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[THIRD SERIES.]

ART. I.—*Contributions to Meteorology; being results derived from an examination of the observations of the United States Signal Service, and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Seventeenth paper. With three plates.

[Read before the National Academy of Sciences, Washington, April 18, 1882.]

Relation of rain areas to areas of low pressure.

IN my seventh paper, I examined all those cases in which the total rain-fall at all the stations of the United States Signal Service amounted to at least eight inches in eight hours, during a period of fifteen months. As the tri-daily observations have since that time been published for twenty-two additional months (viz: from Dec. 1873, to Jan. 1875, inclusive, and from Jan. 1877, to Aug. 1877) I propose to extend the examination to these later observations. The following table exhibits all the cases from Dec. 1873, to Jan. 1875, in which the total rain-fall at all the stations amounted to at least nine inches in eight hours; also all the cases from Jan., 1877, to June, 1877, in which the total rain-fall amounted to at least ten inches in eight hours; and for July and August, 1877, amounted to eleven inches in eight hours. This change in the amount of rain-fall adopted as the standard, was rendered necessary by the gradually increased number of the stations of observation.

In the following table column first shows the reference num-

Total rainfall at all the stations amounting to at least nine inches in eight hours.

No.	Date.	Total rain.	Station of greatest rain.	Rain at do	Low moved.		Bar. change in 8 hours.		Tem. cha'e 24 hours.		Rain, areas.	Highest wind.
					Direct'n	Rate.	Front	Rear.	Fro't	Rear.		
	1873.											
1	Dec. 3–1	10·66	St. Louis	1·35	N.77°E.	22	−·13	+·06	+6°	−20°	4	24 S.W.NW.
2	3–2	10·87	Indianapolis	2·32	S.68W.	12	−·18	−·10	−12	−3	1	36 SW.
3	3–3	15·06	Louisville	2·30	N.31E.	28	−·32	+·07	+1	−39	2	43 W.
4	12–1	10·51	Cleveland	1·12	N.63E.	51	−·08	+·05	+12	−5	2	20 N.NW.SW.
	1874.											
5	Jan. 6–2	12·65	Wilmington	1·35	S.78E.	22	−·18	−·10	+3	−13	3	31 NE.
6	7–1	11·81	Wilmington	1·03	N.20E.	38	−·13	+·10	+22	−21	3	26 E.
7	7–2	9·69	New York	1 68	N.22E.	12	−·12	+·04	+4	+4	3	20 SW.E.
8	22–1	10·25	St. Louis	1·52	S.43E.	13	−·15	+·18	+26	−14	3	24 S.
9	27–2	10·28	Rochester	1·16	S.80E.	32	−·15	+·24	0	−7	5	38 NE.
10	Feb. 13–1	10·75	Cairo	1·91	S.48E.	28	−·07	+·38	+21	−11	3	28 SE.S.
11	13–3	9·45	Baltimore	1·17	N.65E.	26	−·08	+·26	+5	−17	3	30 S.
12	21–1	9 78	Cincinnati	1·25	N.58E.	37	−·02	+·16	+11	−2	1	25 NW.
13	21–2	12·04	Cincinnati	1·45	N.62E.	41	−·03	+·08	+3	0	1	28 S.SW.
14	23–1	10·05	Erie	0·76	N.40E.	39	−·45	+·22	+6	−7	5	65 E.
15	March 4–2	10·23	Eastport	2·08	S.45E.	21	−·30	+·12	+5	−13	1	65 SE.
16	6–1	10·98	Memphis	2·02	S.74E.	21	−·19	+·05	+3	−3	2	24 SE.
17	7–1	9·40	Montgomery	1·19	N.49E.	26	−·40	+·23	+1	−8	3	36 W.
18	16–2	9·43	Montgomery	1·32		0	−·09	−·09	−6	−6	2	36 SE.
19	April 7–1	9·38	Shreveport	2·18	S.34E.	19					1	24 E.
20	8–2	9·70	Vicksburg	3·67	S.77E.	16	−·07	+·04	0	−20	1	28 N.NE.
21	9–1	9·46	Knoxville	0·90	N.30E.	28	−·19	+·14	0	−14	4	25 S.
22	19–2	14·61	Vicksburg	2·49	N.16E.	25	−·42	·00	0	0	2	28 E.
23	19–3	9·31	Omaha	0·87	N.42E.	17	−·16	−·04	0	−5	5	32 NE.
24	20–1	14·38	Milwaukee	1·43	N.50E.	38	−·15	+·22	+1	−10	6	34 E.
25	20–2	9·38	New London	0·91	N.74E.	52	−·24	+·43	0	−1	2	32 S.
26	25–2	10·04	Knoxville	1·38	N.58E.	39	−·40	+·18	+3	−2	3	38 E.
27	July 4–2	10·22	New Orleans	3·25	S.40E.	26	−·06	+·19	+6	0	2	24 N.S.
28	4–3	9·77	New Orleans	2·12	S.65E.	24	−·06	+·09	+2	−2	5	40 NW.
29	Aug. 8–1	11·02	New London	4·45	N.65E.	36	−·10	+·01	+6	−1	4	20 SW.
30	8–2	11·42	New London	3·90	South.	18	−·28	−·01	+5	−5	4	18 W.NW.
31	8–3	9·23	New London	3·40	S.47E.	17	−·17	+·12	0	−2	4	24 W.
32	21–3	10·16	Chicago	2·00	S.29W.	20	+·04	+·10	−3	−10	4	18 SE.NE.
33	Sept. 16–1	9·39	Wilmington	2·04	S.78E.	14	−·06	+·01	−1	+2	3	19 NE.
34	16–2	9·11	Washington	2·37	S.72W.	9	−·10	−·04	0	0	3	22 NE.
35	18–3	10·27	Dubuque	1·94	N.46E.	32	−·02	+·33	−2	−15	2	20 E.NW.
36	19–1	9·53	Memphis	1·15	N.25E.	48	−·32	+·22	+6	−11	4	22 S.NW.
37	28–1	13·01	Savannah	2·80	N.71E.	20	−·36	−·03	−1	−12	2	30 SE.
38	Nov. 22–3	13·25	Cincinnati	1·61	N.61E.	40	−·40	+·47	+12	−2	2	42 SE.
39	23–1	21·45	Barnegat	1·65	N.45E.	36	−·66	+·33	+6	0	3	37 W.
40	23–2	16·93	Portland, Me.	1·62	N.63E.	18	−·12	+·45	+6	−5	3	58 NE.
41	29–1	10·75	Washington	0·88	N.35E.	71	−·35	−·03	+11	+2	1	50 NE.
42	29–2	13·31	Eastport	1·97	N.64E.	29	−·60	+·01	+16	−7	5	70 S.
43	Dec. 7–1	14·83	Cape Henry	1·50	N.35E.	23	−·10	·00	+10	0	2	24 NE.
44	20–2	14·00	Norfolk	1·26	N.81E.	52	−·53	+·35	+3	−6	2	45 NE.
	1875.											
45	Jan. 2–1	14·04	Knoxville	1·03	S.51E.	28	−·44	·00	+14	−9	4	28 N.NW.
46	7–3	10·13	Long Branch	0·80	N.46E.	41	−·17	−·02	+7	−1	1	40 NE.
47	24–2	15·10	Barnegat	1·30	N.86E.	32	−·27	+·10	+7	−5	4	35 W.
	1877.											
48	Jan. 1–2	10·95	Cape Hatteras	1·95	N.49E.	54	−·70	+·21	+2	−6	3	50 E.
49	7–1	13·82	New London	1·60	N.29E.	45	−·78	+·10	+35	0	2	30 NE.SW.
50	7–2	11·22	Halifax	1·30	N.45E.	41	−·86	+·41	+16	+11	2	32 W.

No.	Date.	Total rain.	Station of greatest rain.	Rain at do	Low moved		Bar. change in 8 hours.		Tem. cha'e 24 hours.		Rain, areas.	Highest wind.
					Direct'n	Rate.	Front	Rear.	Fro't	Rear.		
	1877.											
51	Jan. 15–2	13·28	Louisville	1·56	N.70°E.	44	−·35	+·44	+8°	−18°	3	48 N.
52	March 2–1	14·11	St. Marks	1·81	N.31E.	32	−·49	+·10	+11	−4	6	42 S.
53	2–2	18·96	Charleston	1·40	N.44E.	44	−·36	+·24	00	−9	3	40 S.
54	8–2	15·51	Montgomery	1·58	N.72E.	26	−·41	+·09	00	−32	3	34 S.
55	8–3	12·13	Knoxville	0·90	N.57E.	39	−·24	+·12	+8	−12	5	47 S.
56	9–1	22·05	Cape Henry	1·46	N.51E.	35	−·48	+·29	+28	−22	6	50 S.
57	26–1	10·36	Cape Hatteras	1·39	N.60E.	19	−·13	+·07	+3	−10	3	32 N.NE.E.
58	26–2	18·44	New London	2·04	N.69E.	10	−·10	+·02	+1	−8	2	38 N.
59	April 8–2	12·60	Charleston	3·70	S.13E.	4	−·02	+·03	0	−1	4	36 NE.
60	13–1	12·24	Charleston	5·20	N.70E.	36	−·40	·00	+12	−8	1	36 NE.
61	18–1	10·83	Memphis	1·60	S.18E.	21	−·12	+·03	−2	−5	2	32 NW.
62	19–1	15·76	Dubuque	1·55	N.82E.	21	−·05	+·21	−2	−6	5	30 N.
63	19–2	17·47	Milwaukee	1·37	N.84E.	26	−·08	+·15	−6	−18	3	28 N.S.
64	28–2	11·46	St. Marks	1·34	N.85E.	36	−·23	+·13	+15	−16	3	36 N.
65	June 6–3	11·08	New London	2·13	S.76E.	12	+·05	+·10	0	−4	5	16 NE.E.
66	8–2	12·92	Memphis	5·26	N.56E.	44	−·13	+·11	−4	−18	4	38 N.
67	8–3	10·39	Corsicana	1·89	N.46E.	41	−·06	+·17	+3	−10	5	24 S.
68	21–3	14·24	Washington	2·17	N.47E.	39	−·12	+·04	−7	−5	2	22 S.
69	July 16–2	14·21	Uvalde, Tex.	6·00	S.80E.	32	−·07	−·03	+3	+2	3	30 SW.
70	19–2	14·51	Mt. Washin'n	2·04	N.64E.	17	−·04	+·09	−4	−4	6	32 S.
71	20–1	11·05	Philadelphia	1·75	N.10E.	25		+·08		0	4	18 NW.S.
72	28–2	11·79	Decatur, Tex.	2·00	N.82E.	21	−·07	+·05	0	0	3	20 SE.
73	Aug. 9–2	12·54	R. Grande C'y	2·65	S.86E.	16	−·08	·00	−3	−15	7	28 SW.
74	31–2	11·76	Detroit	1·78	S.61E.	29	−·16	+·16	0	−2	6	31 S.

ber; column second shows the day and hour of observation (the numeral one following a date denotes the 7.35 A. M. observation; two denotes 4.35 P. M.; and three denotes 11 P. M.); column third shows in inches the total rain-fall at all the stations since the preceding observation. Unfortunately these intervals are not equal, being severally 9^h; 6^h 25^m; and 8^h 35^m. Column fourth shows the station at which the greatest rain-fall was recorded. Column fifth shows (in inches) the amount of rain recorded at the station mentioned in column fourth; column sixth shows the direction in which the center of least pressure advanced during the preceding eight hours; column seventh shows the rate (in miles per hour) at which this low center advanced; column eighth shows (in decimals of an inch) the change of the barometer during the preceding eight hours at the place occupied by the low center at the date given in column second; column ninth shows the change of the barometer for the same time at the place occupied by the low center at the preceding observation; column tenth shows the change of temperature during the preceding twenty-four hours at the place occupied by the low center at the date given in column second; column eleventh shows the change of temperature for the same time at the place occupied by the low center at the preceding observation; column twelfth shows the number of rain areas at which the rain-fall since the preceding observation amounted to at least one-half inch; column thirteenth shows the velocity (in miles per hour), and also the direction, of the highest wind reported at any of the stations which could be regarded as included within the influence of the low barometer traced in columns sixth and seventh. Occasionally it happened that the same velocity was reported at several different stations. In such cases the direction of the wind is given for each of these stations.

For each of the cases named in this table, the curves of one-half inch rain-fall, and also of one inch rain-fall have been carefully drawn upon the Signal Service maps. These curves show the form and magnitude of the rain-areas and their position with reference to the center of low pressure. The central portion of two of these maps is exhibited on Plate II. The character of these results cannot be fully exhibited without the publication of the entire series of maps; but since such a course is impracticable, I have adopted the following artifice. I took a sheet of transparent paper, and ruled upon it two lines at right angles to each other; one line representing a meridian and the other a parallel of latitude; the point of intersection of these lines being designed to represent a center of low pressure. Beginning with the first date in the table, I marked upon the Signal Service map the center of low pressure for that date, and also the center of low pressure for the last preceding date of observation. The point mid-way between these two centers was regarded as the position of the low center for the middle of the period to which the reported rain-fall corresponded. Placing the center of the sheet of transparent paper over this point of the Signal Service map, I marked upon the paper the position of each of the rain centers for the given date. The rain area in which the fall was greatest was indicated by a small circle; the other rain-areas for the same date were indicated by a cross. In like manner, the position of the rain-areas for each of the dates in the table, was indicated. The results are given upon a reduced scale on Plate I. For convenience of comparison, four large circles are drawn with radii of 250, 500, 750 and 1000 miles from the low center, and a few of the rain centers have numbers attached to them corresponding to the numbers in the table on page 2. Rain-areas distant more than 1000 miles from the low center are not represented on this plate.

One of the most noticeable facts connected with these great rain storms is the large number of rain-centers prevailing simultaneously, and often quite distinct from each other. Plate II, accompanying my seventh paper, shows eight such centers; and at five of them the rain exceeded a half inch.

The table on page 2 shows one case in which there were seven rain-areas exceeding a half inch in amount; it shows six cases in which there were as many as six such areas; fifteen cases in which there were as many as five such areas; twenty-seven cases of four such areas; forty-eight cases of three such areas; and only nine cases in which there was not more than one rain area in which the rain-fall exceeded a half inch. Indeed if the stations of observation were sufficiently numerous, it is quite possible they would show that in every one of these storms there was more than one rain-area amounting to a half inch. This multitude of rain-centers appears to be intimately connected with the complex character of most storms.

If we compare the principal rain-centers of these storms (represented on Plate I by small circles) we shall find that their average distance from the center of low pressure is very nearly 400 miles. In my seventh paper this distance was stated to be 300 miles; but this number represents the distance of the rain-center from the center of low pressure at the date of observation; whereas in the present paper, the distance is measured from the position of the low center at the middle of the period during which the given rain was falling; so that these two results accord pretty well with each other.

An inspection of Plate I shows that there is a marked predominance of rain-centers on the east side of the low center, and that they occur most frequently in the northeast quadrant. In the following table, column second shows, for each of the four quadrants, the total number of rain-areas in which the rain-fall amounted to at least a half inch; and column third shows the number of cases in which the principal rain-center was found in each of the quadrants.

	Rain centers.	
Quadrants.	Half-inch.	Greatest.
Northeast	86	31
Southeast	71	27
Southwest	41	9
Northwest	18	1

Plate I shows only those rain-areas which were situated within a distance of 1000 miles from the principal low center. In several of the cases examined, the greatest rain-fall occurred in the extreme southern portion of the United States, when the low center was in the extreme northern portion. This is the reason why the sum of the numbers in column third is less than the number of cases included in the table on page 2.

Those cases in which the greatest rain-fall occurred in the western quadrants require special examination, and for convenience of reference they are designated on Plate I by the same numbers as in the table on page 2; also all the cases in which the principal rain-center was more than 500 miles south of the center of least pressure are designated by appropriate numbers. The following table shows the nine cases in which the principal rain center was south of the low center more than 500 miles and less than 1000 miles. Column first shows the reference number taken from the table on page 2; column second shows the date of occurrence; column third shows the station at which the rain-fall was greatest, and column fourth shows the latitude of the station.

No.	Date.	Station.	Latitude.
17	1874, March 7–1	Montgomery	32° 22′
36	Sept. 19–1	Memphis	35 7
45	1875, Jan. 2–1	Knoxville	35 56
52	1877, March 2–1	St. Mark's	30 10
53	March 2–2	Charleston	32 45
54	March 8–2	Montgomery	32 22
64	April 28–2	St. Mark's	30 10
67	June 8–3	Corsicana	32 5
71	July 20–1	Philadelphia	39 57

We see that all but one of these stations were south of lat. 36° and the rain in these cases appears to have resulted from opposing winds attending the advance of a wave of high pressure from the west or northwest. In each of the cases there were indications of a cyclonic movement of the winds which was of a local character and of small geographical extent, and produced only a slight effect upon the barometer. These rain-areas were not of very great extent, the majority of them being less than 200 miles in their longest diameter. No. 71 was of very small dimensions, as will appear from the following table which shows the rain-fall for eight hours at all the stations within 175 miles of Philadelphia. The stations are arranged in the order of longitude from west to east.

Washington	0·00 inch.	Atlantic City	0·36 inch.
Baltimore	0·00 "	Barnegat	0·05 "
Philadelphia	1·75 "	Sandy Hook	0·08 "
Cape May	0·44 "	New York	0·07 "

In the nine cases above enumerated, the rain-fall had apparently very little influence upon the direction in which the principal low center advanced, or upon its rate of progress. This result accords with the conclusions arrived at in my sixth paper.

There remain only six other cases in which the principal rain-center was in either of the western quadrants, viz: Nos. 8, 10, 23, 41, 55 and 68.

In No. 8 the lowest isobar (29·70) formed an oval whose length was four and a half times its breadth, having its longest diameter directed towards the northeast, St. Louis being near the southwestern extremity of this oval, and the pressure at St. Louis was only 0·04 inch above the lowest pressure reported at any station.

In No. 10 the isobar 29·50 formed a long oval whose principal axis was directed towards the northeast, Cairo being near the southwestern extremity of this oval, and there were indications of a cyclonic movement of the winds of a local character about Cairo.

In No. 23 the greatest precipitation (0·87 inch) was at Omaha on the northwest side of the low center; but at Cincinnati on the east side the rain-fall was 0·80 inch and the rain-area about Cincinnati was decidedly more extensive than that about Omaha. Under these circumstances the low center advanced eastward, but at a very slow rate, and the precipitation at Omaha apparently served to retard the eastward movement of the low center.

In No. 41 the lowest isobar formed a long oval directed towards the N.N.E. and extending beyond the stations of observation; so that the amount of the precipitation on the northeast side of the low center is not fully known. There was however a considerable fall of snow during the preceding sixteen hours at several of the stations north of the low center. The following are the amounts at four of the stations for the two periods of eight hours each, the snow being expressed in its equivalent of water. Kingston 0·42+0·34=0·76 inch; Ottawa 0·45+0·30=0·75 inch; Montreal 0·20+0·30=0·50 inch; Quebec 0·10+0·27=0·37 inch. It is probable that a considerable fall of snow extended much further northward.

In No. 55 the isobar 29·20 formed an oval whose length was more than double its breadth with its axis directed towards the northeast, and on the northeast side was a rain area of much greater extent than that about Knoxville. The rain-fall at Knoxville was 0·90 inch, and that at Oswego on the northeast side was 0·63 inch.

In No. 68 the lowest isobar is incomplete, but is evidently much elongated towards the north, and extends into Canada beyond the stations of observation.

In order to render this comparison more complete, I will include the similar cases mentioned in my seventh paper. If we refer each rain-area to the position of the low center at the middle of the period during which the reported rain was falling, and omit those cases in which the principal rain-center was more than 500 miles south of the low center, the following are the only remaining cases in which the principal rain-center appeared to be west of the low center, viz: Nos. 14, 26, 46, 47 and 53.

In No. 14 it seems probable that the rain-fall reported at Keokuk did not all fall during the preceding eight hours, but represents the entire rain-fall for the preceding twenty-four hours. This is indicated by a comparison of the record at Keokuk with that at the neighboring stations St. Louis and Davenport. The following is a copy of the record.

