestern portions of James bay, the limestone being transported from the lower flat region about the bay far inland over the higher interior Archean country.

The retrocession of the glacier from the island moraine to the mainland is marked by the morainic matter that fills the bay inside the boundary of the outer islands.

Pleistocene Changes of Level in Labrador.—At the close of the glacial period there was a marked elevation of the western part of Labrador. The extent and limits of this elevation can be traced by the deposits of stratified sands and clays that now cover the lower margin of the peninsula. On the Rupert and East Main rivers these deposits are found a long distance inland. On the latter river continuous deposits are met with for one hundred and ten miles from its mouth, and at that distance reach an elevation of 650 feet above the present sea-level. Although fossil marine shells are only found for some forty miles from the sea, there is no doubt that the beds farther inland are a direct continuation of those holding fossils and mark the limits of the ancient sea-level. As the exploration of the Big river was not continuous, it is impossible to say to what distance inland the marine deposits extend. For the first forty miles from its mouth the river flows between steep banks of clay, capped with sand holding numerous fossils. On the Great Whale river stratified deposits extend inland a distance of thirty miles to beyond the forks. Above this the river passes for several miles through a deep narrow gorge on its way down from the interior plateau. Any stratified deposits which might have existed in this gorge have been washed away, and the only traces of such are isolated patches of fine sand clinging to the rocky sides in protected positions. The highest of these are about 100 feet above the river or, roughly, 600 feet above the sea. Terraces up to 300 feet elevation flank the rocky hills in a number of places along the northern coast. At the mouth of the Clearwater river on Richmond gulf a series of fine sandy terraces are seen, the highest being about 300 feet above the water.

The first portage on the route from Richmond gulf to Clearwater lake passes up a wide valley over old sea beaches facing the gulf; the highest of these on a level with a small plain is 450 feet above the sea. Beyond this for ten miles up the small stream followed by the route there are terraces cut in stratified clays and sands that rise in the highest 160 feet above the river, or 675 feet above the present sea-level. Beyond this line the surface material is unstratified till.

From the above it will be seen that the Pleistocene elevation of the western side of Labrador was nearly uniform from the south end of Hudson bay to Richmond gulf, with a maximum elevation of 675 feet toward the north.

According to Dr A. S. Packard,* raised beaches and terraces are found along the Atlantic coast from the strait of Belle Isle to Hopedale. These are seldom or never more than 200 feet above the sea, or less than one-third of the elevation of the terraces on the western side.

If the theory that the greatest elevation conformed with the areas of greatest ice accumulation, the ice-cap on the western part of Labrador must have been much thicker than that on the eastern portion. This agrees with the state of glaciation observed by Dr Bell † along the northern Atlantic coast, where he reports that the upper parts of the high Coast range form sharp serrated peaks, covered with undisturbed rotted rock, and that evidence of glacial action is only seen in their lower valleys.

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*The Labrador Coast, pp. 306-310.

† Report of Progress, Geol. Surv. Canada, 1882-'83-'84.

The second paper read was:

HEIGHT OF THE BAY OF FUNDY COAST IN THE GLACIAL PERIOD RELATIVE TO SEA-LEVEL, AS EVIDENCED BY MARINE FOSSILS IN THE BOWLDER-CLAY AT SAINT JOHN, NEW BRUNSWICK

BY ROBERT CHALMERS

Remarks were made by Mr Warren Upham as follows:

These fossiliferous beds with till above and below them were doubtless formed close to the ice-front, which, as Mr. Chalmers has shown, probably rested on the neighboring hills of this coast, temporarily receding to them and thence readvancing a short distance into the sea. That the ice-sheet was near is implied by the abundance of the shells of *Yoldia* (*Leda*) *arctica*, which is now found only in Arctic seas and thrives best, according to Baron de Geer's observations in Spitzbergen, near the mouths of streams of very silty water discharged from glaciers.

The paper is printed as pages 361–370 of this volume.

The following paper was read by title:

THE ABANDONED STRANDS OF LAKE WARREN

BY ANDREW C. LAWSON

This paper is incorporated in the Twentieth Annual Report of the Geological and Natural History Survey of Minnesota, 1891, pages 181–239.

The next paper was read by the author, but not submitted for publication:

THE PLEISTOCENE HISTORY OF NORTHEASTERN IOWA

BY W J MCGEE

In the discussion of the paper remarks were made by R. D. Salisbury, C. R. Van Hise, Warren Upham, Robert Bell, and Mr J. M. Macoun, a visitor. The paper is embodied in the Eleventh Annual Report of the United States Geological Survey, 1889–'90, pages 189–577.

The last paper of the morning session was:

ESKERS NEAR ROCHESTER, NEW YORK

BY WARREN UPHAM

This communication is published in the Proceedings of the Rochester Academy of Science, volume ii, pages 181–200.

At the close of the reading of this paper a recess was taken until 2 o'clock p. m.

On reassembling at 2 o'clock the following communication was read:

COMPARISON OF PLEISTOCENE AND PRESENT ICE-SHEETS

BY WARREN UPHAM

The paper provoked a spirited but pleasant discussion, the chief point of division being the evidence as to the existence of man in America during glacial time. Remarks were made by W J McGee, A. R. C. Selwyn, G. F. Wright, R. D. Salisbury and the author. The paper is printed as pages 191–204 of this volume.

The next paper was as follows:

THE SUPPOSED POST-GLACIAL OUTLET OF THE GREAT LAKES THROUGH LAKE NIPISSING AND THE MATTAWA RIVER

BY G. FREDERICK WRIGHT

During the early part of last September, in company with Judge C. C. Baldwin, of Cleveland, D. C. Baldwin, of Elyria, and Professor Albert A. Wright, of Oberlin, and while engaged in the work of collecting fragments of the rock in place along the line of the Canadian Pacific railroad from the Sault Ste Marie to Ottawa to aid in identifying the glacial bowlders of Ohio, we turned aside for a few days to study the evidence which attracted our attention in support of Mr Gilbert's hypothesis that upon the first melting back of the ice of the glacial period the main part of the water of the great lakes ran for a while from Lake Nipissing by way of the Mattawa river into the Ottawa. This theory was, I believe, first presented by Mr Gilbert at the meeting of the American Association for the Advancement of Science at Toronto in August, 1889. The substance of his address upon that occasion was published in the Sixth Annual Report of the Commissioners of the State Reservation at Niagara (pages 61–84) and reprinted in the Smithsonian Report for 1890 (pages 231–257 .

The general facts suggesting such an outlet are those connected with the northerly depression of land known to exist at the close of the glacial period, and revealed in the familiar phenomena of the so-called Champlain epoch. The subsidence at Montreal, as shown by the marine shells resting upon glacial deposits, was a little over 500 feet, while in the valley of Lake Champlain it was considerably less, and in the latitude of New York city very much less still, if it had not wholly disappeared. It is difficult to determine from direct evidence at hand what was the subsidence in the region of the great lakes, though it is evident from Mr Upham's report upon the shore-lines of Lake Agassiz, from the investigations of Mr Gilbert and Mr Spencer upon the raised beaches about Lake Ontario, and from the various reports upon the old shore-lines north of Lakes Huron and Superior, that this differential northern subsidence characterized the whole interior basin east of the Rocky mountains. These facts, coupled with the known relative depression of the col between Lake Nipissing and the Mattawa river, naturally created confidence in Mr Gilbert's theory that the outlet of the great lakes by way of this col was once a reality, for the difference of level between Lake Erie and the col at

North bay, Ontario, is but little more than 100 feet, Lake Nipissing being, as we make it, but 61 feet higher than Lake Huron, 66 feet above Lake Erie (water works, south margin of North bay), and Trout lake, at the head of the Mattawa river, but 20½ feet above Lake Nipissing, while the col between is nowhere more than about 25 feet above Trout lake. A differential depression, therefore, of 150 feet, as between North bay and Niagara, would now divert the waters of the lakes by the Ottawa river, while the passes between the Mattawa and Lake Ontario are all of a considerably greater height. From these facts it was natural to expect that such an outlet existed.

We did not have time to trace the whole line of the supposed outlet, but the following observations upon the local facts seemed to be sufficient to add greatly to our confidence in Mr Gilbert's theory, if they do not, indeed, positively prove it. The col between Lake Nipissing and Trout lake, extending from one lake to another, a distance of two or three miles, is wholly occupied by a level swampy tract, as already said, not more than 25 feet above Trout lake and unobstructed by any continuous ridge of rocks or higher land. On the north this swamp is bordered by an extension of an old beach-line of Lake Nipissing, constituting a clearly defined terrace carrying a great abundance of well-rounded pebbles and extending from lake to lake at a height of about 50 feet above the swamp referred to. This beach borders the more elevated region which rises to the north. Upon the south side of the passage between the two valleys the indentations are so extensive and irregular that we did not have time to trace the corresponding shore line, but this would seem sufficient to show that the water of the lakes for some time stood between Lake Nipissing and Trout lake at such a relative level that if the way down the Mattawa and Ottawa were free from obstruction it must have poured in that direction in torrential volume. If such a torrent poured down the Mattawa the effects should show themselves in a pronounced manner in a bowlder terrace at the junction of the Mattawa and Ottawa rivers, which is about 40 miles distant (46 by railroad), and according to the railroad survey 95 feet lower in level, which is about 80 above the river, making the difference of water levels (that is between the top of the Nipissing-Trout lake terrace and low water at Mattawa) of about 225 feet (95 + 50 + 80).