	January 1.3		January 2.1		January 2.2		Rain. 24 h.
	Weather.	Rain.	Weather.	Rain.	Weather.	Rain.	
Keokuk	Light rain	....	Light rain	....	Light snow	1·63	1·63
St. Louis	Heavy rain	0·30	Foggy	0·64	Cloudy	0·32	1·26
Davenport	Cloudy	....	Light rain	1·01	Light rain	0·10	1·11

At St. Louis, up to Jan. 2.1, the rain in sixteen hours amounted to 0·94 inch; and at Davenport it amounted to 1·01 inch, while at Keokuk (an intermediate station) no rain is recorded in the rain column although rain was reported in the weather column both at Jan. 1.3 and Jan. 2.1. It seems evident that the observer at Keokuk neglected to measure the rain until Jan. 2.2, and that a portion of the amount recorded for Jan. 2.2 must have fallen before Jan. 2.1. If this conclusion is correct, then the observations indicate that the principal rain-center for Jan. 2.2 was on the east side of the low center.

In No. 26 the principal rain-center was 137 miles northwest of the low center, and during the succeeding eight hours the low center advanced 156 miles towards the northwest.

In Nos. 46 and 47 the principal rain-center was northwest of the low center, and the low center advanced towards the northwest, as was fully shown in my seventh paper.

In No. 53 the principal rain-center was 290 miles southwest of the low center. At Nov. 23.3 the lowest isobar formed a very elongated oval whose principal axis extended from Vicksburg to Lake Erie, and the heaviest rain occurred near Vicksburg, around which place prevailed a very decided cyclonic movement of the winds. There was at the same time in the neighborhood of Lake Erie a fall of rain and snow of less amount, but extending over a greater area.

From this comparison we find that during the entire period of the published tri-daily observations (thirty-seven months), if we exclude the cases in which the rain-center was more than 500 miles south of the low center, there were but six cases of great rain storms in which the principal rain-center was southwest of the low center, and in each of these cases the lowest isobar formed an oval whose longest diameter was from three to five times its shortest diameter, and the longest diameter was directed towards the northeast. The principal rain-center appeared to be in the southwest portion of this oval; but at the same time there prevailed in the northeast portion an area of rain of less depth but of equal, or greater, geographical extent, apparently indicating that a small depth of rain in the northern portion of the United States exerts an influence upon the center of low pressure, stronger than that exerted by a greater depth of rain in the southern portion.

We also find four cases in which the principal rain-center was northwest of the low center. In three of these cases the low center advanced towards the northwest. In the other case, although there was a station on the west side where the rain-fall was 0·07 inch greater than at any station on the east side, the rain-area on the east side was much the greatest in geographical extent, and the area of low pressure moved slowly eastward.

We thus learn that for the whole period of thirty-seven months, during great rain storms, the principal rain-center was most frequently situated nearly in the direction of the average progress of the low centers. The average direction of the storm tracks in column six of the table on page 2, is 15° north of east; which corresponds pretty nearly with the direction in which the principal rain-centers were most frequently found. This coincidence indicates an intimate connection between the rain-fall and the direction of a storm's progress. If however we make the comparison for each case separately, we find anomalies which appear to indicate either that the stations of observation are too distant from each other to show satisfactorily the form and position of the rain-areas, or else the direction of a storm's progress is influenced by other circumstances than the amount of rain-fall.

From an examination of columns eight and nine of the table on page 2, we see that the movement of a center of low pressure is attended by a fall of the barometer in front of a storm and a rise of the barometer in its rear; the average fall in front for these seventy-four cases being 0·23 inch in eight hours, and the average rise in the rear being 0·12 inch. There are only two cases in which the barometer rose in front of the low center, and in these cases the rise in the rear was greater than the rise in front. There are ten cases in which the barometer continued to fall for eight hours after the low center had passed, but in these cases the barometer on the front side fell more than it did in the rear. No. 18 is not regarded as an exception to this statement, for in that case the low center was apparently stationary for eight hours.

We also see from columns ten and eleven, that there was generally a rise of temperature in front of each storm, and a fall of temperature in the rear, the average change of temperature in one day from these seventy-four cases being 5° in front and 7°

in the rear. In the few cases in which there was a fall of temperature in the front, there was generally a greater fall in the rear; and when there was a rise of temperature in the rear, there was generally a greater rise in the front.

In my former papers I have given reasons which appear to me to indicate that the progress of a low center does *not* consist in a drifting of the general atmosphere eastward, but is rather like a wave whose characteristic feature is a diminution of pressure in front of the storm, and an increase of pressure in the rear. The question therefore which is now presented for our examination is, what causes the barometer to fall on one side of a storm's center, and to rise on the opposite side? I think it has been conclusively shown that it is only indirectly that the rain-fall contributes to this effect. The fall of the barometer results from the motion communicated to the air, and is due partly to the centrifugal force arising from the circulation about a center, but mainly (in ordinary storms) to the influence of the earth's rotation in deflecting a moving body to the right. By the precipitation of the vapor of the air and the heat which is thereby liberated, the surrounding air is drawn inward towards the region of precipitation; but the movement which this cause *tends* to produce, is modified by causes previously in operation. These causes consist mainly in the existing distribution of pressure, temperature and humidity, not only within the limits of the storm, but throughout an extensive region surrounding it on all sides. Moreover air has inertia, and when once set in rapid motion, it retains the motion acquired until this is overcome by the resistances encountered. In the case of a great winter storm, a system of winds is set in rapid motion over an area fifteen hundred miles or more in diameter. When a new force begins to operate tending to impress a different movement upon this vast mass of air, the effect must be, *not* that which the last cause would produce if it operated alone, but that which results from a combination of the last force with the preceding forces. This principle will assist us in detecting the influence of rain-fall in modifying the direction of a storm's progress. We see from Plate I that the greatest precipitation of vapor generally took place about four hundred miles east of the low center; and this precipitation developed a force which tended to divert the winds eastward, while a cold wind from the north or northwest was pressing in on the western side, and increasing the pressure in the rear of the storm.

The test of the correctness of this general explanation must consist in its successful application to each of the seventy-four cases in the table on page 2. I have made this comparison and consider the results to be satisfactory with the exception perhaps of a few cases, in most of which the storm extended beyond the stations of observation, and adequate information respecting it has not been obtained. As the limits of this article will not allow me to take up each case in detail, I shall confine my notice to those cases which were most remarkable either for a very great velocity of progress, or a very small velocity. There are fourteen cases in which the low center advanced at a rate exceeding forty miles per hour, viz: Nos. 4, 13, 25, 36, 41, 44, 46, 48, 49, 50, 51, 53, 66 and 67. In Nos. 4, 13, 66 and 67 there was a trough of low pressure extending more than one thousand miles across the United States from southwest to northeast. A considerable fall of rain on the front side of the principal center of low pressure carried the low center forward with unusual velocity, although the change of pressure in eight hours was small. In Nos. 66 and 67 there was an area of high pressure on the northeast side and another on the northwest side, which condition seems to favor the rapid progress of low centers as shown in my twelfth paper. In No. 25 the conditions were very similar to those represented on Plate IV accompanying my twelfth paper, viz: a fall of rain and snow of great geographical extent on the northern side of the low center, associated with an area of high pressure on the northeast side and another on the northwest side. In Nos. 36 and 41 the lowest isobar formed a very elongated oval, whose longest diameter extended from southwest to northeast. The principal rain-fall reported was on the south side of the principal low center, but since the lowest isobar extended northward beyond the stations of observation, it is not known what the rain fall was on the northern side. These two cases were therefore apparently similar to Nos. 4, 13, 66 and 67. Moreover in No. 36 there was an area of high barometer on the northeast side and another on the northwest side. In Nos. 44, 46 and 48 the low center, which was already near the Atlantic coast, moved rapidly eastward, being apparently influenced by the great rain-fall near the coast. Many cases have been found in which a storm moving eastward from the United States to the Atlantic Ocean, has suddenly acquired a great increase of intensity, attended by a great fall of rain or snow. Nos. 44, 46 and 48 were apparently of this class. In Nos. 49 and 50 the low center was near the Atlantic coast, and adhered closely to the coast line, being preceded by a heavy fall of snow. Also in No. 46 there was an area of high barometer on the northeast side and another on the northwest side. In No. 51 there was also an area of high pressure on the northeast side and another on the northwest side, with heavy rain on the east side of the low center. Also the winds which attended the area of high pressure on the northwest were unusually violent, being forty-eight miles an hour at Dodge city ; thirty-six at Yankton, thirty-two at Leavenworth, and thirty-one at Escanaba. In No. 53 the low center had already reached Canada, so that the amount of rain fall on the front side of the low center is unknown.

Thus in each of these fourteen cases, whenever the observations furnish the requisite information, we find that a heavy fall of rain preceded the low center, and in six of the cases we find a special cause why a small change of pressure carried the low center forward with unusual velocity. Also in six cases we find an area of high pressure on the northeast side together with an area of high pressure on the northwest side, distant from the former about seventeen hundred miles. These facts are regarded as explaining and confirming the remark made on page 10, that the movement of centers of low pressure is modified by the distribution of pressure existing beyond the limits of the low area.

Among the seventy-four cases in the table on page 2, there are eleven in which the low center advanced at a rate not exceeding sixteen miles per hour, viz: Nos. 2, 7, 8, 18, 20, 33, 34, 58, 59, 65 and 73. In Nos. 2 and 8 there was a trough of low pressure extending more than one thousand miles across the United States from southwest to northeast. A considerable fall of rain on the southwest side of the principal center of low pressure, accompanied by a cyclonic movement of the winds, was apparently the cause of a small fall of the barometer on that side, which in No. 2 carried the center of low pressure towards the southwest, and in No. 8 towards the southeast. In Nos. 7, 33, 34, 58, 59, 65 and 73 an area of low pressure prevailed in the region between the Mississippi River and the Rocky Mountains, and in some of the cases extended as far as the Pacific Ocean. The influence of this low pressure extended eastward, and diverted the westerly winds which otherwise might have been expected to follow the first low center. This was apparently the reason why these low centers advanced so slowly, and in one case the low was diverted westward. In No. 18 the low center was near Fort Sully, but on account of the small number of stations of observation, the exact position of the center cannot be assigned. The observations however, show that for four days, from March 13th to 17th, an area of high pressure prevailed over the United States east of the Mississippi river, while a low pressure prevailed between the meridian of 100° and the Rocky Mountains, and this low area maintained nearly the same position during these four days. On the afternoon of March 17th, a high appeared on the coast of Oregon, which crossed the Rocky Mountains on the 19th, and as it advanced eastward, the low was apparently pushed forward at about the same rate. This is one of numerous cases which appear to indicate that an area of low pressure cannot advance rapidly unless an area of high pressure advances behind it. The Signal Service observations also show numerous cases in which a low area has remained for several days nearly stationary between the Rocky Mountains and the meridian of 100°. In No. 20 there were unusually heavy rains on the north side of the low center and a violent cyclonic movement of the winds about this center, but on the west side of the low center the low pressure extended to a great distance, and a high pressure did not appear on the west side until April 9th, after which date the low moved eastward more rapidly.

Thus we see that nearly all of these cases of extremely slow motion apparently resulted from an unusual extension of a second area of low pressure on the western side. These cases of very slow motion, as well as those of very rapid motion, indicate that the direction of movement and rate of progress of a storm center do not depend exclusively upon the amount of rain-fall or upon the distribution of rain-fall within an area of low pressure, but also upon the distribution of pressure, temperature and humidity throughout an extensive region surrounding the low area on all sides. Moreover the influence of barometric pressure is generally much more obvious than that of temperature or humidity. An examination of the International Weather maps indicates how the progress of a storm center may be influenced by another storm prevailing at a distance of several thousand miles. We find from these maps that the entire northern hemisphere, north of lat. 30°, is generally covered by successive areas of high and low pressure which are advancing eastward with unequal velocities, and are daily undergoing important modifications. If one storm increases or diminishes in intensity, this change must affect the adjoining areas of high pressure, and this in turn must affect the areas of low pressure which prevail beyond these areas of high pressure. If one storm slackens in its rate of progress, it may be overtaken by another area of low pressure which is advancing from the west. If one storm advances with unusual rapidity, it may overtake another storm prevailing on its eastern side and may coalesce with it. While then the precipitation of the vapor of the air appears to be the chief source of that maintaining power which is necessary to sustain the action of violent storms, we cannot certainly predict the direction of movement and the rate of progress of an area of low pressure from a simple knowledge of the amount of rain-fall and position of the rain-areas within the limits of that low area.

The high winds which are uniformly found to prevail somewhere in the vicinity of a great fall of rain deserve particular notice. In my seventh paper the average velocity of the wind at the stations of greatest rain-fall was found to be only ten miles per hour, but in each case there was, within the low area, some station where the wind attained a much greater velocity. From column eleventh of the table on page 2 it is seen that among the seventy-four cases recorded, there was no instance in which the wind did not attain a velocity of sixteen miles per hour at some one of the stations within the low area. We also see that in fifty-three of the cases the velocity rose as high as twenty-five miles per hour; in sixteen of the cases it rose to forty miles per hour; and in three cases it exceeded sixty miles per hour. These high velocities come from all points of the compass, but most frequently from the south and northeast. The southerly winds are slightly stronger than the northerly winds, and the easterly winds are decidedly stronger than the westerly winds. The most remarkable feature of the winds attending a great fall of rain is their very unequal force at stations not very remote from each other. This will appear from the following table which shows the direction and velocity of the wind at nine stations near the Gulf of St. Lawrence for Nos. 14, 15, 40, 41 and 42 of the table on page 2.

	No. 14.	No. 15.	No. 40.	No. 41.	No. 42.
Montreal	N. 19	N. 12	E. 11	N.W. 10	W. 5
Quebec	E. 65	N.E. 9	N.E. 58	N.E. 50	S.W. 19
Portland	N.E. 6	S. 12	N.E. 28	S.W. 20	Calm.
Eastport	E. 28	S. 20	S.E. 24	S. 22	N. 20
Father Point	N.E. 3	W. 4	N.E. 8	E. 11	W. 12
Chatham	Calm.	S. 11	Calm.	S. 10	S. 14
Cape Rosier	W. 1	S.E. 65	S.E. 5	S. 18	S. 70
Halifax	E. 10	S.E. 20	S.E. 17	S.E. 11	S. 33
Sydney	E. 1	S. 17	E. 2	S.E. 5	S. 16

In Nos. 14, 40 and 41 compare the velocity of the wind at Quebec with the velocities at Montreal and Father Point; also in Nos. 15 and 42 compare the velocity at Cape Rosier with the velocities at Chatham and Sydney. It seems difficult to explain these observations except by admitting that near the station where the wind attained its greatest velocity, there was a strong upward movement of the air, and that the void thus left in the lower stratum of the atmosphere was supplied by air flowing in with a smaller velocity from a much greater geographical area.

A similar conclusion is deduced from the observations made near the Atlantic coast for Nos. 44, 48, 53, 55 and 56 as shown in the following table.

	No. 44.	No. 48.	No. 53.	No. 55.	No. 56.
Wilmington	W. 32	W. 4	S.W. 14	S. 20	S.W. 19
Cape Hatteras	S.W. 27	S.E. 31	W. 8	S.E. 44	S. 50
Kitty Hawk		N.E. 30	S. 12	S. 47	S.W. 36
Norfolk	N.W. 16	E. 17	S.W. 13	S.W. 24	S.W. 27
Cape Henry	S.E. 9	E. 50	S. 12	S. 24	S. 20
Cape May	N.E. 28	N.E. 20	S. 34	S. 38	S. 45
Baltimore	N.E. 15	N.E. 8	S.E. 2	S. 16	S. 8
Barnegat	N.E. 25	E. 12	S. 40	S. 26	S. 46
Philadelphia	N.E. 20	E. 14	S.W. 19	S.W. 30	S.W. 40
Long Branch	N.E. 45				
Sandy Hook	N.E. 26		S.E. 32	S. 28	S. 48

In No. 44 compare the velocity of the wind at Long Branch with the velocities at Barnegat and Sandy Hook; in No. 48 compare Cape Henry with Norfolk and Cape May; in No. 53 compare Barnegat with Baltimore and Philadelphia; in Nos. 55 and 56 compare Cape Hatteras and Kitty Hawk with Wilmington and Norfolk.

We frequently find the winds blowing exactly toward each other, from two stations less than 100 miles apart. Generally such winds are feeble, but occasionally they are very strong, and in such cases we generally find that rain is falling in that vicinity. The following table shows the direction and velocity of the wind at Savannah, Charleston and Augusta in eight cases in which at two of these stations the winds were approaching each other at a rate of more than twenty miles per hour. The table also shows the rain-fall for the eight hours preceding and the eight hours following the date given in column second. Charleston is distant from Savannah eighty-five miles and from Augusta 125 miles; the distance from Savannah to Augusta is 104 miles.

No.	Date.	Savannah.				Charleston.				Augusta			
		Wind.		Rain.		Wind.		Rain.		Wind.		Rain.	
				Bef'e.	After.			Bef'e.	After.			Bef'e.	After.
1	'73. Feb. 6.3	S.W.	16	0·22	0·12	S.	18	0·02	0·30	N.	4	0·52	0·27
2	'74. May 4.1	E.	12	0·07	0·45	S.E.	4	1·37	0·52	N.W.	20	0·87	0·93
3	'74. June 27.2	S.E.	24	0·37	0·45	S.	9			N.W.	7		
4	'74. Sept. 28.1	E.	12	2·80	0·95	S.E.	30	1·29	2·57	N.W.	19	2·10	0·50
5	'74. Dec. 6.3	S.W.	12	0·05	0·10	S.	13	0·05	0·27	N.	8	1·02	
6	'77. April 3.2	S.E.	16			N.E.	11			N.W.	8		
7	'77. April 7.3	S.W.	8		0·60	N.E.	19			S.E.	12		1·52
8	'77. April 13.1	S.W.	18	1·98	0·30	N.E.	36	5·20	2·80	N.E.	24	1·76	0·90

Nos. 4 and 8 are represented on Plate II. The isobars for the dates given in the table are represented by continuous black lines; the rain-fall for the eight hours preceding the given dates is indicated by dotted lines. The outer dotted line shows the boundary of the rain region; the other dotted lines show the boundaries of a half inch rain-fall—one inch rain-fall—and two inches rain-fall. The position of the center of low pressure four hours previous to the given dates, is shown by a small circle near the word LOW. The velocity of the wind at each station is indicated by the number placed near the point of the arrow at that station.

In No. 4 the winds at Charleston and Augusta were blowing towards each other with velocities of thirty and nineteen miles per hour, and the rain at Charleston amounted to 3·86 inches in sixteen hours. This case is the same as No. 37 on page 2.

In No. 8 the winds at Savannah and Charleston were blowing towards each other with velocities of eighteen and thirty-six miles per hour, and the fall of rain at Charleston amounted to eight inches in sixteen hours. This case is the same as No. 60 on page 3. The conclusion seems unavoidable that in these cases the air ascended from the earth's surface with great violence and was carried up to such a height that its vapor was condensed with unusual rapidity. It will also be observed that the greatest rain-fall occurred on the northeast side of the low center.

In order to determine the duration of great rain-falls, I proceeded in the manner described in my seventh paper. I selected all those cases in which any of the rain-falls mentioned in the table on page 2, for the years 1873, 4 and 5 were followed by at least four and a half inches of rain (total amount at all the stations) during a succeeding period of eight hours; and for the year 1877 were followed by at least five inches of rain during the next eight hours. The table on page 17 shows the result of this comparison. Columns seven, ten, thirteen, etc., generally show the station of greatest rain-fall for the given date; but whenever the station of greatest rain-fall was not apparently connected by a continuous rain-area with the station mentioned at the preceding observation, if there was a third station where the rain-fall was at least a half inch, and which could be thus connected with the first station, this third station has been inserted in the table instead of the second. This remark applies to the following cases, viz: No. 3 Albany, No. 8 St. Paul, No. 12 Cincinnati, No. 15 Boston, No. 17 Wilmington, New York and Philadelphia, No. 18 Duluth, No. 21 Cape Henry, No. 27 Boston, No. 28 Mt. Washington, No. 30 Memphis, No. 32 New London, No. 33 Charleston, No. 34 Cape May and No. 35 Atlantic City. By this mode of comparison, the continuous rain areas, in the cases named, are made to appear of longer duration than if the comparison had been restricted in all cases to the stations of greatest rain-fall. When a rain area is called continuous between two stations, it is to be understood that there was a belt of rain, amounting to at least a half inch in eight hours, connecting the two stations.

Heavy rain-fall continuing more than eight hours.

No.	Date.	Total rain.	Station of greatest rain.	Date.	Total rain.	Station of greatest rain.	Date.	Total rain.	Station of greatest rain.	Date.	Total rain.	Station of greatest rain.	Date.	Total rain.	Station of greatest rain.	Date.	Total rain.	Station of greatest rain.
1	'73. Dec. 3.1	10·66	St Louis[1]	3.2	10·87	Indianapolis[2]	3.3	15·06	Louisville[3]	4.1	8·47	Knoxville[4]						
2	12.1	10·51	Cleveland[1]	12.2	7·01	Cincinnati[2]	12.3	6·69	Louisville[3]	13.1	6·55	Mobile	13.2	6·77	Boston			
3	'74. Jan. 6.2	12·65	Wilmington[1]	6.3	8·37	Lynchburg[2]	7.1	11·81	Wilmington[3]	7.2	9·69	New York[4]	7.3	6·82	Philadelphia[5]	8.1	5·67	Albany[6]
4	22.1	10·25	St. Louis[1]	22.2	8·30	Cairo[2]	22.3	5·84	Quebec									
5	27.2	10·28	Rochester	27.3	6·02	Montgomery	28.1	5·99	Ottawa	28.2	5·23	Rochester						
6	Feb. 13.1	10·75	Cairo[1]	13.2	7·70	Louisville[2]	13.3	9·45	Baltimore	14.1	7·32	Savannah[1]	14.2	4·88	Savannah[2]	14.3	6·45	Jacksonville[3]
7	21.1	9·78	Cincinnati[1]	21.2	12·04	Cincinnati[2]												
8	Mar. 6.1	10·98	Memphis[1]	6.2	5·21	Vicksburg[2]	6.3	5·82	Lacrosse[1]	7.1	9·40	St. Paul[2]						
9	16.2	9·43	Montgomery[1]	16.3	7·69	Mobile[2]	17.1	8·85	Wilmington[3]									
10	Apr. 7.1	9·38	Shreveport[1]	7.2	5·55	Vicksburg[2]												
11	8.2	9·70	Vicksburg[1]	8.3	6·45	Montgomery[2]	9.1	9·46	Knoxville[3]	9.2	8·41	Cairo	9.3	5·71	Baltimore[1]	10.1	8·42	New London[2]
12	19.2	14·61	Vicksburg[1]	19.3	9·31	Cincinnati[2]	20.1	14·38	Milwaukee	20.2	9·38	New London						
13	25.2	10·04	Knoxville	25.3	6·62	New London[1]	26.1	6·60	Boston[2]									
14	July 4.2	10·22	New Orleans[1]	4.3	9·77	New Orleans[2]												
15	Aug. 8.1	11·02	New London[1]	8.2	11·42	New London[2]	8.3	9·23	New London[3]	9.1	7.29	Boston[4]	9.2	4·61	New London[5]			
16	21.3	10·16	Chicago	22.1	5·61	Memphis[1]	22.2	6·36	Memphis[2]				[18.1	5·99	New York[4]	18.2	7·96	New York[5]
17	Sept. 16.1	9·39	Wilmington[1]	16.2	9·11	Wilmington[2]	16.3	7·60	Augusta	17.1	4·64	Cape May[1]	17.2	6·72	Philadelphia[2]	17.3	4·50	New York[3]
18	18.3	10·27	Dubuque[1]	19.1	9·53	Duluth[2]	19.2	7·51	Duluth[3]									
19	28.1	13·01	Savannah[1]	28.2	7·42	Charleston[2]												
20	Nov. 22.3	13·25	Cincinnati	23.1	21·45	Barnegat[1]	23.2	16·93	Portland[2]	23.3	5·97	Eastport[3]	24.1	5·61	Sydney[4]			
21	29.1	10·75	Washington[1]	29.2	13·31	Cape Henry[2]												
22	'75. Jan. 2.1	14·04	Knoxville	2.2	7·59	New London												
23	'77. Jan. 1.2	10·95	C. Hatteras[1]	1.3	5·04	Lynchburg[2]												
24	7.1	13·82	New London[1]	7.2	11·22	Halifax[2]												
25	15.2	13·28	Louisville	15.3	8·23	Milwaukee	16.1	9·81	Mt. Washin'n									
26	Mar. 2.1	14·11	St. Marks[1]	2.2	18·96	Charleston[2]	2.3	7·18	Portland, Me									
27	8.2	15·51	Montgomery[1]	8.3	12·13	Knoxville[2]	9.1	22·05	Cape Henry[1]	9.2	7·48	Boston[2]				[28.1	5·49	Mt. Washin'n[7]
28	26.1	10·36	C. Hatteras[1]	26.2	18·44	New London[2]	26.3	9·30	New London[3]	27.1	8·40	Mt. Washin'n[4]	27.2	6·69	Mt. Washin'n[5]	27.3	6·74	Mt. Washin'n[6]
29	Apr. 13.1	12·24	Charleston[1]	13.2	9·10	Charleston[2]	13.3	6·99	Norfolk[3]				[20.1	8·55	Lynchburg[2]	20.2	6·83	Sandy Hook
30	18.1	10·83	Memphis[1]	18.2	8·68	Memphis[2]	18.3	6·87	Cairo[3]	19.1	15·76	Dubuque[1]	19.2	17·47	Milwaukee[2]	19.3	9·25	Washington[1]
31	28.2	11·46	St. Marks	28.3	7·04	Pittsburgh												
32	June 6.3	11·08	New London[1]	7.1	8·24	New London[2]	[10.2	5·43	Savannah[1]	10.3	5·76	Charleston[2]	11.1	6·80	Wilmington[3]	11.2	8 62	Wilmington[4]
33	8.2	12 92	Memphis	8.3	10·39	Corsicana	9.1	9·99	Memphis	9.2	8·97	Port Huron[1]	9.3	6·43	Parry Sound[2]	10.1	6·64	Mobile
34	21.3	14·24	Washington[1]	22.1	6·12	Cape May[2]	22.2	5·31	Vicksburg									
35	July 19.2	14·51	Mt. Washin'n	19.3	5·61	Tucson, Ar.	20.1	11·05	Philadelphia[1]	20.2	9·69	Atlantic City[2]						
36	Aug. 31.2	11·76	Detroit[1]	31.3	6·15	Sandusky[2]												

We see from this table that in a period of twenty-one months, there were thirty-six cases in which a total rain-fall of nine inches in eight hours was followed by a total rain-fall of more than five inches during the next eight hours; there were twenty-five cases in which it was followed by a similar rain-fall during a third period of eight hours; there were sixteen cases in which it was followed by at least four and a half inches of rain during a fourth period of eight hours; there were ten cases of a fifth period; seven cases of a sixth period; four cases of a seventh period; three cases of an eighth period; and one case of a tenth period. These rain areas which succeeded each other in order of time, were not however in all cases continuous rain areas, nor were they even adjacent to each other. Those cases which were apparently thus related as forming continuous rain-areas, are indicated by the numerals 1, 2, 3, etc., attached to the names of the stations. We find that out of these thirty-six cases there were only fourteen cases in which the same rain-area continued for as much as three periods of eight hours; and in only seven cases did the same rain-area continue for more than three periods; that is, more than twenty-four hours.

We thus see that in the United States, rain areas, with a fall of at least a half inch in eight hours, seldom continue for more than twenty-four hours. This result accords very closely with that deduced in my seventh paper from observations of sixteen months. During the entire period of the published observations (thirty seven months) we find only nine cases in which the same rain-area, with a fall of at least a half inch in eight hours, continued longer than one day, making on an average three cases in a year, derived from a comparison of all the cases in which there was a total rain-fall of at least nine inches in eight hours at ninety stations. This result has an important bearing upon the philosophy of storms. It was objected to Espy's theory of storms that if his computations were correct, when rain had once commenced it would have the power of perpetuating itself; that is, it should be a veritable perpetual motion, and should never cease. The comparison of three years' observations however shows us that although considerable rain attends all great storms, or areas of low barometer, and these areas of low barometer can sometimes be traced through a distance of many thousand miles, yet the rain-fall in such a storm does not form a regular rain-belt of many thousand miles in length and of nearly uniform breadth, but rather a succession of rain areas grouped irregularly together. The continuity of the belt may not be absolutely broken, but its breadth and density exhibit great irregularities. While a storm is pursuing its path from the Rocky Mountains to the

Atlantic Ocean, the breadth of the rain-belt may vary from 100 or 200 miles to 1500 miles; and the amount of rain near the central line of the belt may vary from 4 or 5 inches to less than one-tenth of an inch.

In order to investigate this subject more fully, I have determined for each of the cases in the table on page 17, the total rain-fall at each of the stations during the period when it was included within the low area under investigation. The following table shows the total amount of rain-fall at each of the stations for No. 1 during the five days from Dec. 1 to Dec. 5, 1873, counting only the rain which fell within the low area; that is, while the barometer was below 30 inches. At Mobile, Montgomery and several other southern stations some rain fell during this period when the barometer was above 30 inches, but this rain is not included in the following table.

Rain-fall from Dec. 1st to Dec. 5th, 1873.

Station.	Rain.	Station.	Rain.	Station.	Rain.	Station.	Rain
Alpena,	0·26	Duluth,	0·15	Leavenworth,	0·77	P. Dover,	0·81
Augusta,	·00	Eastport,	·15	Louisville,	2·30	P. Stanley,	·92
Baltimore,	·01	Erie,	·41	Lynchburg,	·06	Portland,	·00
Boston,	·10	Escanaba,	1·12	Marquette,	·55	Punta Rassa,	·00
Breckenridge,	·11	Farther Point,	·12	Memphis,	·69	Quebec,	1·34
Buffalo,	·64	Ft. Benton,	·00	Milwaukee,	1·09	Rochester,	·26
Burlington,	·00	Ft. Garry,	·29	Mobile,	·00	Santa Fe,	·01
Cairo,	1·25	Ft. Gibson,	·57	Montgomery,	·00	Saugeen,	·55
Cape May,	·00	Ft. Sully,	·00	Montreal,	·37	Savannah,	·00
C. Rozier,	·05	Galveston,	·02	Mt. Washington,	·09	Shreveport,	1·41
Charleston,	·00	Grand Haven,	·44	Nashville.	1·90	St. Louis,	2·68
Chatham,	·01	Halifax,	·17	New London,	·08	St. Paul,	·13
Cheyenne,	·05	Indianapolis,	3·46	New Orleans,	·00	Sydney,	·00
Chicago,	1·20	Indianola,	·00	New York,	·01	Toledo,	2·07
Cincinnati,	2·47	Jacksonville,	·00	Norfolk,	·00	Toronto,	·26
Cleveland,	·64	Keokuk,	·98	Omaha,	·08	Vicksburg,	·03
Davenport,	1·21	Kingston,	·95	Oswego,	·49	Virginia C.,	·00
Denver,	·37	Knoxville,	1·66	Pembina,	·13	Washington,	·01
Detroit,	1·73	LaCrosse,	·86	Philadelphia,	·11	Wilmington,	·00
Dubuque,	·70	Lake City,	·00	Pittsburgh,	·42	Yankton,	·12

The numbers in this table are represented by curves on Plate III, which shows the boundary of the area having a total rain fall of one-tenth of an inch; also the area of a half inch rain-fall—one inch—two inches and three inches. We see that west of the meridian of 98° from Greenwich, the aggregate rain-fall for these five days was less than one-tenth of an inch; and as the low center advanced eastward, the rain-fall rapidly increased up to 3·46 inches at Indianapolis; after which it declined with almost equal rapidity, and in longitude 67° became reduced to one-tenth of an inch. The dotted line shows the course of the center of low pressure, its position at the date of each observation being shown by the figures 2·1; 2·2; 2·3; 3·1, etc. During the progress of this storm, the pressure at the center of the low area underwent great changes. The following table shows for each of the dates, the lowest pressure reported at any of the stations.

Date.	Station.	Barom.	Date.	Station.	Barom.	Date.	Station.	Barom.
Dec. 2.1	Denver,	29·65	Dec. 3.2	Chicago,	29·37	Dec. 4.3	Chatham,	29·29
2.2	Leavenworth,	·55	3.3	Escanaba,	·08	5.1	C. Rozier,	29·65
2.3	Dubuque,	·52	4.1	Marquette,	28·91			
3.1	Escanaba,	·54	4.2	Quebec,	29·43			

We see that the pressure at the center of the low area decreased until Dec. 4, at 7½ A. M., and this was more than eight hours after the time when the rain-fall had reached its maximum; also the pressure slowly increased as the amount of rain-fall decreased. These facts appear to illustrate the inertia of the atmosphere; the minimum of pressure having occurred considerably later than the maximum of rain-fall, and the pressure was slowly restored even when the rain-fall had apparently well-nigh ceased.

The results obtained in this case accord substantially with those found in a large number of other cases. In all of the cases shown in the table on page 17, the rain-fall west of the meridian of 100° was well-nigh inappreciable, and the rain-fall increased rapidly as the low area moved eastward. Whenever there was a heavy rain-fall west of the meridian of 85°, the rain almost invariably declined before reaching the Atlantic coast. The heavy rain-falls near the Atlantic coast generally commence in the south and follow the Atlantic coast towards the northeast.

The facts here developed confirm the remark made in my 7th paper that "the forces which impart that movement to the air which is requisite to an abundant precipitation of its vapor, instead of deriving increased force from a great fall of rain, rapidly expand themselves and become exhausted." In the case of No. 1, the decrease in the rain-fall was apparently caused by a very cold westerly wind which followed the low area and attained in many places a velocity of 40 miles per hour, and in one place a velocity of 49 miles per hour. The following table shows the fall of temperature in 24 hours at various stations during the progress of this storm, and it will be noticed that these changes were independent of the ordinary diurnal variation of temperature.

Fall of temperature in 24 hours, Dec. 2–5, 1873.

Dec. 2.3	Cheyenne,	32°	Dec. 4.1	Chicago,	40°	Dec. 4.2	Memphis,	36°
	Denver,	37		Dubuque,	31		Nashville,	32
	Leavenworth,	36		Indianapolis,	50	Dec. 4.3	Detroit,	32
	Virginia City,	31		La Crosse,	34		Erie,	35
Dec. 3.1	Leavenworth,	37		Louisville,	31		Indianapolis,	30
Dec. 3.2	Keokuk,	36		Memphis,	31		Pittsburgh,	35
	Leavenworth,	35		Milwaukee,	43	Dec. 5.1	Oswego,	31
Dec. 3.3	Dubuque,	42		Nashville,	30		Rochester,	37
	St. Louis,	36		St. Louis,	41	Dec. 5.2	Norfolk,	30
Dec. 4.1	Cairo,	39	Dec. 4.2	Louisville,	33		Washington,	32

On page 14 it was remarked that in great rain-storms the easterly winds are generally much stronger than the westerly winds. In the case of No. 1 the westerly winds were much the strongest, as is shown by the following table which gives all the cases from Dec. 1.2 to Dec. 5.3 in which the velocity of the wind rose as high as 25 miles per hour at any of the stations except Mt. Washington and Pike's Peak. The table shows the direction of these high winds, and also their velocity in miles per hour.

High winds Dec. 1–5, 1873.

Dec.			Dec.			Dec.		
1.2	Grand Haven,	S.E. 29	3.3	Indianola,	N.E. 48	4.2	Buffalo,	S.W. 36
1.3	Escanaba,	S.E. 28		Keokuk,	W. 28		Eastport,	S.W. 32
2.2	Santa Fe,	S.W. 26		Kingston,	S. 27		Father Point,	S.W. 30
2.3	Cape Rosier,	S.W. 25		Knoxville,	S. 28		Gr'nd Haven	W. 39
	Davenport,	S. 28		Milwaukee,	S.W. 28		Milwaukee,	N. 29
	Grand Haven,	S.W. 30		St. Louis,	W. 43		Port Dover,	S.W. 27
3.2	Burlington,	S. 30	4.1	Alpena,	S.W. 40		Rochester,	W. 32
	Cape Rosier,	S.W. 42		Buffalo,	W. 32		Saugeen,	S.W. 30
	Indianola,	S.W. 36		Burlington,	S. 32		Toledo,	S. 28
	Knoxville.	S. 26		Chicago,	S.W. 38	4.3	Buffalo.	W. 40
	Vicksburg,	S. 25		Grand Haven,	W. 49		Father Point,	S.W. 33
	Yankton,	N.W. 35		Kingston,	S. 30		Gr'nd Haven	W. 32
3.3	Breckenridge	N. 28		Port Dover,	S.W. 40		Kingston,	S.W. 34
	Burlington,	S. 26		Toledo,	S.W. 40		Quebec,	S.W. 47
	Cairo,	W. 28		Toronto,	W. 40		Saugeen,	S.W. 28
	Davenport,	W. 28		Washington,	S. 28	5.1	Quebec,	S.W. 46
	Galveston,	N. 36	4.2	Alpena,	N. 27			

On the 1st of December the only winds which rose as high as 25 miles per hour were from the southeast, and they apparently resulted from a high pressure in New England (30·77 inches) combined with low pressure in Nebraska (29·68 inches). On this day very little rain fell; the greatest being at Milwaukee ·55 inch, and Dubuque ·35 inch. Dec. 2d the force of the easterly winds diminished, while the winds from the south and southwest increased in force. The high winds at Davenport and Grand Haven apparently resulted from a local disturbance in that vicinity. The greatest rain was at LaCrosse, ·61 inch, Leavenworth ·57 inch, and Grand Haven ·41 inch. Dec. 3d the south winds were strong on the front side of the storm, while the westerly winds on the rear were still stronger, and on this day the rain-fall was very great, viz: at Indianapolis 3·46 inches; St. Louis 2·60; Cincinnati 2·47; Louisville 2·30; Toledo 1·93; Nashville 1·90; Detroit 1·58; Cairo 1·22; Davenport 1·11, and Chicago 1·02.

Dec. 4th, at the time of the morning observation, the winds were similar to what they had been on the preceding day, and considerable rain-fall was reported; but after the morning observation the rain everywhere ceased almost entirely and the south winds on the front of the low center had mostly disappeared, and were succeeded by winds from the west or southwest. At 4.35 P. M. only one case of high wind from the south was reported, viz: at Toledo, and there is reason for believing that this observation was an error, or that it represented only a temporary veering of the wind, for at no other place within a distance of 500 miles was the wind reported from the south. It will be observed that after Dec. 1st, on the front side of the storm there was no strong wind from any easterly quarter; and the strong winds from the south ceased at about the same time as the rain ceased; while the westerly winds continued to blow with unabated force for 24 hours longer. After midnight of Dec. 3d the westerly winds encroached rapidly upon the south winds; and by the afternoon of the 4th had almost entirely supplanted them. This example seems to show that the diminution of pressure in front of a great storm is caused by a warm wind containing a large amount of vapor, and that the increase of pressure in the rear of the storm is caused by a colder wind containing a less amount of vapor; and that when the former winds are the strongest, there is an abundant rain-fall, and the pressure at the center of the low area diminishes; but when the latter winds are the strongest, the rain-fall declines and the pressure at the center of the low area increases.

In order to prosecute these enquiries under different geographical influences, I have prepared a catalogue showing the principal rain-falls in Europe for a series of years, but am compelled to defer its publication until my next article.

Since the publication of my paper on the mean annual rain-fall for different countries of the globe, I have received a considerable number of letters communicating rain-fall observations. As, however, I am hoping to obtain further observations, I shall defer a little longer the publication of the materials already received. Meanwhile if any meteorologist has information which would be useful in preparing a revised edition of my rain-chart, he is respectfully solicited to furnish me a copy of the observations.

ART. II.—*The Phenomena of Metalliferous Vein-formation now in progress at Sulphur Bank, California;* by JOSEPH LECONTE, Professor of Geology, and W. B. RISING, Professor of Chemistry, University of California.

THE attention of geologists has been already called by Mr. Phillips* and Mr. Rolland† to the fact that metalliferous veins are even now forming at Steamboat Springs, in Nevada, and at Sulphur Bank and other places in California; but the observations heretofore made at these places have been of a very general character, and a more careful examination seems still a desideratum. Believing that any additional light, however small, on so interesting a subject would be welcomed by chemists and geologists, we have made repeated visits to Sulphur Bank, viz: in 1877, 1878, 1879, 1880 and 1881, and spent several days each time in examining the phenomena as they occur there. In the meantime the mines which, during our earlier visits, were mere open surface excavations, have been recently developed in a systematic way, thus affording us opportunities of study which have not been enjoyed by any previous observers. The observations made on the ground have been ever since the subject of continued thought, but the phenomena are so complex that we desire this communication to be considered only as a preliminary discussion. We hope, if possible, to continue the investigation.