Upon going down to the mouth of the Mattawa river we found an enormous bowlder terrace far exceeding our expectations, which it would seem difficult to account for on any other theory than that of the temporary existence at the close of the Glacial Period of Gilbert's supposed torrential current of water from the Great lakes. The bowldery delta terrace begins on the south side of the Mattawa about three-quarters of a mile above the junction of the rivers and extends a somewhat less distance down the right bank of the Ottawa. It enlarges about the middle of this distance and pushes out as a bar almost entirely across the Ottawa river, making deep slack water above and turbulent rapids for a long distance below. The terrace in this lower angle over the space mentioned consists entirely of bowlders and well-rounded pebbles, which completely cover the surface and apparently form the whole body of the terrace. The bowlders range in size from a few inches up to 30 feet in diameter, and the terrace is level-topped, the height above the river being, according to our estimate, about 80 feet. A short distance back from the Ottawa river there is a well-marked river channel cutting across that portion of the deposit which projects as a bar into the Ottawa river. This is the line of the flow of the Mattawa river when it joined the Ottawa about a mile below its present mouth. The bed is well-defined, with its bottom about 25 or 30 feet above the present river and with bowlders of the largest size upon each side.

Upon the north side of the Mattawa river for a mile or more above its junction there is a slender but well-defined terrace of the same height with that upon the south side, but consisting of fine material, presenting an area which has naturally been chosen for the cemetery and for a race-course. On the south side also the great bowldery delta terrace shades into finer material higher up the stream.

We followed up the Mattawa river a distance of about 8 miles, to the vicinity of Eau Claire. Though not able to study the region so carefully as we would have liked, everything so far as we could observe was favorable to the theory of its having been the temporary channel of a great stream of water. Terraces exist here and there, such as would be expected, and the descent of the channel at the portage of Plain Champ would aid in producing that final plunge in the descending stream required to produce the effects described at the junction a mile or more below.

The only theories worth considering in accounting for these phenomena are that this collection of bowlders is of the nature of a moraine modified by temporary local floods which came down the Mattawa upon the melting of the ice, and that of Mr Gilbert, that the torrent of Niagara was for a time diverted down this trough.

The moraine theory would seem untenable from the position of the material. It is not in position for a moraine moving down either the valley of the Ottawa or of that of the Mattawa. It is in fact midway between the two, upon the lower angle of their junction, and runs up the Mattawa valley in a way to indicate the predominant influence of rushing water coming down that valley. The position and character of the bowlder terrace and its relation to the terrace upon the opposite side of the Mattawa is strictly analogous to that which I have described* as occurring at Beaver, Pennsylvania. The accumulation of bowlders is also strictly analogous to that at Pocatello, Idaho, where the Port Neuf valley opens out into the Great Snake River plain, and described by me on pages 235-236 of my recent work, "Man and the Glacial Period." In the case of the Beaver terraces we have to account for them by the vast floods at the close of the Glacial Period, but the accumulation is as nothing in comparison with that at Mattawan. At Pocatello, however, some time after my collection of the facts, the publication of Mr Gilbert's monograph upon Lake Bonneville made it clear that the overflow of that great lake led down the Port Neuf river, and that for a period of 25 years the volume of the flow was comparable to that of the Niagara, and the results are, as we have said, closely analogous to those at Mattawan and almost equal in their extent. The further prosecution of inquiries through the whole length of the valley of the Mattawa will, however, by some be thought necessary to complete the verification of this theory; but for one I expect most confidently the evidence will be forthcoming when attention is sufficiently directed to the region.

Professor Wright's paper was discussed by the President and by Robert Bell. Dr Bell said:

I have been over the ground referred to by Professor Wright and Mr Gilbert. I think Professor Wright's hypothesis interesting as a suggestion, but do not consider that sufficient evidence has yet been offered to make it anything more than that. The matter has not been sufficiently investigated to enable us to come to

* Bull. 58, U. S. Geol. Survey, p. 77.

any acceptable conclusion. The whole course of the supposed outlet should be examined before it can be asserted that some objections fatal to the theory do not exist. The lines of bowlders to the northward of Trout lake, which have been referred to, might belong to moraines and not to lacustrine terraces, which in any case would only prove a former eastward extension of Lake Nipissing.

Lake Huron is 582 feet above the sea and Lake Nipissing 637 feet, or 55 feet higher. As the ground is low between Lake Nipissing and Trout lake, if Lake Huron were only a little more than 55 feet higher than at present its waters might have flowed down the Mattawa river at the time supposed by Professor Wright, provided the relative levels of the whole region were the same then as now; but this was unlikely to have been the case.

The valley of the Mattawa appeared to be only large enough for a river of the small size of the present stream. At the outlet of Trout lake the ground is high and the river passes through a narrow opening. Again, from the outlet of Turtle lake to Lake Talon the stream runs in a very contracted valley, which, speaking from memory, I do not think gives indication of having afforded passage to a larger body of water. Further down in the neighborhood of the south branch, the Amable du Fond, the valley appeared to be quite contracted at several points.

I did not think that the bowlder-covered field or plateau on which Mattawa village is built could be cited as evidence in support of the present theory. Many similar fields were to be found along the Ottawa. The ridge of bowlders, pointing northward, which juts out into the Ottawa river at the mouth of the Mattawa, is of morainic origin and has probably been left by a glacier which came down the north-and-south stretch of the Ottawa just above this locality, or from one of the tributary valleys on the opposite side of that river. Corresponding ridges of bowlders, transverse to the current, formed similar points projecting into the Ottawa in many places all along its course. Some of them ran completely across the bed of the stream, as, for example, the one near Kettle island, only a few miles below Ottawa city, which at low water entirely obstructed navigation except at one narrow gap. All these I regard as having been left by glaciers descending from the north-and-south valleys, which cut through the rocky hills to the northward and fall into the Ottawa at right angles. I have described them in the chapter on Surface Geology written for Sir W. E. Logan, in the *Geology of Canada*, 1863.

If, in comparatively recent geologic times, the valley of the Ottawa river, from the junction of the Mattawa to its mouth, had acted as a channel for the conveyance of a much larger body of water than the present stream, we should see abundant evidence of the fact at many places on its course, but such evidence appears to be wanting. Along its lower reaches for perhaps 200 miles above the mouth clay banks of moderate elevation rise from high-water mark, and from their brink level tracts extend in many places for miles to the southward. The difference between the annual high and low water marks in the Ottawa is a little over 20 feet. During the period of high water the river cuts into the foot of the clay banks and so produces irregular widenings of the stream at the flood line. There is no sign of any former erosion of these clay flats by a higher level of water. In the vicinity of the rapids and falls of the Ottawa evidence also appears to be lacking of the former passage of any larger body of water than at present.

In reference to the terraces around Lake Huron I will say, in connection with the question, that along the north shore of that lake old beaches are to be seen almost everywhere up to a little over fifty feet above its present level, but that they have only been noticed at greater elevations in a few places, such as near

Parry sound, referred to by Mr Gilbert, and also at Wikwemikong on Manitoulin island. More than forty years ago Mr Sandford Fleming, of Ottawa, wrote an account in the Journal of the Canadian Institute of the terraces around Nottawasaga bay, which had also been described by Professor Chapman; and I have made profiles of the country to the southward of Georgian bay from lines of spirit-levels which I ran. These showed lacustrine terraces at almost every height up to some 200 feet, but in the present state of our knowledge these facts might prove nothing in reference to former outlets of Lake Huron, since the whole of the surrounding area may have been slightly canted instead of having been uniformly elevated.

These were some of the unanswered difficulties which have presented themselves to my mind while Professor Wright was reading his paper, and I think that, apart from the upsetting of all the calculations of geologists based on the facts presented by the Niagara gorge, they are sufficient to justify me in not accepting the Professor's hypothesis until further investigations have been made.

The next paper was read for the absent author by Mr W J McGee:

ON CERTAIN FEATURES IN THE DISTRIBUTION OF THE COLUMBIA FORMATION ON THE MIDDLE ATLANTIC SLOPE

BY N. H. DARTON

Remarks upon the paper were made by R. D. Salisbury, Warren Upham and W J McGee.

In the absence of the author the next paper was read by R. W. Ells:

NOTES ON THE GEOLOGY OF MIDDLETON ISLAND, ALASKA

BY GEORGE M. DAWSON

Middleton island is situated opposite Prince William sound, in that part of the north Pacific which on some maps is named the gulf of Alaska. It is distant about sixty-four miles from the mouth of the Copper river, the nearest part of the mainland coast, and some fifty-five miles from the nearest points of any other land—these being parts of the shores of Kaye island, Alaganik island and Montague island. The three islands mentioned are all adjacent to the coast of the mainland and separated from it by comparatively narrow waters. They lie in northeast, north and northwest bearings respectively from Middleton island, which thus stands alone and not far from the edge of the hundred-fathom bank or margin of the continental plateau.

Mr J. M. Macoun was landed on this island on June 15, 1892, by H. M. S. *Nymphe*, and occupied the few hours at his disposal there in making a paced survey around the entire shore of the island, either on the beach or along the summit of the low bordering cliffs when walking on the shore itself proved to be impossible. He collected some specimens of the material of which the island is composed and made a few notes upon it, determining the heights of the cliffs, etc, by means of an aneroid barometer.

Mr Macoun does not profess to be a geologist, but on his return he submitted his specimens to me, and it was at once apparent that these represented a true till or bowlder-clay. The position of this island—lying as it does so far to seaward—

rendered this fact interesting, and some examinations of this bowlder-clay were made. It is proposed to give the results of these examinations.