Some general description of the Coast ranges and of the Sulphur Bank region will be necessary to make the subject clear.

Coast ranges.—The Coast chain of California is a very complex system of ranges with narrow valleys between, contrasting strongly in this respect with the grand simplicity of structure characteristic of the Sierra Nevada. The Cretaceous and Tertiary strata of which it is composed are strongly folded into repeated anticlines and synclines by the lateral pressure which produced the ranges.‡ As shown by the age of the newest crumpled strata which enter into its composition, its birth-time was the end of the Miocene. In some places the strata are unchanged and full of fossils, but in others they are intersected by dikes and overflowed by lava, and are therefore highly metamorphic. This is especially true of the region to the north of the Bay of San Francisco. The high mountain

* Phil. Mag., xlii, 401, 1871. Quar. Journ. Geol. Soc., xxxv, 390, 1879.

† Ann. des Mines, xiv, 384, 1878. It is proper here to remark that our first visit in 1877 was made, and many of the conclusions hereinafter detailed, were given in a verbal communication to the chemical section of the Cal. Acad. of Science before the visit of M. Rolland.

‡ This Journal, xi, 287, 1876.

ridges enclosing the upper part of Napa valley and the mountainous region about the head of the valley are composed wholly of eruptive rocks. The culminating point of former igneous activity, as of elevation in this vicinity, is Mt. St. Helena, an ancient volcano 4,343 feet high; but the evidences of former igneous activity continue northward with little abatement to and beyond Clear Lake. In all this region the country rock is largely overlaid with lava, and feeble secondary volcanic activity still continues in the form of hot springs, carbonated springs, solfataras and fumaroles, or so-called geysers.* In all this region are also found extensive exposures of serpentine, and usually, in connection with the serpentine, cinnabar. The origin of this serpentine is an exceedingly interesting question, but one which we are not now prepared to discuss, for immediately about Sulphur Bank the cinnabar is not associated with serpentine, and it is with cinnabar that we are now concerned.

Clear Lake vicinity.—Clear Lake is a large irregular sheet of water about 25 miles long, 5 to 8 miles wide, and 1320 feet above sea level, situated about 90 miles north of San Francisco and 40 miles from the sea, in the midst of a very rugged portion of the coast chain. The stratigraphic geology of the region has not been carefully studied. The strata, where exposed to view, consist of sandstones and shales much disturbed and almost destitute of fossils; but according to Whitney† they are probably of Cretaceous age. Through these have come up volcanic outbursts, flooding the country and largely covering the strata. Volcanic peaks, some of them with distinct craters, surround the lake on every side, plainly showing that in comparatively late geological times the lake was belted about with a fiery girdle of active volcanoes. The loftiest of these is "Uncle Sam," the summit of which is 4200 feet above sea level.‡ Lava-flows from these volcanoes ran down to the lake margin and into the lake waters, and form now the promontories and islands which diversify its surface. Volcanic activity has now died away into feeble secondary remnants, as hot springs, carbonated springs, solfataras and borax springs, all of which are numerous in and about the lake. The waters from the last have accumulated to form two small borax lakes, or rather pools, near the margin of the greater lake. At one time a considerable quantity of borax was collected as crystals from the mud at the bottom of these pools.

* The geysers of California are not true geysers or eruptive springs depositing silica, but rather fumaroles or smoking solfataras.

† Geol. Surv. of Cal., vol. i, pp. 94 and 100.

‡ "Uncle Sam" is mentioned by Whitney, vol. i, p. 97, as probably metamorphic, but careful examination shows that it is wholly volcanic.

The *time* of the volcanic activity is uncertain but cannot be earlier than the beginning of the Pliocene, for this is the date of the formation of the Coast chain. It is probable that it commenced with the formation of these mountains at the beginning of the Pliocene and may have continued to a much later time. In that case it would be contemporaneous with the much greater volcanic activity of the Sierra and Cascade ranges, which seems to have occupied the whole of the Pliocene and perhaps a portion of the Quaternary.* The eruptive rocks in all this region are andesites and trachytes, somewhat strongly contrasted, but no attempt has been made to determine the order, if any, in which the two kinds have been erupted.

The immediate vicinity of Sulphur Bank.—One of the most active centers of vulcanism during Pliocene times and of solfataric action now, is about Sulphur Bank. This place is situated at the extremity of an eastward-extending bay of Clear Lake, and in its immediate neighborhood are distinctly visible four or five low volcanic cones with almost perfect craters, the nearest two being less than a mile distant. The Bank itself is a low, rounded hill, rising from the lake margin and apparently the lakeward extremity of a lava-stream from one of the nearest volcanoes to the east, toward and almost to which it may be easily traced as a low ridge of lava-blocks. The rock which forms this lava-stream, as well as that of the crater from which it apparently flowed, according to Mr. W. Jackson, the instructor in mineralogy and lithology, to whom we referred it, is an augite-andesite.† During all our earlier visits, the mines were simple excavations in this hill, open to the sky, and none more than 50 to 60 feet deep; but when last visited, in 1881, regular mining operations had commenced by sinking a shaft 260 feet deep, and running drifts at various levels. The stratified rock in the vicinity, when not covered with lava and concealed from view, consists of sandstones and shales inclined at high angles.

* This Journal, vol. vii, pp. 167 and 259, 1874.

† Mr. Jackson has given us the following as the result of his examination: "The normal rock is of a grayish black color, massive, perfectly compact, with a slightly vesicular texture that at times becomes very pronounced. The external appearance is so little distinctive that it has been variously called trachyte, basalt and trap. It consists essentially of plagioclase and augite, but magnetite is also freely disseminated through the rock, and orthoclase is not altogether wanting. The plagioclase is in the form of a very minute, lath-like, colorless microlites, among which are densely crowded the still more minute rounded granules of augite. One can also detect, with very high powers, remnants of a colorless glassy base lurking here and there between the granules. All the constituents are free from inclusions with the exception of a magnetite granule in many of the augites. Considering with Rosenbusch, olivine as an essential constituent of basalt (and I see no other way of upholding a distinction between basalt and augite-andesite), the Sulphur Bank rock becomes an augite-andestite. I have already observed the same rock from many different localities in the Pacific coast ranges."

Description of the bank.—At first sight the volcanic origin of the surface rock of the hill is not conspicuous. The bank looks like an immense oval ash-heap, 300 yards wide, 600 yards long and about 100 feet high above the lake level. The surface consists of snow-white, very fine pulverulent material which on analysis is found to be pure silica. It is evidently the residue resulting from complete decomposition of the volcanic rock, as will be explained hereafter. As we go deeper the rock becomes sounder and the mass now seems to consist of andesite blocks rounded by decomposition with the products of decomposition between, and looking much like rounded "bowlders" imbedded in a white ashy or chalky earth. Very often the rounded blocks (so-called bowlders) disintegrate into concentric whitish shells which scale off to a darker sounder rock in the center. These shells are undoubtedly the evidence of an obscure original ball-structure developed by decomposition. In some places an obscure flow-structure is developed in the same way and gives rise to an appearance of horizontal lamination. Between the loosened shells or laminæ, in the earthy mass between the bowlders, and in every crack or crevice of any kind is found sulphur in abundance and often in very beautiful crystals. As we go still deeper, the rock becomes still sounder until it finally assumes its natural square-jointed structure. Cinnabar now begins to appear mingled with the sulphur, and in increasing relative proportions, as we go deeper and deeper. As a general rule therefore, even in this superficial lava-portion of the mines, the sulphur is more abundant near the surface and the cinnabar at greater depth. In fact the sulphur is not found at all below a depth of a few feet. The mines were therefore at first worked wholly at the surface for sulphur only, then for sulphur and cinnabar, and now, since regular mining has commenced, for cinnabar only.

Iron is also very abundant; near the surface as ferric and magnetic oxides staining in places the disintegrated mass and at greater depths as pyrites impregnating the somewhat firmer rock. In many places, scattered irregularly through the disintegrating mass, are found streaks or pockets, or larger areas of a black spongy material consisting of rotten rock colored with magnetic oxide. This material is usually rich in both sulphur and cinnabar. Again: the decomposed material is in many places strongly acid and astringent from the presence of free sulphuric acid and sulphates of alumina and iron. Lastly, bitumen is found every where in very small quantities impregnating the rocks, and detectable as minute black globules under the microscope. It is also found in the assay of the rocks.

As far as yet described the rocks have evidently been changed by oxidizing agents carried down from above. But when we go still deeper—beyond the influence of atmospheric agencies, though still within the limits of the lava-cap—an entirely different appearance and reaction is observed. The decomposition is now no longer universal, but only in streaks along water-ways; the result of decomposition is no longer white chalky silica, but tough unctuous blue clay, and finally the earthy residuum is no longer acid from down-going acid waters, but alkaline from up-coming alkaline or solfataric waters. In this region and extending a little way above it, irregular cracks and fissures running in all directions are filled with a hydrous silica (opal) in a soft cheesy condition which might easily be mistaken for ozocerite. This half-consolidated gelatinous silica, evidently very recently deposited from the alkaline water, when cut or broken is nearly always found to be streaked and clouded with cinnabar. Here then undoubtedly we have still forming under our eyes, mineral veins with quartz vein-stuff and metallic ore. "The work of nature has been interrupted by the work of the miner." But of this more anon.

Beneath the lava-cap.—Thus far we have confined ourselves within the limits of the lava-cap. The observations of all previous writers have been thus confined, and most of the facts thus far mentioned have been noticed also by others. The facts now about to be mentioned, however, have not been previously described.

At the time of our earlier visits, viz: from 1877 to 1880 inclusive, the underlying country rock was reached and examined only in one place, viz: in the excavation called "the wagon-spring cut."* This, at that time the deepest opening, is situated near the margin of the lava-flow, where the lava is thin, and therefore the stratified country rock is quickly reached and is penetrated thirty or forty feet. The stratified bed-rock consists here of sandstones and shales standing nearly on edge. The opening has followed a soft brecciated stratum, several feet thick, composed of a mere rubble of angular fragments of sandstone and shale with mud of bluish clay between. On either side of this rubble-mud stratum is firmer rock; on one side sandstone and on the other shale. The mud is hot and at the bottom of the cut, hot alkaline waters highly charged with sulphydric, carbonic and boracic acids, are seen to bubble up freely. The rubble-mud stratum is evidently a water-way for the up-coming of hot water containing alkaline sulphides with excess of sulphydric and carbonic acids (solfataric waters). This rubble-mud stratum is rich in cinnabar, though in invisible

* The underlying strata had been previously reached in two other places, viz: the "Bath-house cut" and the "Parrott shaft;" but these openings had been abandoned and at the time of our visits were filled with hot water.

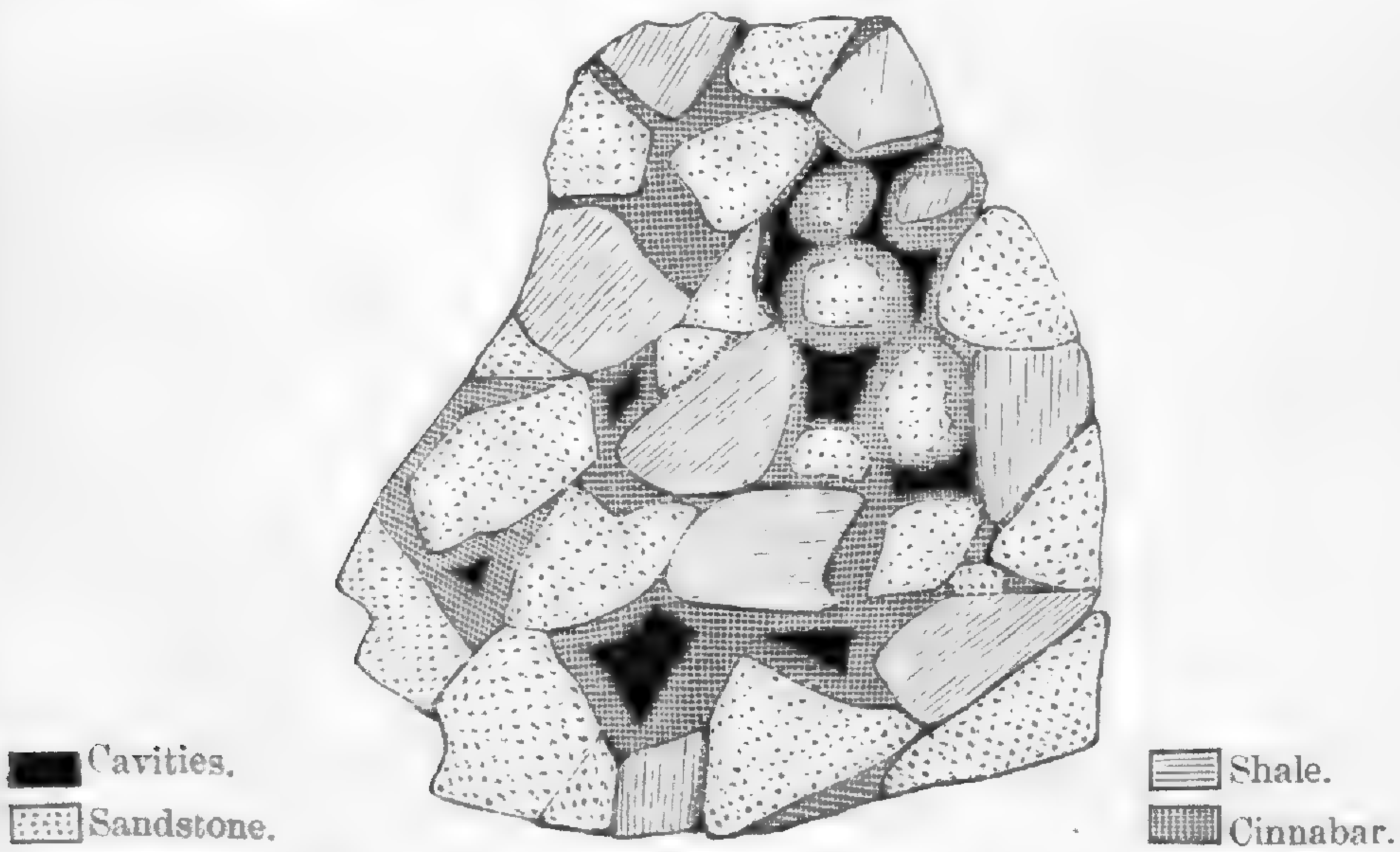
particles. Pyrites is also found in notable quantities both in the rubble-mud and in the bounding rocks on each side, especially in the more porous sandstone. The same rubble stratum can be traced out-cropping on the surface farther east beyond the limits of the lava-flow, and is there also the seat of solfataric action, and has been worked for cinnabar. The question of the origin of this rubble-mud stratum will come up for discussion hereafter.

Completer examination of the strata beneath the lava.—The above is a brief description of the phenomena as seen during our earlier visits. In the summer of 1881, we again visited the mines, and in addition to complete confirmation of previous results, had an opportunity, never enjoyed before, of examining the stratified rocks underlying the lava to a depth of 260 feet. Since our previous visit in 1880, the very intelligent Superintendent, Mr. Fiedler, had sunk a shaft some distance to the south of the "Wagon-spring cut," and about 150 feet outside the limits of the lava-flow, with the intention of reaching the vein by drifting under the lava on several different levels. The upper one of these drifts, viz: the 210-feet level, had already been pushed 150 feet in the direction of the "Wagon-spring cut," but had not yet quite reached a point directly beneath it. The phenomena observed are as follows: for 70 or 80 feet from the shaft the rock is barren sandstone and shale dipping to the south and comparatively dry and cool. Then the rock becomes shattered or brecciated and highly charged with up-coming hot water containing large amount of alkaline sulphides, with excess of CO_2 and H_2S. In the hottest places the temperature of the water is 160° and the CO_2 bubbles up so profusely that a lighted candle near its surface is quickly extinguished. The heat of the freshly cut rock is often too great to be borne by the naked hand. In this hot shattered rock is found the ore. The mine is worked with difficulty on account of the almost insupportable heat. This difficulty has now been largely removed by the more complete ventilation subsequently introduced. The lower-level drift had not at the time of our visit yet reached the ore-body.*

Description of the ore-bodies.—The brecciated layer which forms the water-way, is here, as in the wagon-spring cut, composed of fragments of sandstone and shale, mostly angular but sometimes sub-angular, as if the edges had been either worn away or else dissolved away. In some places, where the up-

* Since our last visit we understand from Mr. Fiedler that the work is now progressing on five different levels, viz: 104 feet, 157 feet, 210 feet, 260 feet and 310 feet. The third level, 210 feet, has been pushed 232 feet, cutting through the ore-body and reaching only barren rock on the other side. The fourth level has been pushed 136 feet and has reached the ore-body. The varying dip on these different levels show that the strata are very much broken up.

coming water is abundant, there is only hot mud between the fragments, but in other places where the rock is drier and the solfataric action finished, the fragments are firmly cemented with a paste of consolidated mud containing disseminated metallic sulphides, or often wholly with deposits from the solfataric waters; and thus the vein becomes a mere breccia united by a paste of cinnabar, pyrites and silica, but mostly cinnabar. The spaces between the fragments are sometimes entirely filled with deposit, sometimes only partially filled, leaving hollow spaces between. In this case the mass may have the appearance of an aggregation of round pellets of cinnabar, but on breaking these pellets they are found to have an angular fragment of rock as a nucleus. The deposits lining or filling the cavities are most commonly cinnabar, but sometimes pyrites, or silica, or all of these in alternate layers. The silica was found in all stages of consolidation,—sometimes chalcedonic, sometimes cheesy, and sometimes gelatinous.* The accompanying figure, roughly drawn from a specimen in our possession, will give a general idea of the appearance of the richer portions of the ore-body.



The vein (if such it may be called) is largely in the brecciated stratum already described, but is apparently not wholly confined to it. It is extremely irregular, sometimes widening out to many yards, then thinning down to a few inches or even pinching out and disappearing entirely, to reappear again

* A similar gelatinous condition of silica has been frequently observed by one of us in the hydraulic gravel mines, usually in connection with decaying driftwood. It is often colored yellowish by oxide of iron and in color and appearance so exactly resembles the protoplasmic mass of some lower forms of vegetation, as to completely deceive all but the most careful observer.

in a different stratum; sometimes repeated several times with barren rock between; sometimes leaving the brecciated layer and appearing in the shattered sandstone on one side or the other. In some places it is extremely rich—a mere breccia with cinnabar paste—often the cinnabar constituting more than one-half the weight of the whole. No free sulphur was found at this depth nor in the wagon-spring cut; nor indeed at any depth greater than a few yards below the surface.

The origin of the brecciated layer is an interesting question. During our last visit we found, outcropping in several places near the lake margin, farther to the southwest, beyond the limits of the solfataric action and striking in the direction of the Bank, an ordinary brecciated stratum consisting of angular fragments of sandstone and shale united by a stony paste. This is probably the same as the rubble-mud stratum of the Wagon spring cut, only in this case the stony paste has not been reduced to mud by solfataric action. It is also probably the same as, or similar to, the brecciated ore-bearing stratum of the underground works, only in this case the paste has not been replaced by deposits from the solfataric waters. This therefore seems to represent the original condition of the ore-bearing stratum. It seems probable therefore that there was here a brecciated stratum (or perhaps several such) conformable with the other strata of sandstone and shales and tilted along with these in the process of mountain formation; and that being a plane of weakness, this stratum was loosened and shattered by repeated subsequent back-and-forth crust movements connected with the volcanic eruptions, and thus became a way for ascending solfataric waters. But the extreme irregularity of the ore-bearing fissures shows that the loosening and shattering was not wholly confined to the brecciated layer, but especially where the inclination of the strata was not very high, passed from stratum to stratum, following now one now another in an uncertain way. Through all this shattered rock, whether in the original brecciated layer, or in the sandstones and shales on either side, the solfataric waters came up and deposited and is still depositing its freight of silica and metallic sulphides.

Explanation of the phenomena.—The ridge of lava which terminates in Sulphur Bank may be a stream from one of the nearest volcanos, to which it can be almost continuously traced; or it may be the remains of a very viscous eruption coming up through a fissure and spreading but little; and thus simulating a lava-stream. We have assumed the former as by far the more probable, because it can be traced almost continuously to a neighboring crater, the rock of which is identical with that of Sulphur Bank, but the question can be definitely settled only by continuing the tunnels beneath the lava cap and ascertaining whether or not a dike is cut through. If the lava cap is a stream from a neighboring volcano, as seems almost certain, then its presence here has nothing to do with the solfataric action or the occurrence of cinnabar. These originate far beneath the lava and would come to the surface, all the same, if there had been no stream in this place or if it had not reached so far. Rolland thinks the solfataric action preceded the volcanism—that the lava stream flowed over and covered *pre-existing* solfataric vents and thus compelled the waters to seek the surface through their jointed structure. This may or may not be true of this particular stream, but is probably *not* true of the volcanic activity of this vicinity. Solfataric action usually *follows* rather than precedes eruptive activity. We suppose therefore that with the decline of Pliocene volcanic activity of this vicinity, the solfataric action commenced, and that the solfataric waters coming up through somewhat definite channels in the tilted strata, but finding itself beneath the lava cap, spread in all directions through its open jointed structure and so reached the surface, depositing more diffusely and therefore in less available form in this surface portion. The same open joint structure has given freer access to air, and therefore produced a more decided surface action, as will be explained below.

Again: There are evidently here two very different and even opposite kinds of chemical action going on; the one *primary* and deeper seated produced by up-coming alkaline subterranean waters, the other *secondary* and superficial, produced by the acid down-going surface waters. This latter is greatly facilitated by the open joint structure of the lava. We wish now to give a general explanation of the action of these two kinds of water, and the mode of formation of the different kinds of products previously mentioned.

Action of the up-coming subterranean water.—(a.) *Clay and Silica.* The ascending waters, by analysis, contain a large amount of sulphides and carbonates of sodium and ammonium with excess of carbonic and sulphydric acid. They also contain a considerable amount of boracic acid. These waters, coming up from unknown depth and at high temperature, dissolve the silica from the rocks and carry it upward on their way in solution, while the rocks thus leached of their excess of silica are left in the water-ways as a tough, unctuous clay—colored bluish by protoxide of iron. The silica thus gathered below and carried upward in solution is again deposited by cooling and relief of pressure in fissures and cracks first as gelatinous silica which then gradually by loss of water becomes cheesy and finally chalcedonic.

(b.) *Cinnabar.* The same alkaline sulphide waters must have held in solution also metallic sulphides, especially mercuric sulphide: for these are found associated with the silica in such wise that the two must have been deposited from the same solution. Sometimes the cinnabar is embedded in the silica, and visible on cutting or breaking as reddish cloudings and streakings, sometimes alternating with silica in successive layers lining cavities and fissures, and sometimes alone lining or filling such cavities and fissures. The solvent of the cinnabar seems undoubtedly to have been alkaline sulphides. There has been it is true, much difference of statement among the best chemists as to the solubility of most metallic sulphides in alkaline sulphides, but recent experiments have made probable at least a feeble solubility, and the most recent and reliable of all, viz: those of Mr. Christy* in which cinnabar was subjected to the prolonged action of alkaline sulphide solutions, exactly imitating the composition of the solfataric waters of California, under heavy pressure and super heat, has placed the solubility under these conditions beyond all reasonable doubt. Whatever be the solvent, it is evident that cooling, relief of pressure and perhaps escape of H_2S and CO_2 in the ascending waters would diminish solubility and produce deposits in the water-ways.

(c.) *Pyrites.* The pyrites found disseminated in the rocks at all depths yet reached may (1) have been brought up from below in solution in the solfataric waters and deposited like the cinnabar, or (2) may have been formed by reaction of alkaline sulphides on iron-silicates of the rocks, especially the lavas, as suggested by Bunsen, in the rocks of Iceland, or finally (3) may have been formed by deoxidation of iron sulphate by organic matter, as we so often see elsewhere. That the first method is the true one in many cases—that the iron sulphide was held in solution and deposited like the cinnabar—is proved not only by the fact that it occurs abundantly beneath the lava in pure sandstones free from other forms of iron, but also by the fact that it is found alternating with silica and cinnabar in successive layers, lining cavities, in such wise that it must have been deposited from the same solution. It may have been deposited also in the other ways, but this one seems certain.†

(d.) *Sulphur.* Sulphur is well known to deposit freely from all springs containing excess of sulphydric acid. By contact with the oxygen of the air the hydrogen of this gas is oxidized and the sulphur deposited. Hence the deposit of sulphur is always very superficial and quickly gives place to metallic sulphides as we go below the influence of the air.

Thus far we have spoken only of the deposits from the up-

* This Journal, xvii, 450, 1879.

† Phillips also found it imbedded like cinnabar in recently deposited silica.

coming subterranean waters. We now come to speak of the action of the down-going surface waters. The deposit of sulphur last spoken of forms the transition between the two, since it requires the presence of air.

Action of descending surface waters. (a) *The sulphuric acid* is, of course, formed by the more complete oxidation of the sulphydric acid gas, the result of more complete contact with air. In fact this takes place mainly in the air, and the effect of prevailing dry winds in carrying it in particular directions is plainly seen. Sulphuric acid is however also formed as a secondary product in the oxidation of pyrites. (b) *Iron Sulphate* is first formed by oxidation of pyrites and then by further oxidation runs down to (c) *ferric and magnetic oxide*, giving up its sulphuric acid. The sulphuric acid thus formed either by direct oxidation of H_2S, or set free from iron sulphate by oxidation of the latter, attacks the iron and alumina, in fact all the bases of the volcanic rock forming iron sulphate and (d) *alumina sulphate*, and leaves the rock as (e) a *snow-white powdery mass of pure silica.*

These surface effects of solfataric waters are seen in many places in the Clear Lake region as, for example, at Chalk Mountain, several miles north of Sulphur Bank, and elsewhere. Somewhat similar effects have been observed also in other parts of the world where solfataric springs occur. But the deeper effects have been less observed and are therefore of the highest interest.

We have attributed the deposit of metallic sulphides and of silica, to cooling and relief of pressure and, possibly, escape of H_2S. Doubtless these are the main causes of decrease of solvent power and therefore of deposit. But it is probable also that at a certain line where the up-coming alkaline meet the down-going acid waters, the deposit is completed by neutralization. Thus the line of demarkation between the two kinds of reaction is sharper than it would otherwise be.

It will be observed that in the present article we have confined ourselves wholly to the description of phenomena and to such immediate explanation as is forced on the observer. We have not attempted any discussion of the bearing of these facts upon the general theory of metalliferous vein formation. This is reserved for a possible future paper in case our investigations justify it.

ART. III.—*Modes of occurrence of the Diamond in Brazil;* by ORVILLE A. DERBY.

THE diamond washings of the vicinity of the city of Diamantina, in the province of Minas Geraes, afford examples of several modes of occurrence of the diamond, which, so far as known at present, may be taken as types of all the washings of the empire.

The diamond region of Diamantina is situated along the crest and on both flanks of the Serra do Espinhaço, the great interior mountain range of Brazil which divides the waters of the São Francisco from those of the Doce, Jequetinhonha and other rivers. The general height of the watershed in this region is about thirteen hundred meters above the level of the sea or about five hundred meters above the general level of the elevated plains of the São Francisco valley, lying immediately to the westward. The prolongation of this range to the northward includes the diamond region of Grão Mogol in the province of Minas Geraes and that of the so-called Chapada Diamantina in the neighboring province of Bahia.

The general geological structure of this region is represented in the following section based on the observations made in three journeys by different routes between the river São Francisco and Jequetinhonha.

A, River São Francisco. B, Gurvea. C, Heights of Guinda. D, Diamantina. E, Heights of Curralinho. F, River Jequetinhonha.

a—White gneiss exposed in a long narrow zone running N.-S., to the southwest of Diamantina near the village of Gurvea. In the journey made farther to the northward going directly west from Diamantina this series did not appear. *b*—Series of hydromica schists, schistose granular quartzites (itacolumites) and itabirites. *c*—Series of granular quartzites passing at times to conglomerate. *d*—Series of argillaceous shales and slates, limestones and sandstones. *e*—Horizontal shales and sandstones.

The point in which this section differs most materially from the descriptions of the region hitherto published is the separation of the upper quartzite (*c*) as a distinct formation, unconformable to the series containing the itacolumites or lower quartzites, with which it has generally been confounded. This confusion is easily explained by the fact that most travelers have confined their observations to the eastern side of the watershed where, owing to the two quartzites having the same strike and the same easterly dip, the unconformability of stratification is not very apparent and the close lithological resemblance of the two rocks throws one off his guard in regard to it. Having recognized the unconformability of these beds on the western slope of the range where in places the dip is in opposite directions, I took pains to look for it elsewhere and found many evidences of it on the eastern side as well.

The junction of the two quartzites is in many places specially interesting. The schistose beds of the lower quartzite enter tooth-like into the mass of the upper, and the two former are apparently homogeneous rock in which only the closest scrutiny can detect the line of junction, indicated by a few scattered pebbles or a very slight difference in the intimate structure of the beds. Away from the line of junction this discrimination of the two series is more difficult and, if no pebbles can be found in the rock, is often impossible, so close is the resemblance between the finer portions of the upper quartzite, and the lower to which I would to restrict the name of itacolumite.*

The relations of series *c* and *d* have not been clearly worked out as the two have not been seen in contact, and it is possible that they should be united. The differences in the lithological characters of the rock and in their distribution is, however, against this view. The limestone of series *d* is the only rock of the region that has afforded fossils. At Bom Jesus da Lapa, on the São Francisco, some distance to the northward I found specimens of the corals *Favosites* and *Chætetes* which indicate Silurian or Devonian age. Liais reported fossil cirripeds of the genus *Pollicipes* in the same limestone at Lapa do Urubú on the Rio das Velhas, but at this locality I only found plates of white calcite which might be mistaken for fossils. The fossil oyster of the same author from the sandstone of the Abacté (series *e*) appears to be based on structure lines in the rock. I failed to find any evidence in support of his view of the Secondary age of these rocks, and on the contrary have direct evidence in opposition.

These preliminaries are necessary for a correct appreciation of the phenomena presented in the various washings which will now be described. The miners established a distinction, which it is convenient to retain, between river washings (*servicos do rio*) and prairie washings (*servicos do campo*). Of the former the most famous are in the bed of the Jequetinhonha where I had an opportunity of examining three, the only ones that have been worked of late years.

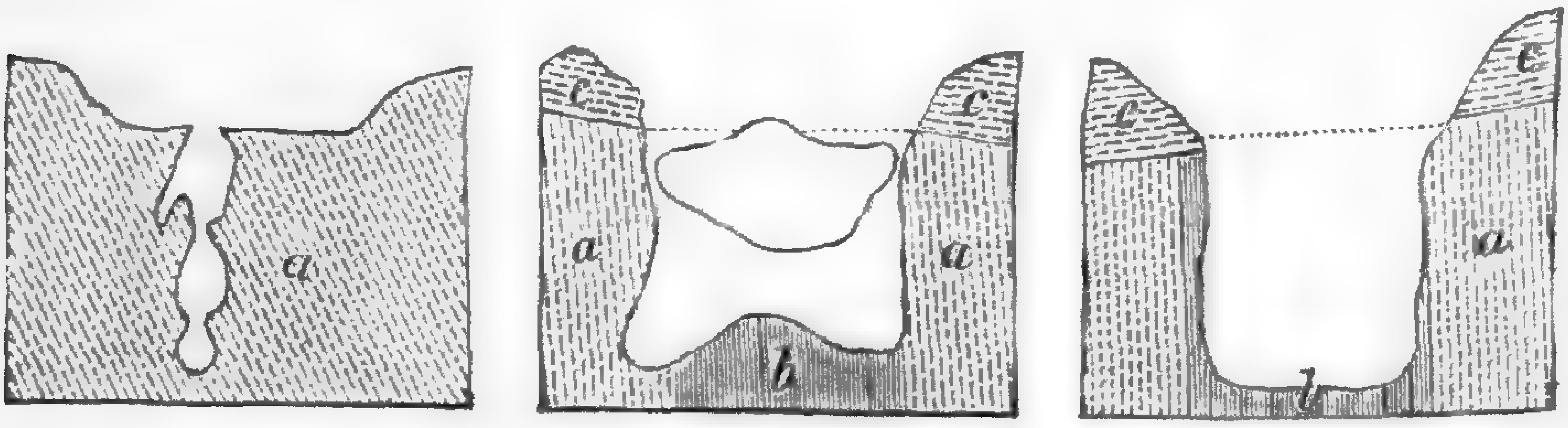
These mines are situated to the eastward and southeastward

* Both series occur in the Serra do Itacolumi at Ouro Preto from which the rock takes its name. It is only the lower one however that affords, and that rarely, the flexible variety to which the name is more particularly applied.

of Diamantina at distances of from 6 to 15 miles from the city and three or four miles from each other along the course of the river. The upper one, the Canteiro, is situated a mile or two below the bridge on the road to the provincial capital. The Santo Antonio mine is a little above and the Acaba-Mundo a little below the confluence of the Jequetinhonha with its equally famous tributary, Ribeirão do Inferno. The Jequetinhonha is here a wild mountain torrent flowing in an exceedingly rugged and picturesque narrow gorge. The river had been turned for short distances by means of temporary dams and wooden sluices and the sand and gravel had been removed from those parts of the bed thus exposed which were known or supposed to be unworked.

The rocky river-bed was found to be excavated in a most remarkable manner to a depth of 75 to 100 feet below the normal bed, presenting what may be called subterranean cañons filled with fallen rocks, sand and gravel up to the natural level of the rocky and sandy bed. These cañons had served as natural launders in which at some time rich diamond-bearing gravel had been deposited. Some of them had been more or less thoroughly cleaned out by former workings and of course refilled immediately when the river took possession of its bed. This newly deposited gravel is not considered worth washing, although it contains some diamonds, and in fact since diamond-washing commenced in the river the newly formed deposits consist of material that has already been more or less thoroughly washed.

Each of these submerged cañons presents some peculiar features dependent on the character of the beds and the relation of the river to them. A diagramatic section of each is given below.



Canteiro. Santo Antonio. Acaba-Mundo.
a—Lower quartzite (itacolumite). *b*—Schists. *c*—Upper quartzite.

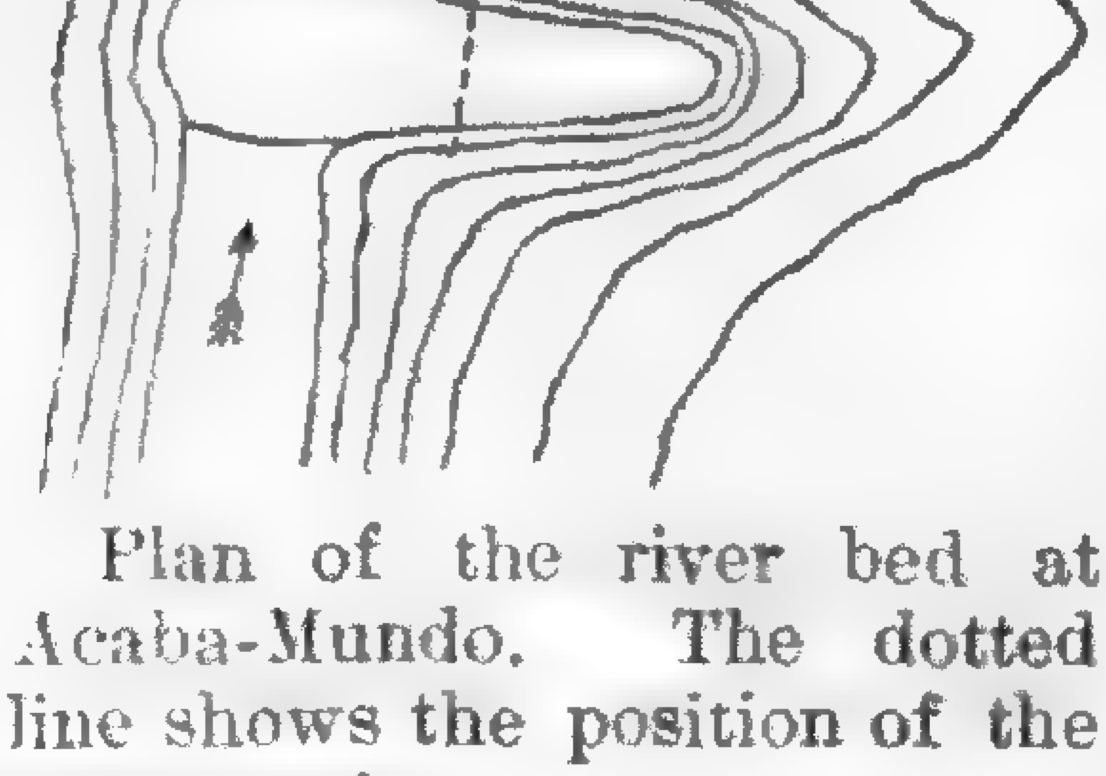
At the Canteiro mine the river runs N. 25° E. along the strike of a series of beds of the lower quartzite, dipping 60° to the eastward. The cañon, several hundred metres long, is formed of a line of pot-holes which are generally confluent below the surface so as to form a nearly continuous underground channel. Some of the pot-holes widen out to three or four metres but in general they are much narrower. Some are regular from top to bottom, while others present constrictions as represented in the diagram. The upper levels of these pot-holes had been worked out by former owners and were found filled with new unproductive gravel but in the lower levels rich virgin gravel was found.

At Santo Antonio the cañon occupies the whole width of the river-bed and has even widened out below so that the walls are overhanging. The river has here cut through the upper quartzite so as to meet the junction of the two series at about the present natural level of the river-bed. Flowing along the strike of the lower series, it has encountered the thin layer of softer beds of schists and schistose quartzites which form the floor of the cavern, enclosed between the more massive beds which form the walls. The cañon which is about 100 feet deep was filled with fallen masses of rock and gravel which had been removed at the two extremities of the working, but a large rock tightly wedged in between the walls, and which had formed a small fall in the river, had been left, and shored up by stout wooden braces, while work was being carried on underneath by the light of torches.

The Acaba-Mundo cañon is similar in many respects to that of Santo Antonio, but is remarkable in being transverse to the bed of the river which it cuts completely across. The position of the beds is here approximately as follows:

Upper quartzite, strike N. 40° W., dip 15° S.W.
Lower " " N. 20° W., " 80° E.N.E.

This extraordinary *cul-de-sac* cut nearly 100 feet below the natural river-bed, which is here quite shallow, appears at first sight to be an old river channel. That this is not the case is proved by the fact that on the right side (where it was open to examination) it abuts against a hill, as is shown in the accompanying plan. The small stream which, flowing from this hill, falls into the head of the *cul-de-sac* is too insignificant to have excavated this channel as wide as that of the main river which above and below the cut has exercised but little excavating power. The true explanation of its formation is to be found in the fact that the river here flows across the strike of the lower beds and that, having cut the compact upper beds, it found a soft bed of schist cutting across its course and enclosed between two harder beds. The soft bed now forms the soft clayey bottom of the cañon, and though decomposed still shows its schistose character. The constric-



Plan of the river bed at Acaba-Mundo. The dotted line shows the position of the cross section.

tion in the river just below would naturally form a back-water with eddies at this point. The small stream mentioned may have facilitated the process by cutting a narrow channel through the upper quartzite, and thus admitting the river to undermine it by the excavation of the softer bed below. The cañon was filled with fallen blocks, and with sand and gravel. The latter, having been introduced since a former working a number of years ago, was unproductive. It was on the supposition that the former cleaning out had been incomplete that work was undertaken again, but as the event proved only unimportant remnants of the original gravel were met with.

The gravel of the Jequetinhonha is very varied. Professor Gorceix gives a partial list of 28 minerals, which he has recognized among the finer and heavier pebbles which the miners distinguish under the name of *diamond formation*, and which they consider as indicative of the presence of the gem, and notes the abundance of quartz, the oxides of iron and of titanium, tourmalines, and the presence of chlorophosphates (Comptes Rendus, No. 25, 1881). The coarser material of the gravel is evidently derived from the rocks of the two series through which the river flows at the mines and has not been transported very far. The finer material including many rare minerals with the diamond may have come from greater distances, either from the main river, or its tributaries, but there is a strong presumption in favor of the view that this also has been derived from one or the other or both of the two series. Having followed the river for nearly the whole of its course between the Acaba-Mundo mine and its source, and having crossed the upper valley along several lines, I have never seen any evidence of the existence of any other series from which the gravel can be supposed to be derived. It should be mentioned that at many points along the river the upper series presents a conglomerate character.