Knowing that Dr W. H. Dall had visited the island some years ago, I wrote to him, after having examined the specimens, to ask whether any account of its geology had been previously published, and learned that a very brief note, based on Dr Dall's observations made in 1874, had lately been printed in Bulletin No. 84 of the U. S. Geological Survey, pages 259–260. Dr Dall further obligingly supplied me with an early copy of this publication, but the facts now ascertained appear to throw a wholly new light on the structure and geologic age of the island.

Mr Macoun has furnished me with a very clear general description of the island, based on his survey of it, which it is proposed to quote as introductory to the few remarks based on my study of the specimens. He writes:

"Middleton island is a little over five miles in length and a mile and a quarter in breadth at its southern and wider end. At its northern extremity it narrows to a low sandy point, from which a spit extends northward more than two miles. This spit is bare at low tide. For more than ten miles off the southern end breakers are to be seen at all stages of the tide, and at low tide several rocks or shoals show above water.

"About the center of the west side of the island there is good anchorage, and from there to the southern end there is no beach, the cliffs rising perpendicularly from the water to a height of about 100 feet. From 100 to 300 yards back from the edge of the cliff the ground is level and boggy, but it then rises abruptly between 25 and 40 feet. There is, in fact, here a distinct terrace cut back in the material of the island, at a height of 100 feet above sea-level. The surface of the island slopes gradually up from the eastern side to the high ground on the west, so that the greater part of the water that falls upon the island runs off on the eastern side. Not even the smallest stream is to be seen, but everywhere there is a constant trickling of water over the cliffs, and so soft is the material of which the island is composed, that on the eastern side it is being gradually worn away and forms a steep incline from the summit to the water.

"The cliffs on this side are from 30 to 50 feet in height, and from their summit it can be seen that the rock or general material of the island extends for some distance out from the shore, the slope being much less after the level of the sea is reached.

"For about two miles along the eastern shore of the island the beach is strewn with pebbles and small limestone bowlders. At the northern end and for about two miles along the northwestern shore, the level rises but a few feet above the sea and the beach is composed of sand only. For nearly a mile beyond this, toward the south, there are a good many bowlders along the shore, consisting of granites, as well as black argillite. Just opposite the anchorage a band of gravel not more than two feet in thickness was noticed running along the cliffs, and there may be more bands or beds of the same material elsewhere, as no special importance was attached to these at the time and they were in consequence not looked for or precisely noted, and none of the cliffs along the southern half of the island were seen from the water. In my notes, the material of which the island appears otherwise to be entirely composed was called a soft conglomerate, and the stones contained in it are often as large as the head or larger.

"These seen along the shore appear to be derived, at least for the most part, from the wearing away of the general material of the island, and vary in size from minute pebbles to large ones a foot or more in diameter. This action must be very rapid, for when there is no true pebbly or sandy beach, which is the case for about three miles of the shore line, the waves wash in against the actual base of the cliffs, which are in several places undercut. For about one and a half miles along the middle part of the island, on the east side, where the cliffs are from 10 to 25 feet high only, there is no beach, but the characteristic rock of the island extended here at half-tide from 10 to 20 yards out from the base of the cliff as a level floor. The sea was nearly calm at this time, but the water was discolored by earthy matter for some distance from the shore; and when wet, along the edge of the sea the material is not only very slippery, but so soft that it may be rubbed away by the hand. About two miles from the northern end of the island one of the officers of the *Nymphe*, who had been walking along the shore and had come to a point he could not pass, had climbed up the cliff by cutting places for his feet with his knife, and when I reached this place I ascended to the summit of the cliff in the same way."

The component material of Middleton island, as represented by the specimens brought back by Mr Macoun, is, as already stated, a good typical bowlder-clay or till, of rather dark, bluish-gray color, and somewhat unusually hard and compact. It shows no sign of oxidation by weathering, and in the actual specimens received is packed with small stones which vary in size from about an inch and a half in diameter downward. These lie in all positions, and there is no apparent stratification or lamination whatever, though here and there small parts of the whole appear to be more arenaceous than the rest. None of the stones are perceptably facetted, nor on these seen can any distinct striation be observed. They are either subangular or fairly well-rounded in shape, and the surfaces of a few of them are so smooth as to be described as polished. It is apparent, in fact, that they represent water-rounded material.

The stones themselves consist almost exclusively of a hard, fine-grained, nearly black material, which has not been microscopically examined in thin sections, but appears to be undoubtedly a rather indurated argillite, resembling rocks seen by the writer on several parts of the Alaskan coast, and which, merely from their lithologic analogy with similar rocks on the better-known coast of British Columbia, may represent what has been named the Vancouver Group, of Triassic Age.

The material also contains rather numerous fragments of shells, but all so much broken in the specimens actually received as to be impossible of exact determination. One small piece of a ribbed shell appears, however, to represent a small specimen of *Cardium blandum*. Several fragments, when microscopically examined, were found to be slightly rounded on the broken edges, while others were quite angular. The whole mass of the clay is more or less calcareous, effervescing freely when an acid is applied. Though very hard when dry, fragments broken from the inner surfaces of the specimens of bowlder-clay when placed in water partially break up, and with the aid of agitation and occasional slight pressure applied to the harder lumps the whole was easily and completely disintegrated.

After removing the larger stones from about an ounce of the material, the residue was subjected to a series of decantations at different intervals of time, by means of which its constituents were separated in accordance with their size and specific gravity, the *modus operandi* being the same as that employed in previous investigations of bowlder-clays.*

A microscopic examination of the various samples thus obtained, showed this bowlder-clay to comprise a considerable proportion of very fine silty matter, of which the particles are nearly equal in size; also some formless argillaceous matter and a larger proportion of sand.

All grades of the sand proved to consist, to the amount of about one-third or one-half, of partially or well rounded grains of the dark argillaceous rock above referred to, while the remainder was chiefly composed of quartz, generally glassy and usually quite angular, though in part subangular or slightly rounded.

Two samples of this sand, of medium grade, were kindly examined in detail by Mr W. F. Ferrier, who states that, in addition to the argillite grains, the constituents of the coarser of these samples are as follows, in order of abundance:

Medium coarse.—Quartz, feldspar (no striated grains were observed), magnetite, a dark brown pyroxene (?), hornblende of various shades of green, brown mica, (biotite ?) and a very few grains of titanite.

Medium fine.—The same materials, but with mica and hornblende rather more abundant than in the last.

It may be added that the feldspar, pyroxene, hornblende, etc, are found in rather

*Bull. Chicago Acad. Sci., vol. i, no. vi.

small quantity, the impression conveyed being that the sand cannot in any large part be considered as directly derived from crystalline rocks. In the coarsest specimens of sand resulting from the mechanical analysis of the bowlder-clay the constituent grains were easily separable by the unaided eye, and among them were found small fragments of shells and a number of foraminifera. Of these a small collection was picked out and mounted, comprising about two dozen individuals, and representing perhaps half the number present in about an ounce of the material.

These have been examined by Mr J. F. Whiteaves, who reports all the specimens but three to be referable to *Polystomella striatopunctata*, Frichtel and Moll, while of the remaining specimens one is *Pulvinulina karsteni*, Reuss, another probably *Nodosaria* (*Glandulina*) *lævigata*, D'Orb., and the third not determinable, being encrusted and badly worn.

The *Polystomellæ* are rather small and depauperated in appearance, resembling in this respect those found in the upper part of the gulf of Saint Lawrence,* where the water becomes distinctly less saline than normal, but the collection so far examined is quite too small to warrant any theorizing on this fact.

In examining the medium grades of sandy material under the microscope numerous fragments of sponge spicules were noticed. These were generally straight, simple and tubular, but, so far as observed, never perfect. No diatomacæ were seen, though more extended and minute search might probably lead to this discovery.

In containing broken shells and other forms of marine life, the bowlder-clay here described resembles that of some parts of the Queen Charlotte islands already described by the writer.† The available evidence is, however, insufficient to enable us to refer the deposit of bowlder-clay of which Middleton island is composed to its proper place in the sequence of events of the glacial period, for elsewhere on the coast, and probably generally, there are two distinct bowlder-clays, which can only be separated with certainty when both are seen. This bowlder-clay may have been formed as a marine bank in proximity to the fronts of great glaciers debouching along the coast of the mainland to the northward, upon which detached icebergs grounded from time to time.

The interstratified layer or layers of pebbly material observed by Mr Macoun might thus be explained, and it appears further to be borne out by the description by Mr Dall, whose attention seems to have been more particularly directed to evidences of bedding, and who writes:

"The island is composed of nearly horizontal layers of soft clayey rock, containing many pebbles and even bowlders of syenite and quartzite, some rounded and others of angular shape. Above the claystone is a layer of gray sand covered with several feet of mould and turf."‡

It is perhaps, however, on the whole more probable that this projecting mass of bowlder-clay forming Middleton island represents a portion of a morainic accumulation formed at or near the seaward edge of an ice-field derived from the adjacent mainland, and which pushed southward or in a direction at right angles to that of the average trend of the nearest continental coast.

The broken character of the shells seems to favor the belief that the material was ploughed up from the sea bottom and greatly disturbed, rather than to show that it represents merely a bank upon which glacial débris was occasionally discharged. Such a bank might probably be from time to time poached up by

*See Canadian Naturalist, 1870, p. 172.