Of the *servicos do compo* some of the most extensive are situated on the high ridge between Diamantina and the Jequetinhonba, known as the Heights of Curralinho. Of these the most interesting are those of Bom Successo and Boa Vista which almost overlook that of Acaba-Mundo. The heights of Curralinho are capped by a heavy mass of coarse bowlder conglomerate belonging to the upper quartzite series. Bom Successo and Boa Vista are situated on opposite sides of a small valley at the northern extremity of the conglomerate ridge and the material washed is the disintegrated conglomerate, parts of which have been redistributed by water while other parts have never been disturbed.

A similar mode of occurrence is seen on the high ridge to the southwestward of Diamantina at Guinda and Sopa. These localities are on opposite sides of a high rounded ridge forming the divide between the Jequetinhonha and the Rio Pardo, an affluent of the Rio das Velhas. This ridge is composed for the most part of schists and quartzites of the lower series, with occasional outliers of the upper series. At the Sopa mine a deep excavation near the top of the ridge shows at the top a layer of red soil with a thin bed of gravel beneath; then a thick layer of reddish sand with scattered pebbles which passes into a coarse gravel containing pebbles of various kinds and bowlders of quartzite and schists. The bottom of the excavation is formed by decomposed schists and schistose quartzite in highly inclined beds traversed by veins of lithomarge and smoky quartz. These beds present an irregular surface which is evened up by the sand and gravel deposit.

There is a marked difference between the upper and lower diamantiferous gravel beds of this place which though hard to define has been recognized by the miners who give a special name, *Sopa* (soup), to the lower gravel. I take the upper bed to be the usual superficial and modern gravel deposit due to sub-aerial denudation, and the lower one to be a decomposed conglomerate, belonging to the upper quartzite series. At the neighboring locality of Guinda the conglomerate character of the deposit is even more apparent, and I am convinced that both of these deposits can with safety be referred to the same category as those of Bom Successo and Boa Vista.

About 100 miles to the northward of Diamantina on a stream called Corrego dos Bois near the city of Grão Mogol, there is a famous locality where the diamond has been mined in a solid rock which has always been classed as itacolumite. Neither Claussen von Helmreichen, nor Heusser and Claraz, who visited this locality, recognized the distinction between the upper and lower quartzites, and their descriptions therefore leave one in doubt as to which series the diamond-bearing rock should be referred. The rock is described as a compact itacolumite enclosing rounded concretionary masses of the same character as the gangue, in which they are embedded, and which are well described by the miners' name of "pigeon eggs."

The presence of these masses led von Helmreichen to consider the view, which he ultimately rejected, that this was a regenerated rock, that is, a conglomerate. I have elsewhere (Archivos do Museu Nacional, vol. v), maintained the opinion that these masses are true rolled pebbles, and that this rock belongs to the upper quartzite series.

The conglomerate character of the diamond-bearing rock has now been clearly established by Professor Gorceix who was so fortunate as to obtain at Diamantina a specimen showing a rolled pebble of hyaline quartz alongside of an embedded diamond (Comptes Rendus, No. 25, 1881). Professor Gorceix considers, however, that this rock may possibly belong to the lower series since conglomerates with pebbles of hyaline quartz have recently been discovered in that series as well. In von Helmreichen's complete memoir, which I have only recently seen, there is a sketch of the locality which shows conclusively that both quartzites occur at the Corrego dos Bois, and that the diamonds are found in the upper one just above the line of junction of the two series. This sketch is interesting also as showing how close must be the resemblance of the two rocks to have led so able a geologist (as von Eschwege also, in other places) to overlook such unmistakable evidence of the existence of two unconformable series.

In the four localities of Bom Successo, Guinda, Sopa and Grão Mogol the diamond occurs with rolled pebbles derived from older rocks and must itself be regarded as a pebble in its secondary deposit. In many other *servicos do campo* it occurs in gravel deposits that are clearly of modern origin. The facts above presented proving the existence in this region of a conglomerate formation or of a quartzite containing scattered pebbles which has suffered extensive denudation, will explain the origin of these deposits without recourse to theories of glaciation or of former systems of drainage different from the present ones. I may mention here by way of parenthesis that in many other parts of Brazil, where anomalous gravel deposits occur that in northern latitudes would be set down without hesitation as of glacial origin, I have recognized the presence of pebble-bearing formations. In other washings the gravel consists of angular fragments of vein quartz left on the surface by the wearing down of the soft beds traversed by the veins. In these cases the matrix of the diamond must be near at hand, but so far as I am aware it has never been sought for.

By far the most interesting of the *servicos do campo* is that of São João da Chapada, situated some twelve miles to the west of Diamantina on a high rounded ridge lying between the Caethé-mirim, a famous affluent of the Jequetinhonha, and a stream flowing to the Rio das Velhas. The singular feature of this mine is the occurrence of the diamond in clay or earth (*barro*). It has been examined and described by Heusser and Claraz, von Tschudi and Burton, but its true character was first pointed out by myself (Archivos do Museu Nacional, vol. v, 1881), and by Gorceix (Comptes Rendus, No. 25, 1881).

Two mines, the Barro (clay) and the Duro (hard), opened on opposite sides of the ridge, have been worked until they met at the center producing an excavation several hundred meters long and some twenty or more meters deep which closely resembles a railroad cutting the sloping sides of this cut show a layer of red soil above, with some coarse ferruginous gravel at the base, resting on soapy parti-colored clays. The disposition of these clays is much obscured by slides, but in a number of places it may be seen that they result from the decomposition *in situ* of unctuous (hydromica) schists underlying a bed of itacolumite which is well exposed at the entrance of the Barro mine. This bed strikes N. 5° W. and dips 40° E. The direction of the cut is approximately N.–S., showing that the diamond-bearing material has been followed along the strike of the beds.

The diamond-bearing clays are found in layers up to 1½ meters in thickness intercalated in the midst of the barren clays. Three distinct layers have been described of which I only saw specimens of two in considerable masses that had been dislocated by slides. One was a soft bluish black mass showing on a fresh fracture thin alternating layers of white clay and black powdery hematite. The second mass consisted of a section of a quartz vein adhering to a mass of reddish mottled earth about half a meter thick. Layers of red decomposed schist adherent on one side to the quartz, and to the earth on the other, prove beyond a doubt that this, as well as the quartz, belongs to a vein. The third layer is described by Professor Gorceix as consisting of lithomarge with crystals of quartz presenting the same aspect as the topaz-bearing lithomarge veins of Ouro Preto.

The reddish earth of the second mass is the diamond-bearing material of that layer. It is evidently a decomposed rock consisting of a clayey and a sandy portion. The sand consists, according to Professor J. W. Mallet, who has kindly examined specimens for me, of quartz grains, microscopic tourmalines, and another black silicate. The clayey portion consists largely of iron. The original character of the rock from which this material is derived can only be guessed at. The only rock known to me in the province which might produce on decomposition such a mixture of quartz, iron and tourmaline is that of the veins of pyrites with quartz and tourmaline of some of the gold mines, notably that of Passagem near Ouro Preto, where the vein occurs under somewhat similar circumstances and in the same geological series. The quartz portion of the São João vein is much splintered and full of brilliant plates of specular iron.

Professor Gorceix states that the diamond-bearing layers or veins accompany the stratification of the enclosing beds, and notes the great similarity of this diamond mine to the topaz mines of the vicinity of Ouro Preto, as well as the marked identity in the minerals which in one place accompany the diamond and in the other the topaz. The most important minerals obtained by him in washing several tons of material from the different layers were, besides the diamond, anatase, rutile, specular iron, martite, and tourmaline.

In the Diamantina region, therefore, the diamond occurs *in situ* in its original matrix in more or less well-defined veins traversing the hydromica schist and itacolumite formation. It occurs also as a transported pebble in the upper quartzite formation. In the superficial gravel beds of the highlands, it occurs in its second or third place of deposit according as these have been derived from the wearing down of one or the other of the older diamond-bearing series. In many places it is probable that the superficial gravels contain an admixture of diamonds from both these series, and it is certain that this is the case in the river gravels, which may also contain diamonds washed from the superficial gravels and that are therefore in their fourth place of deposit.

If an observation made to me by Mr. Meziel F. de Aguiar, owner of the Sopa mine, be exact, the diamond-bearing veins are persistent over long distances. He stated that a straight line drawn from the São João mine through the Sopa and prolonged to the southward would pass through or near some half dozen of the most noted *campo* washings. Such a line would have a length of about twenty miles, and it corresponds exactly with the general strike of the beds in this region. In fact I noticed at the Sopa mine that the line of strike prolonged would cut the deep excavation of São João which was plainly visible at a distance of four or five miles, I have reason to suspect, from the information given by this intelligent miner, that the true *barro* formation occurs also at the Sopa, though it has never been recognized as such.

Near the river São Francisco there is a rich river washing on the river Jequetahy, which flows over beds of series *e* of the general section which here consist of conglomerates that have probably furnished the diamonds. The same conditions are repeated on the river Abaeté on the opposite side of the valley. The divide between the São Francisco and Upper Parana valleys, which has rich diamond washings on each slope, presents a repetition of the geological features of the Serra do Espinhaço, and so far as can be learned the general geological structure of the diamond fields of the provinces of Bahia, Goyaz, Matto Grosso and Parana is substantially the same as that above described for the central part of the province of Minas Geraes.

ART. IV.—*On the Influence of Time on the Change in the Resistance of the Carbon Disk of Edison's Tasimeter;* by T. C. MENDENHALL, Columbus, O.

[Read, by invitation, at the April meeting of the National Academy.]

ABOUT five years ago Edison announced the discovery of the remarkable property possessed by carbon when prepared in a special manner, in virtue of which its electrical resistance was greatly lessened by subjecting it to an increase of pressure. Among the numerous interesting applications of this discovery which were quickly made, none was more promising or more interesting than the Tasimeter devised by Edison himself. The extreme sensitiveness of the carbon to the slightest changes in pressure gave rise to the hope that the instrument would far exceed in delicacy those previously in use for the detection of minute quantities of heat.

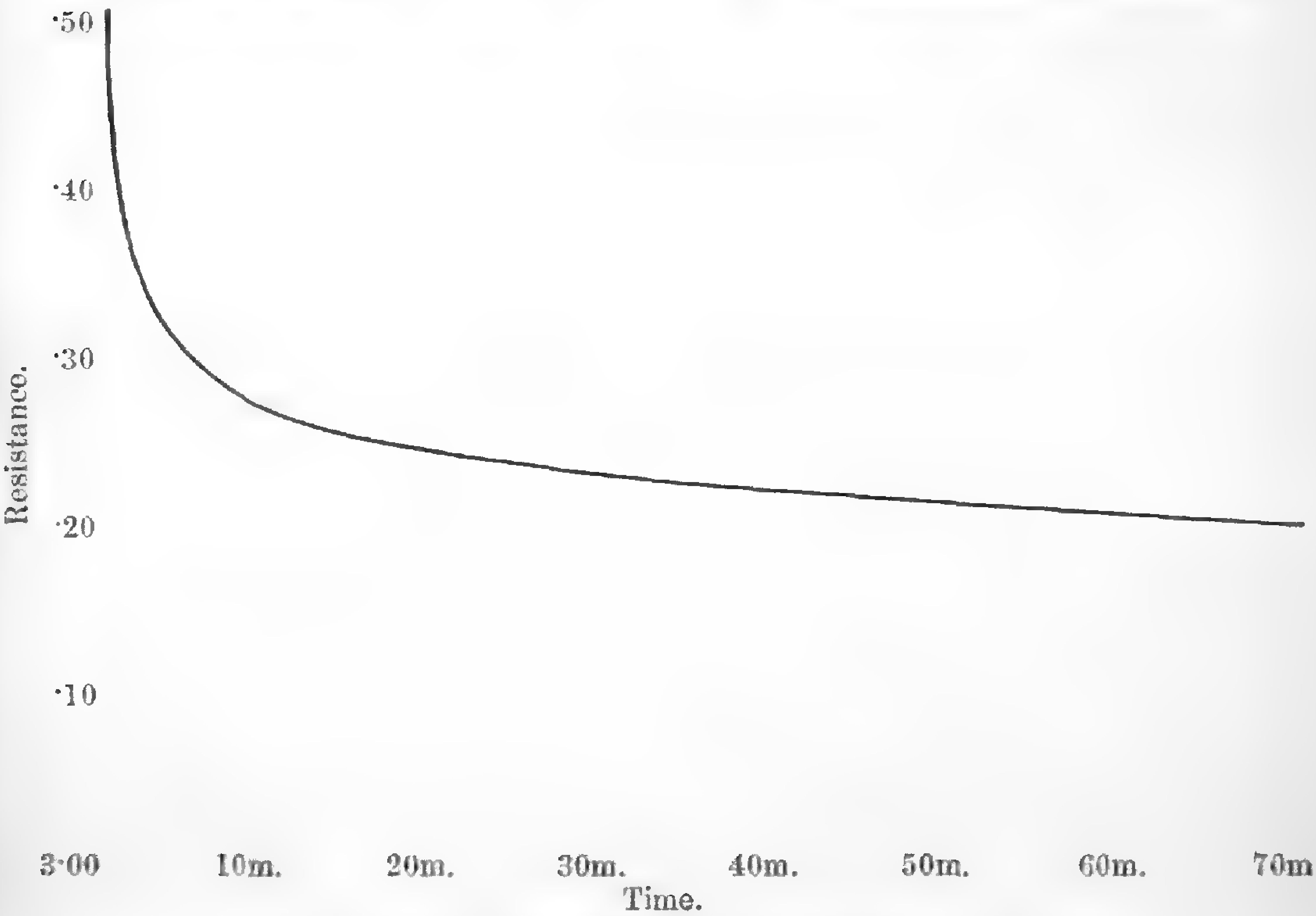
Mr. Edison was a member of the Draper Eclipse Expedition in the summer of 1878, and used his Tasimeter during the total eclipse of July 29 in that year, attempting to measure the heat emitted by the sun's corona. His report to the director, Dr. Henry Draper, was published in the Proceedings of the American Association for the Advancement of Science for the same year. This report shows that the attempt was by no means as successful as could have been desired, the principal obstacle being apparently the difficulty in the adjustment of the Tasimeter so that the galvanometer needle would remain at zero, and to secure its return to that point after it had been deflected. In fact, the zero adjustment was only made by the use of a peculiar shunt of variable resistance ingeniously contrived by Mr. Edison for the purpose.

The writer is not aware of any other systematic attempt to secure quantitative results through its use, and, as far as known, the instrument has been generally regarded as peculiarly inconstant and unreliable in its indications.

Having in his possession a Tasimeter constructed after the model of that described in the report referred to above, the writer undertook a short time ago to investigate the quantitative relation between pressure and resistance for the carbon disk which belonged to it. In a series of preliminary experiments, the use of the toothed wheel and screw, by means of which the pressure is communicated to the disk, was found to be extremely objectionable on account of the impossibility of exactly reproducing a given pressure. This portion of the instrument was therefore entirely removed, and an arrangement made by means of which any definite pressure might be quickly brought to bear upon the disk or removed from it. A slender brass rod was placed in a vertical position upon the center of the upper contact piece, the upper end of which rested lightly in a small conical cavity made on the under side of the scale-pan of a balance. The weight was suspended above by a fine thread passing over a pulley, so that by raising or lowering it the pressure was applied or removed as was desired. The carbon disk was made one of the branches of a Wheatstone's Bridge as described by Mr. Edison. In lowering the weight care was taken to make the movement slow enough to avoid any shock to the disk. When the apparatus stood with the weight lifted, the adjustment of the galvanometer to the zero was made without any difficulty, the resistance of the disk appearing to be quite constant. When the pressure was applied, however, the adjustment became very troublesome, and after a few trials it was discovered that *time* was a very important element in the problem. The addition of a pressure of fifty grams reduced the resistance to nearly one fourth of what it was in its normal condition *instantly*, but it was found that the minimum was not reached at once. The resistance continued to fall during the first two or three minutes with considerable rapidity and after that more slowly. A series of experiments was accordingly undertaken for the investigation of this phenomenon. After a number of trials, the bridge was adjusted so that when the key was closed simultaneously with the application of the pressure the needle of the galvanometer would remain momentarily at zero, for the instantaneous effect of this pressure seemed to be quite constant. In a few seconds, however, the needle began to move, showing that the resistance was diminishing. With this constantly decreasing resistance it was, of course, difficult to obtain balances which were very accurate, but generally one could be obtained within a minute after the application of the pressure, and another a minute or two later, and so on. The operation was repeated many times, and a number of points for the curve shown below were obtained, which, though necessarily somewhat scattering, were so situated as to render its general form almost certain. In almost every instance immediately after the removal of the pressure, the normal resistance was again measured, and it was found that while time was necessary for the resistance to reach a minimum after the application of the pressure, the disk seemed to recover its maximum normal resistance instantly upon its removal.

After the construction of the curve showing the relation between time and resistance, and on the supposition that it correctly represents that relation, it was easy to know what the adjustment of the bridge should be at the end of any given time, and thus the difficulty of that adjustment disappeared.

When tested in this way, the curve was found to be correct within the errors of experiment. The following table exhibits the resistances after various times, the *instantaneous* resistance



Curve showing the relation between Resistance and Time.

being called 100. The resistance before the addition of the pressure of 50 grams was 11·67 ohms, which immediately fell to 3·52 ohms upon the application of the weight.

Time in Minutes.	Resistance.	Time in Minutes.	Resistance.
0	100	15	92·9
1	96·6	20	92·5
2	95·4	25	92·3
3	94·9	30	92·1
4	94·5	35	92·0
5	94·2	40	91·8
6	93·9	50	91·5
7	93·7	60	91·2
8	93·6	70	90·9
9	93·4	80	90·8
10	93·3	90	90·7
12	93·1		

It will be seen that the resistance falls a little more than three per cent in one minute, about five per cent in three minutes, and about ten per cent in one and a half hours, and it seems tolerably certain that even then a minimum is not reached. In two or three instances, the time of continuous pressure was prolonged to twenty-four hours, the resistance at the end being slightly lower than at any previous reading. Finally, the apparatus was left with the weight applied for one week. No measurements were made during that time, but at the end the resistance was found to be decidedly lower than it was at the end of two hours after the application of the pressure, and it is especially to be noticed that on the removal of the pressure the normal resistance of a week before was instantly recovered. In this case the pressure applied was 100 grams. The resistance before the application of the pressure was 11·08 ohms. Upon applying the pressure it immediately fell to 2·34 ohms. In two hours this had been reduced to 2·10 ohms, and at the end of a week it was 1.93 ohms. Thus in two hours it was reduced by about ten per cent, and after one week it was again about ten per cent lower.

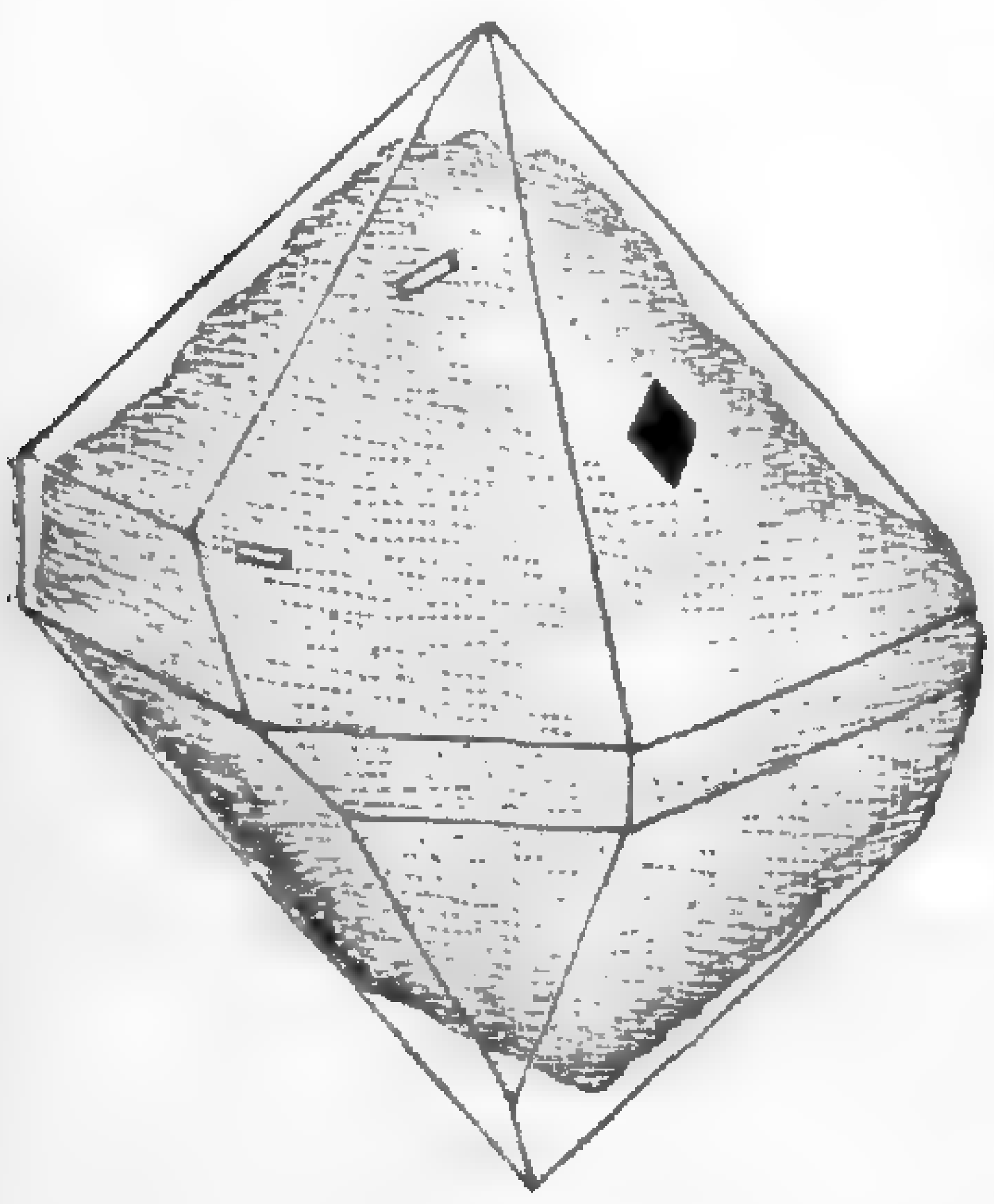
It appears, therefore, that the element of time plays an important part in the phenomena exhibited by the carbon disk, and it seems highly probable that this has been one of the principal causes, if not the chief cause, contributing to the inconstancy and unreliability of the indications of the Tasimeter. The experiments made thus far indicate a fair degree of constancy in its results when this factor is considered. The writer hopes to be able to make further examination concerning the extent to which all of the conditions necessary to its use may be controlled.

The resistance of carbon under pressure has been made the subject of investigations recently by Mr. Herbert Tomlinson and Professor Sylvanus Thompson. The conclusion reached by both is that the diminution of resistance is really due to the contact between the electrodes, and it appears that Professor W. F. Barrett has arrived at a similar conclusion, as a result of experiments made upon a "button of compressed lamp-black." Without knowing anything about the nature of these experiments, the writer desires to record his belief that this theory does not entirely account for the facts stated above. Besides, it seems a little difficult to understand how so small a pressure as fifty grams added to an already existing pressure of about the same amount can increase the area of contact between a flat plate and a flat disk nearly four times, to say nothing of the "recovery" which takes place so promptly upon the removal of the pressure.

ART. V.—*Further observations on the Crystallized Sands of the Potsdam Sandstone of Wisconsin;* by Rev. A. A. YOUNG.

A BRIEF note on the crystallized sands of the Potsdam sandstone quarried at New Lisbon and the St. Peter's sandstone of Wisconsin is published on page 257 of the last volume of this Journal. A fuller account of the observations which I have made is here given.

The quarries near New Lisbon affording the sands described are situated five miles north of the place. The rock is a hard, compact and mainly very fine-grained sandstone. Some slabs carry excellent ripple-marks and fossil tracks. The rock sparkles brilliantly in the sunlight through the reflection from innumerable but minute faces of crystals. When broken up and prepared for the microscope, nearly all the grains show, at least on some part of their surface, a portion of an edge, or face, or an apex of a crystal.



The most finished crystals occur among the minuter grains, some of which are only ·004 in. × ·0035 in. in longer and shorter axes. Much of the sand varies from $\frac{1}{50}$ to $\frac{1}{100}$ of an inch in longer diameter. Some of the small grains are complete in their crystalline form, save at some spot of detachment from a neighboring grain. The simplest form is that of the double six-sided pyramid, but others have portions of the intermediate prism of varying lengths; and besides these are others with modifying planes. A frequent form is roughly pear-shaped, carrying at the smaller end a point of a pyramid, and at the larger a cluster of minuter pyramids. The larger part of the grains have many irregularities of form, whose explanation is obvious when the sand is mounted in balsam.

Accompanying the sand are certain brown kidney-shaped grains, ·003 in. in diameter and smaller, smooth for the most part, which closely resemble certain enclosures that are found in the grains of sand. The rough exterior of part of the grains appears to have sometimes come from the breaking apart of cohering grains. Some of these rough spots occur in the midst of smooth faces, and are shallow six-sided pits with straight sharp edges.

While dry mounting exhibits to the best advantage the crystalline faces, a balsam mounting, or its equivalent, discloses best the interior structure and the mode of origin. Thus examined the lack of homogeneity becomes apparent at first glance. The crystals—the most complete as well as those least so—are found to inwrap fragments of varying size, contour and structure. When viewed by reflected light, on a dark background, the crystallized exterior is barely discernible as a thin transparent envelope, while the enclosed fragment appears often semi-opaque and has a sharply defined outline.

Generally the longer and shorter diameters of the whole grain accords with those of the enclosed fragment; but in some they are reversed so that the narrowest part of the fragment lies in the line of the greatest length of the grain of sand. Viewed alternately by reflected and transmitted light, one sees apparently two different objects.

The greatest thickness of the crystal envelope which I have yet measured is ·004 in. Ordinarily the maximum thickness—at the extremities of the pyramids—is from ·001 in. to ·0015 inch; but over much of the surface the envelope is so thin as to be but barely appreciable with a power of 150 diameters. In this envelope bubbles or cloudiness are very rare.

The enclosed grains vary much in *contour*. Many are rounded in portions of the outline, though few are symmetrically so. Some are as sharp-angled and jagged as fragments of freshly broken rock. Sometimes their surfaces show by reflected light groovings of a length double or quadruple their breadth, either in single lines or sets of lines, or in lines crossing at varying angles, and in the nuclei of crystals of only ·005 in. in length, as well as in larger. They are furrows rather than scratches, as though the fragment had been rolled with a dragging motion over cutting points. This structure appears also in the nuclei of the crystals of the St. Peter's sandstone. Such facts throw light on the previous history of the individual fragments. These groovings are also finely exhibited in sand, from friable rock of a higher horizon of Potsdam, in which only occasional traces of a crystal envelope appear.

In *structure* the enclosed fragments show great diversity. Homogeneity is the exception. In some a general cloudiness exists, or irregularly scattered bubbles; and in others there are planes or belts of bubbles. Aside from these are other noteworthy enclosures. Some grains are traversed by needle-like lines, suggestive of rutile threads in quartz, which occasionally terminate abruptly against the inner surface of the transparent crystalline envelope. In some grains these threads form a parallel system, and in others they are set at all angles with one another. Very rarely they are curved or bent. In one grain, only ·02 in. × ·015 in., nearly fifty such threads occur. I have found this rutile-like structure also in the samples of the Potsdam sand from various horizons; in sand from the Pictured rocks of McGregor, Iowa, and in the St. Peter's sand.

Enclosures of another type are transparent spaces irregular in shape; some of these of the form of six-sided prisms, and others appearing to be cylindrical. One of the latter, occurring in a grain measuring ·016 in. × ·008 in., was ·0045 in. × ·0003 in. In another grain a tubular or prism-shaped cavity occurred measuring ·003 in. × ·001 in., with an *enclosed brown* spot ·001 in. long. A grain measuring ·013 in. × ·012 in. contained eleven of these transparent cavities.

Other enclosures are colored brown, yellowish, reddish, neutral, or nearly black. Some are evidently cavities with colored contents, a few with solid contents. One of the larger measured ·0045 in. × ·0035 in. Some are of irregular contour, but the most give hints of regular sides and forms. From one brown enclosure, ·0045 in. × ·0033 in., there extended a tube, at right angles, ·003 in. long × ·001 in. broad. In one grain, ·024 in. × .020 in., there was one brown cavity, ·007 in. × ·006 in., with upper and lower sides parallel planes; a second similar cavity, ·003 in. × ·002 in., in some positions showing a six-sided shape; a third cavity, drab colored, ·002 in. × ·001 in., and five minor ones, are plainly hexagonal. Such enclosures appear to be common to all horizons of Potsdam, and are found to some extent in St. Peter's.

In two instances I have found inclusions that were apparently minute grains of worn quartz. One was furnished by a nearly oval grain of sand, measuring ·03 in. × ·025 in., whose crystal envelope was very thin. Embedded in this grain, at a depth of ·005 in. from its upper surface, and nearly as much above the under, lay a grain of worn quartz of rounded outline. It measured ·0045 in. × ·0035 in. and was traversed by four paralell bands of cloudiness. The second instance occurred in a grain nearly oval, ·017 in. × ·014 in. across. The enclosed grain measured ·0035 × ·003 in. When viewed by reflected light it was very distinct in outline; and translucent, but in a less degree than the grain in which it was embedded.

The quarried rock, that is composed of this crystal-sand, gleams brilliantly in the sunlight. It may be worthy of record that the same sparkle of minute crystals appears also in the smooth surface of some of the fossil tracks, and in the ripple-marks, many of which are preserved with admirable distinctness.

The grain of sand figured above is one of special symmetry and completeness of finish, which shows well the relation of the crystal envelope to the imprisoned nucleus with its inclusions.

Art. VI.—*On the Origin of Jointed Structure;* by G. K. Gilbert.

In the March number of this Journal, President LeConte proposes to explain the jointed structure of the Quaternary clays of the Great Salt Lake Desert by referring it to the same category with certain shrinkage cracks observed in recent Californian alluvial deposits. The cracks he describes form by their intersection "more or less rude approximations to quadrangular or hexagonal prismatic blocks,"—and these words seem to imply the irregular arrangement characteristic of sun cracks. The joints dividing the clays of the Desert have, on the contrary, a regular arrangement. In describing them in the January number of the Journal, I spoke of a drainage system to which they give rise, and said that the blocks marked out by that system are "rudely rectangular," but the adjective *rude* could not with propriety be applied to the blocks cut out by the joints, for these are well-defined parallelograms. The joints are definitely divided into two systems, one nearly at right angles to the other, and within each system they are parallel. For this reason I am led to regard the proposed explanation as insufficient.

When a moist clay stratum shrinks by drying, its fracture is resisted, first, by its internal cohesion, and second, by its adhesion to that on which it rests. The average size of the blocks into which it divides is determined by these two conditions—the cohesion tending to make them large, the adhesion to make them small. The forms of the blocks are determined primarily by the fact that the contraction is equal in all directions, and we may conceive that each block tends to be circular about its center of adhesion—becoming actually polygonal, with as many sides as there are contiguous blocks. The arrangement of the centers of adhesion follows no law, but is conditioned in part by slight inequalities of adhesion or cohesion, and is irregular. There is always some inequality in the size of the blocks and the number of their sides ranges ordinarily from 4 to 7. It is a general characteristic of the cracks thus formed that they meet but do not cross each other. If four come together in such way as to include equal angles it is purely a matter of accident. Ordinarily only three meet in a point and neither of the three is, properly speaking, the continuation of one of the others.

The features characteristic of sun cracks in clay are repeated wherever a superficial layer of any material shrinks so rapidly as to crack. They are illustrated by a great variety of cooling and drying processes in the arts, and conspicuously by the cooling of lava beds. The system of cracks formed on the surface of a congealing lava stream are carried downward as solidification and contraction progress, and cause the rock to be divided into a system of polygonal, prismatic blocks.

Cracks of this type are included by some writers under the head of joints, but it will be convenient here to call them distinctively *shrinkage cracks* and follow Professor Dana in giving to the word *joints* a more restricted meaning. The joints which occur so generally in indurated rocks are characterized primarily by parallelism. By means of parallelism they are grouped in systems, and most rock-bodies are traversed by two or more of these systems. Their tracings at the surface constitute a lattice of straight lines or of lines nearly straight. The lines of two systems cross each other without interference. From each point of intersection lines go in four directions, and the alternate lines are prolongations of each other. Exceptional points can be found in which three lines meet, but the meeting always makes a letter T and never a letter Y—that is to say, two of the three meeting lines always agree in direction so as to constitute a continuous line, against which the third terminates. Usually the hammer will reveal an inchoate joint in the prolongation of the third line. In each of these respects joints differ from shrinkage cracks.

Joints of the same system are parallel; shrinkage cracks are not parallel. Joints of different systems cross each other: shrinkage cracks do not cross each other. In jointed structure the joint is the leading feature, the block is incidental, and the wide-spread evidence of system everywhere observed shows that the causative force either is diffused or is extraneous. In shrinkage-crack structure the causative force is localized in the shrinking block, and the crack is incidental.

Yet other points of difference could be enumerated, but enough have been adduced to show that the two series of phenomena are not closely parallel. Perhaps the shrinkage hypothesis for joints should not be set aside as absolutely untenable, but it certainly cannot be adopted until division planes demonstrably due to shrinkage are in some instance shown to have the peculiar characters of joints.

If we turn, now, to the relation between jointed structure and slaty cleavage, we find, to say the least, a close analogy. They agree in the parallelism of division planes. Just as one system of joints intersects another, so a system of joints is found to intersect a system of cleavage planes; and it is probable, though perhaps not certainly known, that two or more systems of slaty cleavage may exist in the same rock mass. The most striking difference between the two structures may possibly be one of degree merely:—in the case of joints the parting planes are separated by wide interspaces, while in the case of slaty cleavage the interspaces are small. Another difference is exhibited by the internal structures of the blocks separated by the division planes. In slaty structure the blocks are themselves cleavable in the direction parallel to the planes of division, while in typical jointed structure the blocks are not thus cleavable. These two differences are perfectly evident when typical samples are considered, but it may be doubted if they are universal and diagnostic. Many examples are difficult to class with one type or the other, and there appears to be a gradation of character alike in regard to the thickness of the parted blocks and in regard to their cleavability. It is practically impossible to draw a hard and fast line between the two structures, and the geologists who regard jointed structure as identical with slaty cleavage certainly have much to say in support of their opinion.

When however we come to the question of cause, serious doubts arise. We have a well-sustained theory that slaty cleavage is due to compression, the direction of the compressing force being normal to the planes of cleavage. If this theory is true, and if joints are essentially identical with cleavage planes, then joints too are caused by pressure and compression. Should we grant this we must accept joints in every instance as evidence of compression, and we must conclude that all or nearly all level-lying strata have been subjected to coercive pressure from one or more directions. Two systems of joints must indicate pressure from two directions at two different times, for coincident pressures could only induce jointing planes normal to the direction of their mechanical resultant. The occurrence in the same rock-mass of a number of systems of joints, theoretically indicates the successive, and not the coincident, existence of the same number of mechanical stresses. The application of this rule to the Quaternary strata of the Salt Lake Desert imposes a severe strain upon the imagination, for it requires us to believe that a broad sheet of freshly-formed sediments—so fresh that the shore-trace of the formative lake has scarcely been impaired by the weather—has been compressed by forces acting first in one direction and afterward in a direction nearly at right angles. There are, indeed, evidences of Post-Quaternary orographic movements in the region, but those movements were small and vertical, and the type of structure exhibited by all the surrounding mountains is one implying vertical displacement and no lateral contraction.

If the theory of lateral compression were valid, and if each epoch of compression left its record in a system of joints, it would be reasonable to expect that the older strata would be found to contain a greater number of joint systems than the newer, and that, *cæteris paribus*, there would be found a more or less gradual increase in the complexity of joint division from new rocks to old. Such, however, is not the case. Restricting our attention to those rocks which lie nearly level, we find that Paleozoic rocks rarely exhibit more than three or four joint-systems and frequently only two, while the same remark applies to Secondary and Tertiary rocks, and while the Quaternary clays of the Salt Lake Basin have two systems. In the range of my own experience the rocks freest from joints are the massive, cross-laminated, Triassic and Jurassic sandstones of the Colorado Plateaus, and these strata afford the only localities in which I have ever observed a *single* joint system. Indeed, the record of single systems of joints is so rare that I am disposed to question my own observation and suspect that the minimum number of coincident joint systems is two. However this may be, it is certainly an objection to the compression theory that, while the number of joint-systems in level-lying formations of all ages is frequently no more than two, it is rarely or never one.

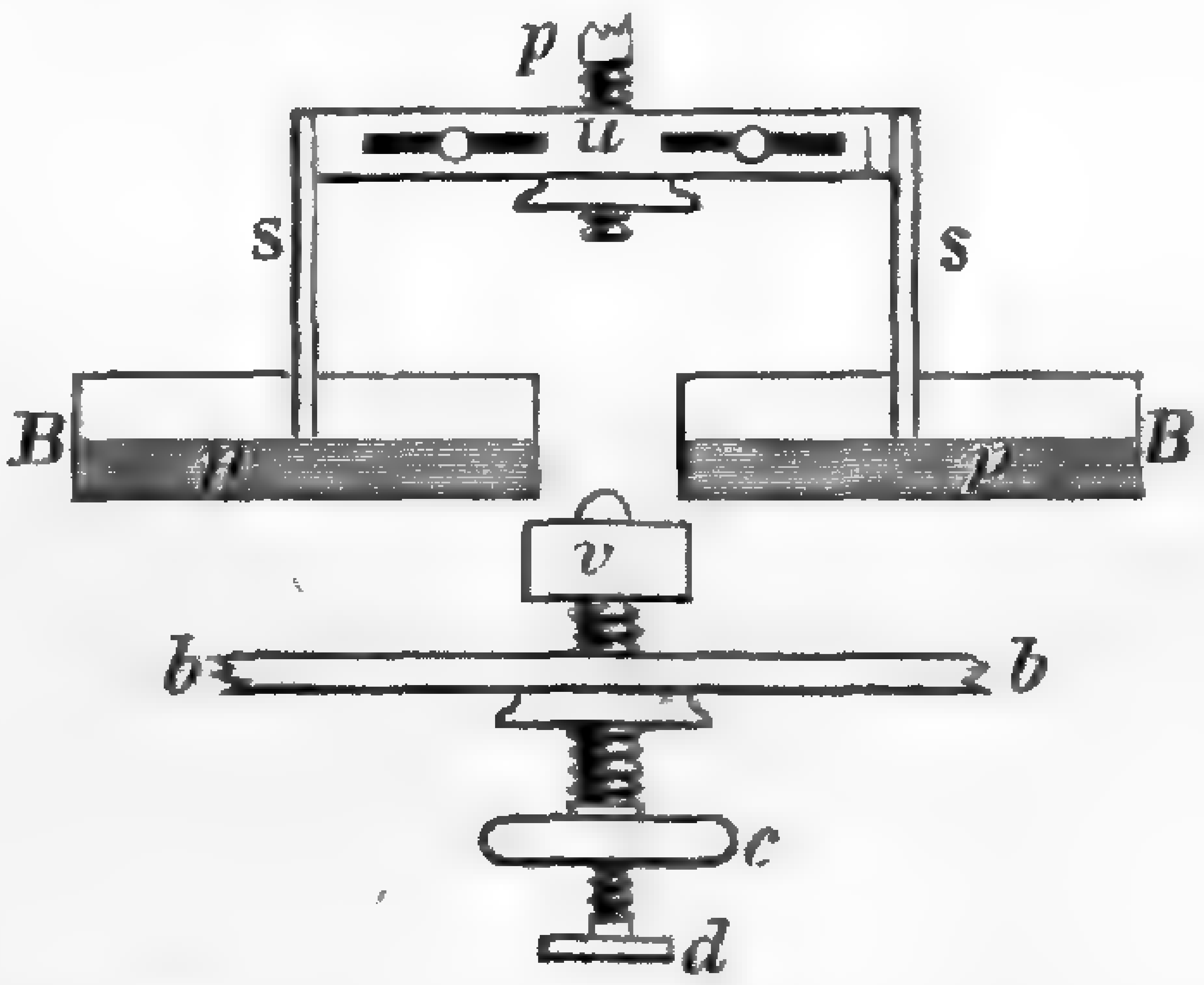
Now, unless we include the suggestion that joints have a magnetic cause, or the absolutely baseless hypothesis that they are due to shearing force, there seem to be only the two hypotheses above discussed to account for them. The most competent writers who have treated of them have classed them either with shrinkage cracks or with slaty cleavage, ascribing them on one theory to mechanical pulling and on the other to mechanical pushing. If the considerations here adduced have weight, then neither hypothesis is satisfactory, and the problem is an open one. It is certainly hard to correlate the parallelopipedons into which the clays of the Salt Lake Desert are divided with the polygonal prisms normally arising from shrinkage; and it is equally hard to admit that the clays have been subjected since their deposition to coercive pressure from two independent directions.