†Quart. Jour. Geol. Soc., May, 1881. Report of Progress, Geol. Surv. of Canada, 1878-'79, p. 91 B.

‡Op. supra cit., p. 260.

grounding ice, but this alone would appear to be scarcely sufficient to explain the always broken appearance of the mollusks in the specimens actually to hand.

The distance from the border of the mainland (about 55 miles) would seem to indicate that it represents a portion of the morainic deposits formed at the outer edge or along the retreating front of that part of the continuation of the Cordilleran glacier which is believed to have occupied the highlands of the corresponding part of the Alaskan coast during the first and most important period of glaciation.*

It will be noted that the island lies opposite an extensive indentation in the general coast line, marked by Prince William sound and also by the Copper River valley, and it is therefore possible that the corresponding portion of the great glacier here stretched further seaward than elsewhere. The water between the mainland coast and Middleton island is not very deep, varying, according to the few soundings shown on the chart, from 30 to 50 fathoms. It is therefore quite probable that a glacier-sheet moving outward from the land may still have borne upon the sea-bed with sufficient weight to produce the effects above alluded to, even were the relative elevations of sea and land the same as those of to-day. There is, however, so much reason to believe that very extensive changes in levels have occurred in the region during and subsequent to the glacial period, that it is not safe to assume that the relative levels were identical with those now existing. It is reasonably certain that the island, composed of such relatively soft material, and exposed as it is with few protecting beaches to the full force of denudation exerted by a stormy ocean, has not for any very protracted period, from a geologic point of view, stood at its present level. Mr Macoun's description of the western side of the island in fact distinctly indicates the existence there of a well-marked terrace, cut back at a height of about 100 feet above the present sea-level. Whether this actually represents, in a modified form, that pause in elevation which the coast further south seems to have experienced during the closing events of the glacial period (there at an elevation of about 200 feet) † it is difficult to say; but it indicates, with scarcely any doubt, one stage in that general and last process of elevation. The unoxidized character of the bowlder-clay itself seems to show that it can never for a very prolonged period have been subjected to subaërial agencies.

In Dr Dall's observations on Middleton island, already quoted, the following statements are in conclusion made:

> "Below the sea-level some of the rock appeared to be quartzite in place and very hard. Whatever its nature, it extends in reefs and shoals to a distance of several miles from the island in different directions. No fossils were found in the claystone, but from its character it was suspected to be post-Miocene and possibly Pliocene" ‡

Respecting the existence of a quartzite basis of the island, Dr Dall writes doubtfully as above, while Mr Macoun did not note any such underlying rock in following the shores. It would appear to be very probable that the surrounding reefs or shoals are merely the higher parts of a plane of marine denudation or banks thrown up upon such a plane, which now surrounds this rapidly diminishing island and corresponds with its original size under the existing relative levels of sea and land in the region. As to the age of the material composing the island itself there seems to be no room for doubt that this is Pleistocene and referable to the Glacial Period.

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* Later Physiographical Geology of the Rocky Mountain Region, etc: Trans. Royal Soc. Canada, vol. viii, sec. iv, map 4.

† Ibid, p. 54.

‡ Op. supra cit., p. 200.

Remarks upon Dr Dawson's communication were made by C. W. Hayes.

The next communication was read by title:

TWO NEOCENE RIVERS OF CALIFORNIA

BY WALDEMAR LINDGREN

The paper is printed as pages 257–298 of this volume.

The following paper was read by the author:

THE LAURENTIAN OF THE OTTAWA DISTRICT

BY ROBERT W. ELLS

It was discussed by F. D. Adams, C. R. Van Hise, A. R. C. Selwyn and the author. It is printed as pages 349–360 of this volume.

The last paper of the day was—

THE CONTACT OF THE LAURENTIAN AND HURONIAN NORTH OF LAKE HURON

BY ROBERT BELL

A full synopsis of this paper will be found in the American Geologist for February, 1893, pages 135–136.

Before adjourning it was announced that the Fellows were invited to the annual dinner of the Logan Club at the Russell house, Thursday evening.

Session of Friday, December 30

The President called the Society to order at 8.15 a. m.

The Auditing Committee reported that the accounts and report of the Treasurer had been found correct. The report of the committee was accepted and the committee discharged.

The following letter was read by the Secretary:

Boston Society of Natural History,
Boston, Massachusetts, December 27, 1892.

Dear Sir: I have the honor of extending the cordial invitation of the Boston Society of Natural History to the Geological Society of America to hold its next winter meeting in Boston, at our building. I am pleased to assure you that if the geologists come to Boston one year from this time they will receive a cordial welcome.

Most respectfully, William H. Niles, *President.*

To Professor H. LeRoy Fairchild,
Secretary of the Geological Society of America.

A telegram from Sir J. W. Dawson, the President-elect, in response to one sent him notifying him of his election, was received, and read at a later hour during the morning session.

The President announced that the summer meeting would be held at Madison, Wisconsin, the precise date in August to be announced later.

The annual address of the President was read from the chair·

CONTINENTAL PROBLEMS

BY G. K. GILBERT

The address is printed as pages 179–190 of this volume.

The first paper of the program was—

THE ARCHEAN ROCKS WEST OF LAKE SUPERIOR

BY W. H. C. SMITH

Mr Smith,* a member of the Geological Survey Department of Canada, was introduced by R. W. Ells. The paper was discussed by C. R. Van Hise and A. R. C. Selwyn. It is printed as pages 333–348 of this volume.

The second paper was—

RELATIONS OF THE LAURENTIAN AND HURONIAN ROCKS NORTH OF LAKE HURON

BY ALFRED E. BARLOW

Remarks were made by C. R. Van Hise. The paper is printed on pages 313–332 of this volume. It was read under the title "On the Archean of the Sudbury mining District."

A recess was taken until 2 o'clock. When the Society reconvened the following paper was read for the absent author by Mr W J McGee:

THE WORK OF THE UNITED STATES GEOLOGICAL SURVEY

BY J. W. POWELL

The communication was illustrated by samples of the maps published and projected by the Survey. Remarks were made by A. R. C. Selwyn and B. K. Emerson. The paper is printed in Science, volume xxi, number 519, pages 15–17.

* Soon after the adjournment of the meeting came the sad announcement of the death of Mr. Smith. To his activity was in no small measure due the success of the Ottawa meeting, and, indeed, his death may be said to have been partly due to his persistent efforts, exerted even in the face of his physician's warning.

The next paper was—

GEOMORPHOLOGY OF THE SOUTHERN APPALACHIANS

BY C. WILLARD HAYES AND M. R. CAMPBELL

Remarks were made by W J McGee. This paper will be published in the National Geographic Magazine.

The Society then, at 3.30 p. m., adjourned until the evening, in order that the Fellows might be able to accept the invitation to a reception tendered the Society by Her Excellency The Lady Stanley of Preston, at Government house, at 4 o'clock.

Evening Session of Friday, December 30

The Society was called to order at 8 p m, Mr F. D. Adams in the chair.

The first communication was—

NOTES ON THE GOLD RANGE IN BRITISH COLUMBIA

BY JAMES MCEVOY

Mr McEvoy, who is a member of the Geological Survey Department of Canada, was introduced by H. M. Ami. Remarks upon the paper were made by A. E. Barlow.

The second paper of the evening session was—

THE IMPORTANCE OF PHOTOGRAPHY IN ILLUSTRATING GEOLOGICAL STRUCTURE

BY R. W. ELLS

The paper was illustrated with a series of large photographs, and was discussed by B. K. Emerson, F. D. Adams and Mr J. Lainson Mills, a visitor.

In the absence of the author of the following two papers, the first was read by Mr U. S. Grant and the second by Mr J. S. Diller:

SOME MARYLAND GRANITES AND THEIR ORIGIN

EPIDOTE AS A PRIMARY COMPONENT OF ERUPTIVE ROCKS

BY CHARLES ROLLIN KEYES

These two papers were discussed by F. D. Adams. They are printed as pages 299–312 of this volume.

The next two papers were read by the authors, being, on account of their relationship, placed in juxtaposition:

CRETACEOUS AND EARLY TERTIARY OF NORTHERN CALIFORNIA AND OREGON

BY J. S. DILLER

This paper is printed as pages 205–224 of this volume.

THE FAUNAS OF THE SHASTA AND CHICO FORMATIONS

BY T. W. STANTON

This paper is printed as pages 245–256 of this volume.

President Gilbert assumed the chair, and the following paper was read:

THE HURONIAN VOLCANICS SOUTH OF LAKE SUPERIOR*

BY C. R. VAN HISE

[*Abstract*]

South of Lake Superior are extensive areas of Huronian rocks, consisting of a succession of basic lava flows, with interstratified contemporaneous fragmentals. Associated with these are occasional porphyries.

Petrographically the volcanic series includes porphyrite, augite-porphyrite, amygdaloid, devitrified glass, flowage breccia, and greenstone conglomerate. Included under the latter term are agglomerates, tuffs, mingled tuff and lava, and true detrital conglomerates, the material of which is chiefly derived from the volcanic series.

The porphyrites and augite-porphyrites are fine-grained, dense, and frequently show, when weathered, a very curious spheroidal parting; also at times they pass into flowage breccias.

The amygdaloids vary from pumiceous or scoriaceous rocks into those in which the amygdules are rare, until finally the porphyrites are reached. Like the porphyrites, they show at times a spheroidal parting or brecciation, and not infrequently in the spheroidal phases, each of the spheroids is dense and non-amygdaloidal on one side and distinctly amygdaloidal upon the other. Moreover, the amygdaloidal portions are all on the upper sides of the blocks. It would seem that while the rock was still viscous it must have cracked, and that before solidification occurred, in each block the amygdaloidal cavities rose to the upper part.

The amygdules are chlorite, feldspar, epidote, and quartz, including chalcedony and jasper. In the more open amygdaloids the amygdules are sometimes as much as 8 or 10 inches in diameter. The ferruginous quartz, known as jasper in these amygdaloids, is so remarkably like the jasper of the iron-bearing formation south of Lake Superior that it was at first thought that these are inclusions caught in the lava, but a closer study shows their undoubted amygdaloidal character, since the

*Published by permission of the Director of the United States Geological Survey.

amygdules are found of all sizes down to ordinary ones and with all gradations in color into the white chalcedony and quartz. As the chert and jasper formation in one of the districts rests directly upon the amygdaloid it is believed that the jasper of the ore formation and that in the amygdaloid are secondary rocks, formed simultaneously, as has been advocated by Irving and myself in reference to the major part of the ore formations of the Lake Superior region.

The term greenstone-conglomerate, rather than agglomerate, is used because this latter implies a definite theory of origin. A study of these rocks, in the field and under the microscope, shows undoubted gradations from rocks which are true detritals to those which are tuffs, from this to tuff and lava intermingled, and then to true lava flows, which are often brecciated. Probably also some of the rocks are true agglomerates. Some of the clastics are undoubtedly sub-aqueous ash-beds, from which there are gradations into the true detritals.

The interstratification of volcanics and detritals, combined with the lithologic similarity of the rocks, at once suggests a comparison between the Huronian volcanic series and the Keweenawan. There are, however, important differences. The Huronian volcanics are for the most part very much more altered than those of the Keweenawan. Many of thom have been sheared, and they then pass into crystalline greenstone-schists. The detritals, in common with the igneous rocks, have also frequently been metamorphosed into mica-schists, hornblende-schists, etc.

These volcanic series are known at various places south of Lake Superior, but the most extensive areas are at the east end of the Gogebic series, west of Gogebic lake, Michigan, and north of Crystal Fall, in the Michigamme district, Michigan. In the Gogebic area the volcanic group is 7,000 or 8,000 feet in thickness. The strata, in approaching the volcanic center, both from the east and the west, take a sudden swing to the south, showing a sinking of the formations about the volcanic foci, as a result of the loading of the earth's strata by a mountainous mass of volcanic material. Moreover, this great thickness of volcanic material stands as the equivalent in time to the iron-bearing formation of the west, which is, upon an average, not more than 700 or 800 feet thick. We thus are able to compare in this area the rate of deposition of a formation analogous to a limestone and a group of volcanic strata. Also the district gives an excellent illustration of the principle that in the pre-Cambrian rocks, lithologic character may be no guide as to age, for within a few miles we have a simple sedimentary series passing laterally into a volcanic series. If the two areas chanced not to be connected, there would be great temptation to infer that they are not contemporaneous.

Remarks upon Professor Van Hise's paper were made by W. H. C. Smith and W J McGee.

In the absence of the author of the following paper, it was read by Mr W J McGee:

ON TWO OVERTHRUSTS IN EASTERN NEW YORK*

BY N. H. DARTON

Last autumn I mapped the Helderberg and associated formations in New York for the geologic map of that state now in course of publication. In the western and central portions of the state these formations lie in the general, gently south-

* Extracted by permission from a report to Dr James Hall, State Geologist of New York.

dipping monocline, but in their eastward extension to the vicinity of the Hudson river they are traversed by small but steep and characteristic flexures of the northern prolongation of the Appalachians. Davis * has described two typical areas in this flexed belt, and in a memoir "On the Helderberg and associated formations of eastern central New York," to accompany the report of the state geologist for 1892, I shall describe the entire area from Schoharie to Ellenville. It is the purpose of this paper to exhibit two particularly interesting details of the structure of the region: one an overthrust fault near Rosendale, in the great cement region, and the other a composite overthrust west of South Bethlehem.

In Mather's report on the southeastern district of New York faults were proposed to account for nearly every prominent topographic feature in his district, but I find only a few faults in the Helderberg belt and these only of small amount and local influence. Mather's report is very meagre of details regarding the structure of this region, and his statements and sections are nearly all erroneous.

The relations of the overthrust near Rosendale are shown in the following figure:

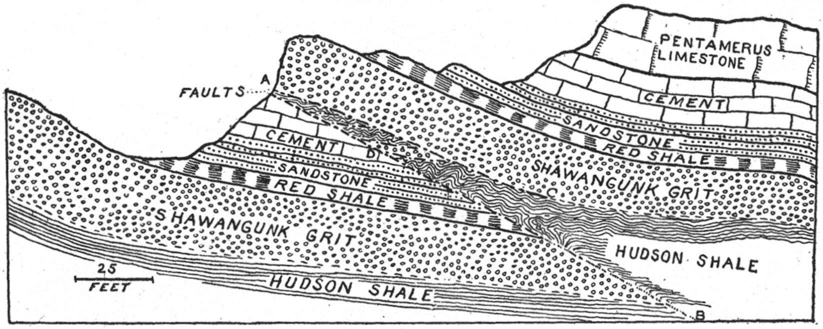

FIGURE 1.—*Cross-section of Ridge on south Side of Rondout Creek, at Rosendale, Ulster County, New York, looking North.*

The fault is on the eastern flank of the great corrugated anticlinal of the Shawangunk mountains, which pitches northward in the vicinity of Rosendale and involves the cement series and Helderberg formations. To the north the fault extends across the creek, through the village and up a depression, dying out in about two miles. To the south it soon runs out into the high, sand-covered terrace lying east of the Shawangunk ridges. Its maximum displacement is about 200 feet, which it attains at the village of Rosendale. The details of the fault are finely exposed in an abandoned cement quarry on the slope just south of the creek, and it is here that my section passes. The wedge of cement has been worked out for a length of 200 feet and the fault plane is the hanging wall of the quarry. Many minor features of slate wedges and crumpling are not represented in the figure, but I have shown at *D* a small wedge of grit which is faulted and cross-faulted into the main slate wedge at one point. The principal fault plane is along *A-B*, but there has been considerable movement along *A-C*, which has beautifully slickensided the surface of the grit. Cross-faults and minor crumples are irregularly intermingled

* The Little Mountains east of the Catskills: Appalachia, vol. iii, p. 20. The Folded Helderberg Limestones east of the Catskills: Harvard College, Bull. Mus. Comp. Zoöl., vol. 7, p. 311. Nonconformity at Rondout: Am. Jour. Sci., 3d ser., vol. xxvi, p. 389.

in the displacement, and I could not work out their relations. The relations below the cement wedge are not fully exposed, but there are scattered outcrops exhibiting the beds and their dips.

The overthrust west of South Bethlehem is in the gentle flexures near the region in which the Helderberg formations pitch up to the northward and extend to the northwestward out of the flexed belt.

The characteristics of this overthrust are the fault in the hard, massive beds of pentamerus limestone and an "underturned" flexure in the thin-bedded lower limestone, involving the subjacent soft Hudson slates.

The overthrust is exposed only on Sprayt creek, which it crosses at an old mill about three-quarters of a mile west-southwest of the village. Its trend is approximately north and south, but it does not appear to extend for any great distance. The relations at the mill are illustrated in the accompanying figures, in which the features above the broken-line portions of the sections are exposed in the bed and banks of the creek. It is unfortunate that the exposures are not more complete, but sufficient is in sight, I believe, to substantiate the interpretation I have given in the figures. Only the upper surface of the crumple is exposed in the limestone, but the greater part of the fault-plane is visible in the south bank of the creek

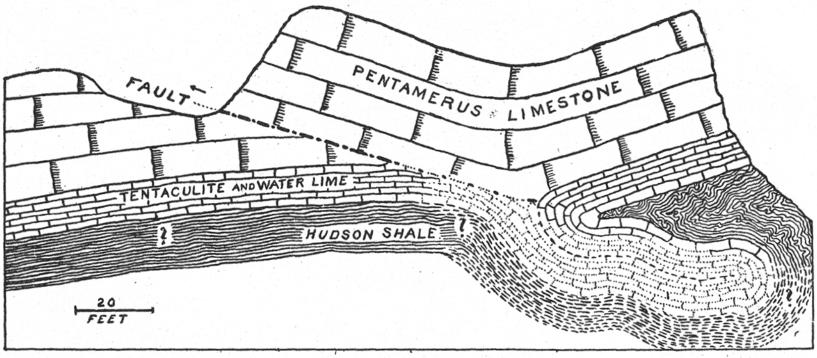

FIGURE 2.—*Cross-section of Overthrust West of South Bethlehem, Albany County, New York.*

Exposure on south bank of Sprayt creek, looking north (reversed).

above the dam. The overturned synclinal of slates and lowest limestone bed is clearly exposed in the base of the high bank on the south side of the creek, where the slate is seen to be excessively crumpled and its original bedding and cleavage planes obliterated. In the north bank, under the mill, the exposure is less extensive, but, as is shown in figure 3, essentially similar relations exist.

The mechanism of this overthrust is, I believe, not difficult to understand. I have represented the hypothesis of its development in the diagrams in figure 3: I, the first stage; II, the second, and the present conditions the third. The broken line on I indicates the line of weakness, the arrow the direction of thrust. The fault sheared diagonally through the hard, massive beds of pentamerus limestone, but the softer, thin-bedded, underlying limestones in moving forward with the thrust were not fractured, but folded downward and backward into the soft shales below, as shown by the arrows in II. The fault truncated a small portion of a preëxistent arch of the lower limestones at *A* and carried them to *B*. The amount

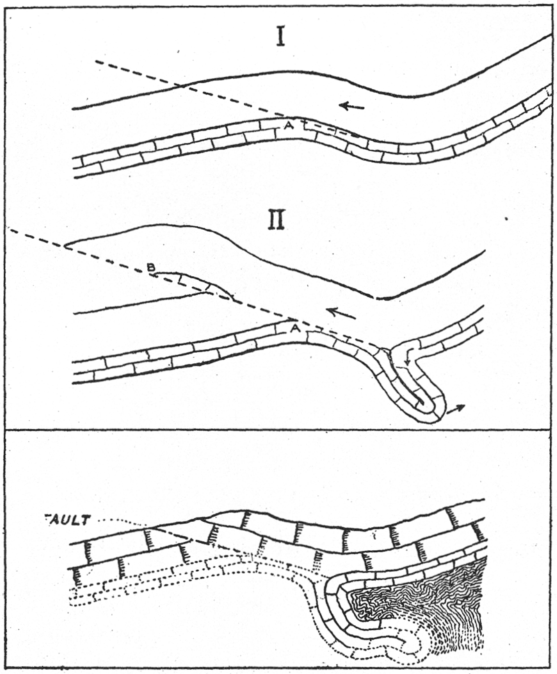

FIGURE 3.—*Overthrust on Sprayt Creek. Section on north Bank, looking North.*

I and II are hypothetical sections to illustrate two stages in the development of the overthrust.

of displacement was about 100 feet. The principal force in the overthrust was from the east, and almost horizontal in direction, unless the present low angles of fault and axial planes are due to subsequent backward tilting.

The last paper was read by title:

A GEOLOGICAL RECONNOISSANCE IN THE CENTRAL PART OF THE STATE OF WASHINGTON

BY ISRAEL C. RUSSELL

The President announced the completion of the scientific program.

The following resolutions were offered by Mr Frank D. Adams and unanimously adopted:

"*Resolved,* That the thanks of the Geological Society of America be tendered—

"To His Excellency the Governor-General of the Dominion of Canada for the cordial welcome which he extended to the Society, and to Her Excellency Lady Stanley for her very kind hospitality;

"To the Logan Club for its invitation to the Society to meet in Ottawa and for its generous hospitality, and especially to its committee, consisting of Dr A. R. C. Selwyn, Dr R. W. Ells, Mr J. B. Tyrrell and Mr W. H. C. Smith, whose untiring efforts have so largely contributed to the success of the meeting;

"To the Royal Society of Canada, and to its committee, consisting of Dr J. G. Bourinot and Mr James Fletcher, for their invitation to meet in Ottawa, and for their kind attentions during the Society's visit;

"To the Clerk of the House of Commons, Dr J. G. Bourinot, for the ample suite of rooms which he has placed at the disposal of the Society during this meeting."

Remarks upon the resolutions were made by C. R. Van Hise, H. L. Fairchild, W J McGee, B. K. Emerson and G. K. Gilbert expressing the general sentiment that the Fifth Annual Meeting had been surpassingly successful and pleasant.

With a few appropriate remarks the President declared the meeting closed.

Register of the Ottawa Meeting, 1892.

The following Fellows were in attendance upon the meeting:

F. D. Adams.
H. M. Ami.
A. E. Barlow.
Robert Bell.
H. P. H. Brumell.
Robert Chalmers.
J. S. Diller.
R. W. Ells.
B. K. Emerson.
H. L. Fairchild.
E. R. Faribault.
G. K. Gilbert.
N. J. Giroux.
U. S. Grant.
C. W. Hayes.
C. H. Hitchcock.
L. M. Lambe.
A. P. Low.
W J McGee.
W. McInnes.
R. D. Salisbury.
A. R. C. Selwyn.
T. W. Stanton.
J. B. Tyrrell.
Warren Upham.
C. R. Van Hise.
I. C. White.
G. F. Wright.

J. F. Whiteaves, Fellow-elect.

Total attendance, 29.

LIST OF

OFFICERS AND FELLOWS OF THE GEOLOGICAL SOCIETY OF AMERICA.

OFFICERS FOR 1893.

President.

SIR J. WILLIAM DAWSON, Montreal, Canada.

Vice-Presidents.

T. C. CHAMBERLIN, Madison, Wis.
J. J. STEVENSON, New York City.

Secretary.

H. L. FAIRCHILD, Rochester, New York.

Treasurer.

I. C. WHITE, Morgantown, W. Va.

Councillors.

Class of 1895.

E. A. SMITH, University, Alabama.
C. D. WALCOTT, Washington, D. C.

Class of 1894.

HENRY S. WILLIAMS, Ithaca, New York.
N. H. WINCHELL, Ann Arbor, Mich.

Class of 1893.

GEORGE M. DAWSON, Ottawa, Canada.
JOHN C. BRANNER, Little Rock, Arkansas.

Editor.

J. STANLEY-BROWN, Washington, D. C.

FELLOWS, JULY 31, 1893.

* Indicates Original Fellow (see article III of Constitution).
† Indicates decedent.

FRANK DAWSON ADAMS, Montreal, Canada; Lecturer on Geology at McGill College. December, 1889.

VICTOR C. ALDERSON, 6721 Honore St., Englewood, Ill. December, 1889.

TRUMAN H. ALDRICH, M. E., 92 Southern Ave., Cincinnati, Ohio. May, 1889.

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

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

ALFRED E. BARLOW, B. A., M. A., Geological Survey Office, Ottawa, Canada; Assistant Geologist on Canadian Geological Survey. August, 1892.

GEORGE H. BARTON, B. S., Boston, Mass.; Instructor in Geology in Massachusetts Institute of Technology. August, 1890.

WILLIAM S. BAYLEY, Ph. D., Waterville, Maine; Professor of Geology in Colby University. December, 1888.

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

CHARLES E. BEECHER, Ph. D., Yale University, New Haven, Conn. May, 1889.

ROBERT BELL, C. E., M. D., LL. D., Ottawa, Canada; Assistant Director of the Geological and Natural History Survey of Canada. May, 1889.

ALBERT S. BICKMORE, Ph. D., American Museum of Natural History, 77th St. and Eighth Ave., N. Y. city; Curator of Anthropology in the American Museum of Natural History. December, 1889.

WILLIAM P. BLAKE, New Haven, Conn.; Mining Engineer. August, 1891.

STEPHEN BOWERS, A. M., Ph. D., Mineralogical and Geological Survey of California, Ventura, California. May, 1889.

AMOS BOWMAN, Anacortes, Skagit Co., Wash. State. May, 1889.

EZRA BRAINERD, LL. D., Middlebury, Vt.; President of Middlebury College. December, 1889.

* JOHN C. BRANNER, Ph. D., Menlo Park, Cal.; Professor of Geology in Leland Stanford Jr. University; State Geologist of Arkansas.

* GARLAND C. BROADHEAD, Columbia, Mo.; Professor of Geology in the University of Missouri.

* WALTER A. BROWNELL, Ph. D., 905 University Ave., Syracuse, N. Y.

HENRY P. H. BRUMELL, Geological Survey Office, Ottawa, Canada; Assistant Geologist on Canadian Geological Survey. August, 1892.

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

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

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

FRANKLIN R. CARPENTER, Ph. D., Rapid City, South Dakota; Professor of Geology in Dakota School of Mines. May, 1889.

ROBERT CHALMERS, Geological Survey Office, Ottawa, Canada; Field Geologist on Geological and Natural History Survey of Canada. May, 1889.

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

HENRY M. CHANCE, M. D., Philadelphia, Pa.; Geologist and Mining Engineer. August, 1890.

*† J. H. CHAPIN, Ph. D., Meriden, Conn. (Died March 14, 1892.)

CLARENCE RAYMOND CLAGHORN, B. S., M. E., 204 Walnut Place, Philadelphia, Pa. August, 1891.

*WILLIAM B. CLARK, Ph. D., Baltimore, Md.; Instructor in Geology in Johns Hopkins University.

*EDWARD W. CLAYPOLE, D. Sc., Akron, O.; Professor of Geology in Buchtel College.

AARON H. COLE, A. M., Englewood, Ill. December, 1889.

*JOHN COLLETT, A. M., Ph. D., Indianapolis, Ind.; lately State Geologist.

*THEODORE B. COMSTOCK, Tucson, Ariz.; President of the University of Arizona.

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

*EDWARD D. COPE, Ph. D., 2102 Pine St., Philadelphia, Pa.; Professor of Geology in the University of Pennsylvania.

*FRANCIS W. CRAGIN, B. S., Colorado Springs, Col.; Professor of Geology and Natural History in Colorado College.

*ALBERT R. CRANDALL, A. M., Lexington, Ky.; Professor of Geology in Agricultural and Mechanical College of Kentucky.

*WILLIAM O. CROSBY, B. S., Boston Society of Natural History, Boston, Mass.; Assistant Professor of Mineralogy and Lithology in Massachusetts Institute of Technology.

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

*MALCOLM H. CRUMP, Bowling Green, Ky.; Professor of Natural Science in Ogden College.

GARRY E. CULVER, A. M., Beloit, Wis. December, 1891.

*HENRY P. CUSHING, M. S., Cleveland, Ohio; Instructor in Geology, Adelbert College.

T. NELSON DALE, Williamstown, Mass.; Assistant Geologist, U. S. Geological Survey. December, 1890.

*JAMES D. DANA, LL. D., New Haven, Conn.; Professor of Geology in Yale University.

*NELSON H. DARTON, United States Geological Survey, Washington, D. C.

*WILLIAM M. DAVIS, Cambridge, Mass.; Professor of Physical Geography in Harvard University.

GEORGE M. DAWSON, D. Sc., A. R. S. M., Geological Survey Office, Ottawa, Canada; Assistant Director of Geological and Natural History Survey of Canada. May, 1889.

Sir J. WILLIAM DAWSON, LL. D., McGill College, Montreal, Canada; Principal of McGill University. May, 1889.

DAVID T. DAY, A. B., Ph. D., U. S. Geological Survey, Washington, D. C. August, 1891.

ANTONIO DEL CASTILLO, School of Engineers, City of Mexico; Director of National School of Engineers; Director Geological Commission, Republic of Mexico. August, 1892.

FREDERICK P. DEWEY, Ph. B., 621 F St. N. W., Washington, D. C. May, 1889.

ORVILLE A. DERBY, M. S., Sao Paulo, Brazil; Director of the Geographical and Geological Survey of the Province of Sao Paulo, Brazil. December, 1890.

*JOSEPH S. DILLER, B. S., United States Geological Survey, Washington, D. C.

EDWARD V. D'INVILLIERS, E. M., 711 Walnut St., Philadelphia, Pa. December, 1888.

*EDWIN T. DUMBLE, Austin, Texas; State Geologist.

CLARENCE E. DUTTON, Major, U. S. A., Ordnance Department, San Antonio, Texas. August, 1891.

*WILLIAM B. DWIGHT, M. A., Ph. B., Poughkeepsie, N. Y.; Professor of Natural History in Vassar College.

*GEORGE H. ELDRIDGE, A. B., United States Geological Survey, Washington, D. C.

ROBERT W. ELLS, LL. D., Geological Survey Office, Ottawa, Canada; Field Geologist on Geological and Natural History Survey of Canada. December, 1888.

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

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

JOHN EYERMAN, 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 and Natural History in University of Rochester.

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

EUGENE RUDOLPH FARIBAULT, C. E., Geological Survey Office, Ottawa, Canada. August, 1891.

P. J. FARNSWORTH, M. D., Clinton, Iowa; Professor in the State University of Iowa. May, 1889.

MORITZ FISCHER, 721 Cambridge St., Cambridge, Mass. May, 1889.

*ALBERT E. FOOTE, M. D., 4116 Elm Ave., Philadelphia, Pa.

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

*P. MAX FOSHAY, M. S., M. D., 282 Prospect St., Cleveland, Ohio.

*PERSIFOR FRAZER, D. Sc., 1042 Drexel Building, Philadelphia, Pa.; Professor of Chemistry in Franklin Institute.

*HOMER T. FULLER, Ph. D., Worcester, Mass.; Professor of Geology in Worcester Polytechnic Institute.

HENRY GANNETT, S. B., A. Met. B., U. S. Geological Survey, Washington, D. C. December, 1891.

*GROVE K. GILBERT, A. M., United States Geological Survey, Washington, D. C.

ADAMS C. GILL, A. B., Northampton, Mass. December, 1888.

N. J. GIROUX, C. E., Geological Survey Office, Ottawa, Canada; Assistant Field Geologist, Geological and Natural History Survey of Canada. May, 1889.

ULYSSES SHERMAN GRANT, Ph. D., University of Minnesota, Minneapolis, Minn.; Assistant on Geological Survey of Minnesota. December, 1890.

*GEORGE B. GRINNELL, Ph. D., 318 Broadway, New York city.

LEON S. GRISWOLD, A. B., 238 Boston St., Dorchester, Mass. August, 1892.

*WILLIAM F. E. GURLEY, Sptingfield, Ill.; State Geologist.

ARNOLD HAGUE, Ph. B., U. S. Geological Survey, Washington, D. C. May, 1889.

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

*JAMES HALL, LL. D., State Hall, Albany, N. Y.; State Geologist and Director of the State Museum.

HENRY G. HANKS, 1124 Greenwich St., San Francisco, Cal.; lately State Mineralogist. December, 1888.

JOHN B. HASTINGS, M. E., Boisé City, Idaho. May, 1889.

*ERASMUS HAWORTH, Ph. D., Oskaloosa, Iowa; Professor of Natural Sciences in Penn College.

*ROBERT HAY, Box 562, Junction City, Kansas; Geologist, U. S. Department of Agriculture.

C. WILLARD HAYES, Ph. D., U. S. Geological Survey, Washington, D. C. May, 1889.

*ANGELO HEILPRIN, Academy of Natural Sciences, Philadelphia, Pa.; Professor of Paleontology in the Academy of Natural Sciences.

CLARENCE L. HERRICK, M. S., 324 Hamilton Ave., North Side, Cincinnati, Ohio; Professor of Geology and Biology in the University of Cincinnati. May, 1889.

*LEWIS E. HICKS, Lincoln, Nebraska.

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

FRANK A. HILL, 208 S. Centre St., Pottsville, Pa.; Geologist in Charge of Anthracite District, Second Geological Survey of Pennsylvania. May, 1889.

*ROBERT T. HILL, B. S., U. S. Geological Survey, Washington, D. C.

*CHARLES H. HITCHCOCK, Ph. D., Hanover, N. H.; Professor of Geology in Dartmouth College.

WILLIAM HERBERT HOBBS, B. Sc., Ph. D., Madison, Wis.; Assistant Professor of Mineralogy in the University of Wisconsin. August, 1891.

*LEVI HOLBROOK, A. M., P. O. Box 536, New York city.

*JOSEPH A. HOLMES, Chapel Hill, North Carolina; State Geologist and Professor of Geology in University of North Carolina.

MARY E. HOLMES, Ph. D., 201 S. First St., Rockford, Illinois. May, 1889.

†DAVID HONEYMAN, D. C. L. (Died October 17, 1889.)

*JEDEDIAH HOTCHKISS, 346 E. Beverly St., Staunton, Virginia.

*EDMUND O. HOVEY, Ph. D., Jefferson City, Mo.

*HORACE C. HOVEY, D. D., Bridgeport, Conn.

*EDWIN E. HOWELL, A. M., 537 15th St. N. W., Washington, D. C.

†THOMAS STERRY HUNT, D. Sc., LL. D., Park Avenue Hotel, New York city. December, 1889. (Died February, 1892.)

*ALPHEUS HYATT, B. S., Bost. Soc. of Nat. Hist., Boston, Mass.; Curator of Boston Society of Natural History.

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

A. WENDELL JACKSON, Ph. B., Berkeley, Cal.; Professor of Mineralogy, Petrography and Economic Geology in University of California. December, 1888.

THOMAS M. JACKSON, C. E., Morgantown, W. Va.; Professor of Civil and Mining Engineering in West Virginia University. May, 1889.

*JOSEPH F. JAMES, M. S., Department of Agriculture, Washington, D. C.

WALTER PROCTOR JENNEY, E. M., Ph. D., United States Geological Survey, Washington, D. C. August, 1891.

*LAWRENCE C. JOHNSON, United States Geological Survey, Meridian, Miss.

* WILLARD D. JOHNSON, United States Geological Survey, Berkeley, Cal.

ALEXIS A. JULIEN, Ph. D., Columbia College, New York city; Instructor in Columbia College. May, 1889.

EDMUND JÜSSEN, Ph. D., Temple, Carroll Co., Ga. December, 1890.

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

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

CHARLES ROLLIN KEYES, A. M., Ph. D., Assistant State Geologist, Des Moines, Iowa. August, 1890.

JAMES P. KIMBALL, Ph. D., Washington, D. C. August, 1891.

CLARENCE KING, 18 Wall St., New York city; lately Director of the U. S. Geological Survey. May, 1889.

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

* GEORGE F. KUNZ, 402 Garden St., Hoboken, N. J.

RALPH D. LACOE, Pittston, Pa. December, 1889.

GEORGE EDGAR LADD, A. B., A. M., 81 Oxford St., Cambridge, Mass. August, 1891.

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

LAWRENCE M. LAMBE, Ottawa, Canada; Artist and Assistant in Paleontology and Geological Survey of Canada. August, 1890.

ALFRED C. LANE, Ph. D., Houghton, Mich.; Assistant on Geological Survey of Michigan. December, 1889.

DANIEL W. LANGDON, Jr., A. B., University Club, Cincinnati, Ohio; Geologist of Chesapeake and Ohio Railroad Company. December, 1889.

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

* JOSEPH LE CONTE, M. D., LL. D., Berkeley, Cal.; Professor of Geology in the University of California.

* J. PETER LESLEY, LL. D., 1008 Clinton St., Philadelphia, Pa.; State Geologist.

FRANK LEVERETT, B. S., 4103 Grand Boulevard, Chicago, Ill.; Assistant U. S. Geological Survey. August, 1890.

JOSUA LINDAHL, Ph. D., Springfield, Ill.; State Geologist. August, 1890.

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

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

ALBERT P. LOW, B. S., Geological Survey Office, Ottawa, Canada; Assistant Geologist on Canadian Geological Survey. August, 1892.

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

HENRY MCCALLEY, A. M., C. E., University, Tuscaloosa County, Ala.; Assistant on Geological Survey of Alabama. May, 1889.

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

JAMES RIEMAN MACFARLANE, A. B., Pittsburg, Pa. August, 1891.

* W J MCGEE, Washington, D. C.; Bureau of North American Ethnology.

WILLIAM McINNES, A. B., Geological Survey Office, Ottawa, Canada; Assistant Field Geologist, Geological and Natural History Survey of Canada. May, 1889.

PETER McKELLAR, Fort William, Canada. August, 1890.

OLIVER MARCY, LL. D., Evanston, Cook Co., Ill.; Professor of Natural History in Northwestern University. May, 1889.

OTHNIEL C. MARSH, Ph. D., LL. D., New Haven, Conn.; Professor of Paleontology in Yale University. May, 1889.

VERNON F. MARSTERS, A. B., Bloomington, Ind.; Associate Professor of Geology in Indiana State University. August, 1892.

P. H. MELL, M. E., Ph. D., Auburn, Ala.; Professor of Geology and Natural History in the State Polytechnic Institute. December, 1888.

* FREDERICK J. H. MERRILL, Ph. D., State Museum, Albany, N. Y.; Assistant State Geologist and Assistant Director of State Museum.

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

JAMES E. MILLS, B. S., Quincy, Plumas Co., Cal. December, 1888.

* ALBRO D. MORRILL, A. M., M. S., Clinton, N. Y.; Professor of Geology in Hamilton College.

THOMAS F. MOSES, M. D., Urbana, Ohio; President of Urbana University. May, 1889.

* FRANK L. NASON, A. B., 5 Union St., New Brunswick, N. J.; Assistant on Geological Survey of New Jersey.

* HENRY B. NASON, Ph. D., M. D., LL. D., Troy, N. Y.; Professor of Chemistry and Natural Science in Rensselaer Polytechnic Institute.

* PETER NEFF, A. M., 361 Russell Ave., Cleveland, Ohio.

*† JOHN S. NEWBERRY, M. D., LL. D. (Died December 7, 1892.)

FREDERICK H. NEWELL, B. S., U. S. Geological Survey, Washington, D. C. May, 1889.

WILLIAM H. NILES, Ph. B., M. A., Cambridge, Mass. August, 1891.

* EDWARD ORTON, Ph. D., LL. D., Columbus, Ohio; State Geologist and Professor of Geology in the State University.

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

*† RICHARD OWEN, LL. D. (Died March 24, 1890.)

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

RICHARD A. F. PENROSE, Jr., Ph. D., 1331 Spruce St., Philadelphia, Pa. May, 1889.

JOSEPH H. PERRY, 176 Highland St., Worcester, Mass. December, 1888.

* WILLIAM H. PETTEE, A. M., Ann Arbor, Mich.; Professor of Mineralogy, Economical Geology, and Mining Engineering in Michigan University.

* FRANKLIN PLATT, 1319 Walnut St., Philadelphia, Pa.

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

WILLIAM B. POTTER, A. M., E. M., St. Louis, Mo.; Professor of Mining and Metallurgy in Washington University. August, 1890.

* JOHN W. POWELL, Director of U. S. Geological Survey, Washington, D. C.

* JOHN R. PROCTER, Frankfort, Ky.; State Geologist.

* CHARLES S. PROSSER, M. S., Topeka, Kan.; Professor of Geology in Washington College.

* RAPHAEL PUMPELLY, U. S. Geological Survey, Newport, R. I.

HARRY FIELDING REID, Ph. D., Johns Hopkins University, Baltimore, Md. December, 1892.

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

* EUGENE N. S. RINGUEBERG, M. D., Lockport, N. Y.

CHARLES W. ROLFE, M. S., Urbana, Champaign Co., Ill.; Professor of Geology in University of Illinois. May, 1889.

* ISRAEL C. RUSSELL, M. S., Ann Arbor, Mich.; Professor of Geology in University of Michigan.

* JAMES M. SAFFORD, M. D., LL. D., Nashville, Tenn.; State Geologist; Professor in Vanderbilt University.

ORESTES H. ST. JOHN, Topeka, Kan. May, 1889.

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

FREDERICK W. SARDESON, University of Minnesota, Minneapolis, Minn. December, 1892.

* CHARLES SCHAEFFER, M. D., 1309 Arch St., Philadelphia, Pa.

WILLIAM B. SCOTT, M. A., Ph. D., Princeton, N. J.; Professor, College of New Jersey. August, 1892.

HENRY M. SEELY, M. D., Middlebury, Vt.; Professor of Geology in Middlebury College. May, 1889.

ALFRED R. C. SELWYN, C. M. G., LL. D., Ottawa, Canada; Director of Geological and Natural History Survey of Canada. December, 1889.

* NATHANIEL S. SHALER, LL. D., Cambridge, Mass.; Professor of Geology in Harvard University.

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

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

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

* JOHN C. SMOCK, Ph. D., Trenton, N. J.; State Geologist.

CHARLES H. SMYTH, JR., Ph. D., Clinton, N. Y.; Professor of Geology in Hamilton College. August, 1892.

* J. W. SPENCER, A. M., Ph. D., Atlanta, Georgia; State Geologist.

JOSEPH STANLEY-BROWN, Assistant Geologist U. S. Geological Survey, Washington, D. C. August, 1892.

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

* JOHN J. STEVENSON, Ph. D., LL. D., University of the City of New York; Professor of Geology in the University of the City of New York.

GEORGE C. SWALLOW, M. D., LL. D., Helena, Montana; State Geologist; lately State Geologist of Missouri, and also of Kansas. December, 1889.

RALPH S. TARR, Cornell University, Ithaca, N. Y. August, 1890.

MAURICE THOMPSON, Crawfordsville, Ind.; lately State Geologist. May, 1889.

* ASA SCOTT TIFFANY, 901 West Fifth St., Davenport, Iowa.

* JAMES E. TODD, A. M., Vermillion, S. Dak.; Professor of Geology and Mineralogy in University of South Dakota.

* HENRY W. TURNER, U. S. Geological Survey, Washington, D. C.

JOSEPH B. TYRRELL, M. A., B. Sc., Geological Survey Office, Ottawa, Canada; Geologist on the Canadian Geological Survey. May, 1889.

* EDWARD O. ULRICH, A. M., Newport, Ky.; Paleontologist of the Geological Survey of Minnesota.

* WARREN UPHAM, A. B., Assistant Geological Survey of Minnesota; Minneapolis, Minn.

* CHARLES R. VAN HISE, M. S., Madison, Wis.; Professor of Mineralogy and Petrography in Wisconsin University; Geologist U. S. Geological Survey.

* ANTHONY W. VOGDES, Alcatraz Island, San Francisco, Cal.; Captain Fifth Artillery, U. S. Army.

CHARLES WACHSMUTH, M. D., Burlington, Iowa. May, 1889.

* MARSHMAN E. WADSWORTH, Ph. D., Houghton, Mich.; State Geologist; Director of Michigan Mining School.

* CHARLES D. WALCOTT, U. S. National Museum, Washington, D. C.; Paleontologist U. S. Geological Survey.

LESTER F. WARD, A. M., U. S. Geological Survey, Washington, D. C.; Paleontologist U. S. Geological Survey. May, 1889.

WALTER H. WEED, M. E., U. S. Geological Survey, Washington, D. C. May, 1889.

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

* ISRAEL C. WHITE, Ph. D., Morgantown, W. Va.; Professor of Geology in West Virginia University.

* CHARLES A. WHITE, M. D., U. S. National Museum, Washington, D. C.; Paleontologist U. S. Geological Survey.

JOSEPH FREDERIC WHITEAVES, Ottawa, Canada; Paleontologist and Assistant Director Geological Survey of Canada. December, 1892.

* ROBERT P. WHITFIELD, Ph. D., American Museum of Natural History, 77th St. and Eighth Ave., New York city; Curator of Geology and Paleontology.

CHARLES L. WHITTLE, West Medford, Mass.; Assistant Geologist U. S. Geological Survey. August, 1892.

* EDWARD H. WILLIAMS, Jr., A. C., E. M., 117 Church St., Bethlehem, Pa.; Professor of Mining Engineering and Geology in Lehigh University.

* GEORGE H. WILLIAMS, Ph. D., Johns Hopkins University, Baltimore, Md.; Professor of Inorganic Geology in Johns Hopkins University.

* HENRY S. WILLIAMS, Ph. D., New Haven, Conn.; Professor of Geology and Paleontology in Yale University.

* † J. FRANCIS WILLIAMS, Ph. D., Salem, N. Y. (Died November 9, 1891.)

* SAMUEL G. WILLIAMS, Ph. D., Ithaca, N. Y.; Professor in Cornell University.

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

* † ALEXANDER WINCHELL, LL. D. (Died February 19, 1891.)

* HORACE VAUGHN WINCHELL, 1306 S. E. 7th St., Minneapolis, Minn.; Assistant on Geological Survey of Minnesota.

* NEWTON H. WINCHELL, A. M., Minneapolis, Minn.; State Geologist; Professor in University of Minnesota.

* ARTHUR WINSLOW, B. S., Jefferson City, Mo.; State Geologist.

JOHN E. WOLFF, Ph. D., Harvard University, Cambridge, Mass.; Instructor in Petrography, Harvard University. December, 1889.

ROBERT SIMPSON WOODWARD, C. E., Columbia College, New York city; Professor of Mechanics in Columbia College. May, 1889.

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

LORENZO G. YATES, M. D., Santa Barbara, Cal. December, 1889.

Summary.

Original Fellows	109
Elected Fellows	124
Aggregate	233
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