In my judgment it is proper to conclude, first, that joints are not due to shrinkage, and second, that the theory which regards them as identical with slaty cleavage and ascribes both to compression is untenable. If pressure and compression suffice for the explanation of slaty cleavage, then jointed structure is something distinct from cleavage and needs an independent explanation. If joints and cleavage are merely diverse examples of the same general structure, then the theory of slaty cleavage which has been so widely received fails to comprehend all the facts and needs to be revised.

ART. VII.—*Break-circuit arrangement for transmitting clock-beats;* by FRANCIS E. NIPHER.

[Read before the St. Louis Academy of Science, March 20th, 1882.]

A SIMPLE device for the transmission of clock-beats upon telegraph lines has been found so satisfactory in its action, that a description is here given for the benefit of any to whom it may be of service. The break-piece, which is represented in the cut, is best attached to the lower end, *p*, of the pendulum. It consists of a small brass bar which is screwed to the end of the pendulum rod, and set with a "jam nut" below. Two U-shaped strips of brass (*u*) are slipped around the vertical sides of the bar, to which they are clamped by bolts. The U strips are slotted to admit of lateral adjustment, as shown. Stiff strips



of brass (*s*) are soldered to the bottoms of the U pieces, and carry the two blades B which terminate below in platinum sheets *p*. It is evident that the adjustment of the slotted U pieces enables one to adjust the width of the gap between the blades B. For telegraphic transmission, where the signals are repeated, with a pendulum vibrating so that the amplitude chord is 2 inches, the interval between the blades should be about $\frac{7}{16}$ inch, while for chronographic work it should be somewhat smaller.

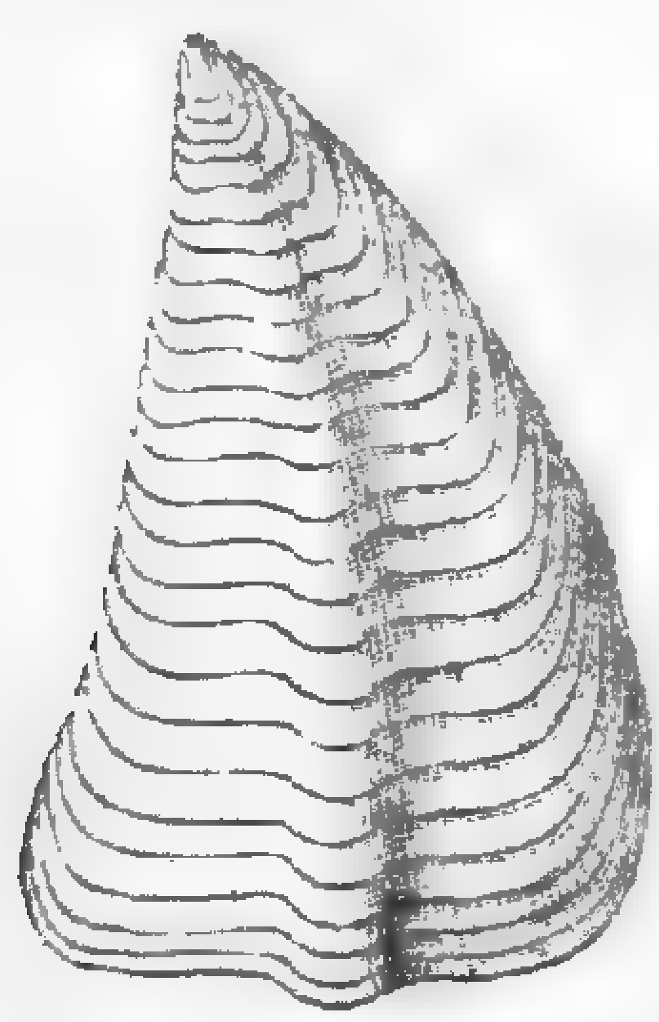
The mercury is, as is usual, contained in the hollow screw *c*, which is carried by the bed plate *b*. The screw *c* is tipped with a cylinder of wood or vulcanized fiber, and the mercury cavity terminates at the top in a long, narrow slot, at right angles to the plane of vibration.

This break is now in daily use by Professor Pritchett at the Observatory of Washington University, and the clock-beats are sent over something like ten thousand miles of wire. Arrangements now pending will increase the number of miles of wire to 28 or 30 thousand.

ART. VIII.—*Cirriped Crustacean from the Devonian;* by JOHN M. CLARKE.

THE genus *Plumulites* was erected by Barrande to cover certain fossils regarded by him as the capitulum plates of sessile Cirripeds and the name has been so interpreted as to cover the genus *Turrilepis*, proposed by Woodward (Quart. Jour. Geol. Soc. 1865) for a form which he regarded as bearing a scaly peduncle, the latter name having priority in time but not sufficiently carefully defined to entitle it to stand. Barrande, in regarding his specimens as all capitulum plates and not the scales of the peduncle, has based his conclusions upon the external markings of the plates rather than upon any such variation in shape and size as we should expect to find in the capitulum plates of a Lepadoid, and though his conclusions are probably correct, they are hardly fair deductions from his premises. It is interesting to notice that the species here to be mentioned and which closely resembles Barrande's species, *Plumulites fraternus*, shows some variation in the form of the plates, increasing thus the probability that they all belong to the capitulum, fig. 1 showing the more common elongate-triangular outline, being perhaps a *scutum*, and fig. 2 possibly one of the *latera*. In one example, four plates were found together, two having the outline of fig. 1, and two of fig. 2, the valves, thus of the capitulum having been detached but not scattered.

1.



2.

This species, *Plumulites Devonicus*, is from the base of the Hamilton shales at various localities in the towns of Canandaigua and Hopewell, Ontario Co., N. Y., and is interesting in being the first representative of fossil barnacles from the Devonian, Barrande's species of *Plumulites* and *Anatifopsis*, as well as the *Turrilepis* of Woodward being from the Upper and Lower Silurian and *Plumulites Jamesi* (Hall & Whitf., Pal. Ohio, vol. ii), from the Hudson River group.

Plumulites Devonicus.—Scutum (?). Length 4^{mm}, width at base $1\frac{1}{2}^{mm}$. Outline elongate sub-triangular or feather-like.

A curving median elevation runs from apex to base, growing more marked with each younger accretion to the valve. Lines of growth strongly marked. Nucleus apical. *Latus* (?). Length $2\frac{1}{2}^{mm}$, width 2^{mm}, round-triangular. Lines of growth strong; no median ridge; nucleus sub-apical.

May 4, 1882.

Since this note was put in type I have received from Mr. R. P. Whitfield a copy of a paper by him ("Descriptions of new species of Fossils from Ohio"), read before the New York Academy of Sciences and bearing the date of March, 1882. In this paper the identification of this genus *Plumulites* is announced, in the Huron (Genesee and Portage) shales, and a new species *Pl. Newberryi* described. Mr. Whitfield has, however, stated to the author his reason for feeling some doubt as to the advisability of referring his forms to this genus as they present considerable variation from the typical forms, though there can be no doubt of their Cirriped characters. *Pl. Devonicus*, however, so closely agrees with the type of the genus that, as suggested, it resembles almost to specific identity one of Barrande's species from Etage E. *Pl. fraternus*. *Pl. Newberryi* and *Pl. Devonicus* have no specific characters in common. J. M. C.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Absorption-Spectrum of Ozone.*—Chappuis has studied with care the absorption-spectrum of ozone. He finds it exceedingly characteristic, so much so that it serves for the detection of this substance better than any other of its physical or chemical properties. By its means he has investigated the decomposition of ozone by heat, the formation of ozone when carbon dioxide is subjected to the electric discharge, the production of pernitric oxide when oxygen and nitrogen are electrised, and other similar phenomena. The spectroscope used had two prisms, only one of which might be employed if desired. The ozonized oxygen was contained in a tube 4·5 meters long, and was prepared under atmospheric pressure and at 15° C. Eleven bands were observed in the spectrum, their wave-lengths being as follows: (1) 628·5, (2) 609·5–593·5, (3) 577·0–560·0, (4) 547·0–544·5, (5) 535·0–527·0, (6) 508·5–502·0, (7) 492·5–491·0, (8) 484·5–479·0, (9) 470·0–468·5, (10) 464·5–460·0, (11) 444·0. The first band was observed only twice and this where the ozone had been prepared with great care and was examined in a long tube. The second band is the most easily visible of all. It contains a darker portion near its center, from 603·5 to 597·0. The third band appears much darker in the region near D, the maximum being at 573·5. The other bands are alike in intensity and are nebulous on their edges. Photographs show absorption of the more refrangible rays but no new bands. By no method tried

could any of the bands be resolved into lines. As the thickness and the density of the gaseous layer increase, the bands increase in width and intensity and new ones make their appearance; a fact observed with nitrogen tetroxide by Brewster. The first bands which appear in the spectrum of ozone are 2 and 3. Then come 5, 6 and 8, and finally 10 and 11. Only in rare cases are 4, 7 and 9 seen, and 1 is extremely rare. Lowering of the temperature also deepens the color of the gas and increases the number and intensity of the bands. The blue liquid, obtained when a mixture of ozone and carbon dioxide is compressed, gives an absorption-spectrum essentially similar, showing both the absorption bands near the solar line D.—*C. R.*, xciv, 858, March, 1882.

G. F. B.

2. *On the Liquefaction of Ozone.*—When a highly condensed mixture of oxygen and ozone is suddenly expanded a dense mist appears; and from the character of this mist and the circumstances of its production, HAUTEFEUILLE and CHAPPUIS concluded that ozone was but a little less easily liquefiable than carbon dioxide. Upon mixing carbon dioxide and ozone together and compressing, they obtained a blue liquid. These authors have now succeeded in obtaining pure liquid ozone. By means of a Cailletet's apparatus a mixture of oxygen and ozone was compressed to 125 atmospheres. The glass tube containing the gas was recurved at its extremity so as to be immersed in liquid ethylene, by which its temperature was lowered probably to $-100°$ C. If the oxygen contains 10 per cent of ozone the ascending portion of the tube is colorless while the recurved and cooler portion shows a blue color. On sudden expansion, the entire tube becomes colorless and there appears at its capillary extremity a drop of dark indigo-blue liquid ozone. Once liquefied, it volatilized with extreme slowness. It remained for thirty minutes under a pressure of 75 atmospheres and its evaporation was not very rapid even when the pressure in the tube reached that of the atmosphere without.—*C. R.*, xciv, 1249, May, 1882.

G. F. B.

3. *On Nitrogen Sulphide.*—BERTHELOT and VIEILLE have examined nitrogen sulphide with a view to determine the heat of its formation. It is a beautiful, well-defined crystallized body having the formula N_2S_2 corresponding to the dioxide N_2O_2. It is produced by the action of ammonia gas on sulphurous chloride according to the reaction: $(NH_3)_8 + (S_2Cl_2)_3 = (NH_4Cl)_6 + N_2S_2 + (S_2)_2$. It is permanent in the air, detonates with violence under the hammer, and deflagrates at 207°. Its density at 15° is 2·22. The heat of detonation is: N_2S_2 solid $= N_2 + S_2$ solid, at constant volume $+64·4$ calories. The heat of formation is therefore negative: $N_2 + S_2 = N_2S_2$ solid $-64·4$ calories. This body is therefore formed with absorption of heat like all the other binary compounds of nitrogen except ammonia. Hence it cannot be produced except by indirect methods, under the condition that the energy absorbed in the union of the nitrogen and the sulphur

be furnished by some auxiliary reaction. These constituents should therefore be in the nascent state, as it used to be called; they should come from preëxisting combinations the reciprocal actions of which, giving rise to new compounds, evolve more heat in their formation than the nitrogen sulphide absorbs. Thus in the above reaction the formation of hydrogen chloride and then ammonium chloride furnishes the energy absorbed in the formation of the nitrogen sulphide. The pressures developed in a closed space by the explosion of nitrogen sulphide are very near those obtained with fulminate for the same density of charge.—*Bull. Soc. Ch.*, II, xxxvii, 388, May, 1882. G. F. B.

4. *On Pernitric oxide.*—When especial precautions are not taken to avoid the presence of nitrogen in the oxygen submitted to the silent electric discharge, there is produced at the same time with the ozone, a compound of oxygen and nitrogen more highly oxygenated than nitrogen pentoxide, which gives a characteristic absorption spectrum, and to which Hautefeuille and Chappuis have given the name pernitric oxide. CHAPPUIS has examined the spectrum of this new oxide and finds it to consist of eight absorption bands. Since ozone is also present always, its bands are superposed upon the pernitric spectrum. But the intensity of the bands in the latter is much greater and they are more sharply defined. Traces even of the oxide show two lines between A and D in a region containing no ozone bands. Moreover, the oxide spectrum shows fine black lines in addition. The following bands were observed, the tube being two meters long: (1) 668·0–665·0, (2) 639·0, (3) 632·0–628·0, (4) 628·0–625·0, (5) 617·0, (6) 606·0, (7) 598·0, (8) 588·5–590·0. The lines 1 and 4 are the sharpest and the most intense; they are therefore the most characteristic and may be seen in a tube a decimeter long. Line 3 is gray and hardly separable from 4. It may be seen in a tube a meter long. Bands 6 and 7 are superposed on the second band of ozone. Their edges are nebulous and the above figures refer to their middle portion. They appear at the same time as band 8, which is superposed on D. These bands require a tube 1·5 meters long. Lines 2 and 5 are very fine and are seen when the length of the column is at least 2 meters.

In a second paper HAUTEFEUILLE and CHAPPUIS give the conditions of the formation of pernitric oxide. Like ozone the action of the electric discharge is limited, the maximum production corresponding to any given temperature being fixed by the diminution of volume which the gaseous mixture undergoes. Moreover there is a retrograde effect here as with ozone. As soon as the pernitric oxide has reached the maximum tension corresponding to the temperature, further discharges decompose it suddenly into nitrogen tetroxide and oxygen, shown by a sudden diminution of pressure and an intense red color. The heat thus set free destroys at the same time the ozone formed. If the nitrogen tetroxide be present in certain proportions, neither ozone nor pernitric oxide is reproduced by the discharge, if the tension be considerable. At very feeble tensions, however, this re-formation takes place. Experiments made for the purpose showed that the maximum yield of pernitric oxide was, at 15° and 600mm., about 30 per cent, and that, independently of the proportions of the gaseous mixture. Lowering the temperature from 25° to 5° increased the product by one-quarter. In preparing pernitric oxide then, it is necessary to watch the progress of the conversion carefully so as to obtain the largest quantity and avoid retrogradation. This is best done by means of the spectroscope. In the author's apparatus the characteristic lines of pernitric acid appear at the end of about an hour.

In a third paper these authors give the results of their determination of the molecular weight and formula of pernitric oxide. On exposing the electrised mixture to a cold of −23°, crystals were obtained, but they were very volatile and in too small quantity for examination. The gaseous mixture was then exposed to concentrated sulphuric acid. Knowing its initial and the final composition, that of the absorbed portion was calculated. The following mixtures were electrised from an hour to an hour and a quarter at a temperature of 4° to 16°. Nitrogen 2 vols., oxygen 5·22, 5·56, 5·94, 6·18, 6·70, 7·63, 7·46, 9·51. The gas absorbed contained to 2 vols. nitrogen, 6·3, 6·2, 6·0, 6·5, 6·6, 6·2, 6·6 vols. oxygen. The latter ratio remains sensibly constant though the former varies widely. The mean ratio of nitrogen and oxygen absorbed by the sulphuric acid is 2 : 6·3. A second mode of fixing the composition of the pernitric oxide was based on the contraction which accompanied its formation. For this purpose the numerical value of the contraction, at the time when the electric discharges have given the maximum tension for the ozone and for the oxide produced at the temperature of the experiment, is noted and the volume of the nitrogen combined is determined. The sudden rupture of the equilibrium produced when the limiting tension is reached enables this volume to be fixed, since after this retrogradation the nitrogen of the pernitric oxide forms the tetroxide which is easily determined in a gaseous mixture when it contains no ozone. Both these indirect methods agree in assigning to pernitric oxide the formula N_2O_6. Further researches upon it are in progress.—*C. R.*, xciv, 946, 1111, 1306, April, May, 1882. G. F. B.

5. *On the Crystallization of Anhydrous Glucose from an Aqueous Solution.*—Anhydrous glucose has hitherto been obtained only from alcoholic solutions, methyl alcohol being the more recently used. BEHR has found that anhydrous glucose may be made to crystallize from aqueous solutions. The hydrated product may be made to crystallize from its aqueous solution, as is well known, by the simple device of dropping in a few fragments of the solid. It occurred to Behr to drop into this aqueous solution a fragment of the anhydrous glucose. The next morning he was surprised to observe that the mass had crystallized, but with an appearance quite different from that ordinarily seen. By

centrifugal action the syrup was separated and after washing with methyl alcohol, the crystals had the fusing point, crystalline form, etc., of anhydrous glucose. The best result is obtained with a solution containing 12 to 15 per cent of water, though the result takes place within wide limits. The author has observed, further, that under certain conditions of concentration and temperature, the anhydrous product is the normal product of crystallization. Solutions of a purity of 97 to 98 solidify over night to a hard mass which, after the separation of the syrup, resembles loaf sugar. The importance of this observation to the industry of glucose cannot fail to be very great. The facility with which the result can be produced, the excellent appearance of the product, and the large use it will have in replacing loaf sugar made from the cane and the beet, all ensure its rapid introduction. The author estimates its sweetening power as compared with cane sugar as $1:1\frac{2}{3}$.—*Ber. Berl. Chem. Ges.*, xv, 1104, May, 1882. G. F. B.

6. *On the Transformation of Carbonyl Sulphide into Urea.*—BERTHELOT pointed out some time ago the fact that carbonyl sulphide and ammonia gas form, by their combination, oxysulphocarbamate of ammonium, transformable into urea by the simple elimination of hydrogen sulphide:

$$COS(NH_3)_2 = H_2S + CH_4N_2O.$$

In presence of metallic oxides this reaction is very sharp. He now finds that by simple evaporation of the aqueous solution of this salt, at a moderately high temperature, there is obtained a crystalline mass formed principally of urea but mixed with a notable quantity of sulph-urea, together with a little ammonium sulphocyanate, formed thus:

$$COS(NH_3)_2 = H_2O + CH_4N_2S.$$

This formation of both bodies is due either to the existence of two isomeric oxysulphocarbamates, or to two simultaneous reactions resulting from the multiplicity of the points of attack of a single one.—*C. R.*, xciv, 1069, April, 1882. G. F. B.

7. *Note on the Littrow form of Spectroscope;* by Professor C. F. BRACKETT, Princeton, N. J. (Communicated.)—In the employment of the Littrow form of spectroscope, in which a single tube serves for both collimator and telescope, great difficulty has been found in observing, on account of the light which is thrown back, by reflection, from the surfaces of the lens. As this form of spectroscope recommends itself from considerations of economy as well as those of convenience, it was decided to attempt the construction of one which should give great dispersion, on account of the very long focus of the lens employed. After consultation with Professor Young, whose well-earned distinction in spectroscopic studies is everywhere acknowledged, an order was given to Alvan Clark & Sons for the construction of a lens, with the following specifications: the lens to be of about eight feet focal length; the surface of the flint member of the combination looking towards the slit to have a radius of curvature equal to the focal length of

the combination,—a condition which evidently prevents the light reflected from this surface coming to the eye, since it can only pass back through the slit; the second surface of the flint to have the same radius as the contiguous surface of the crown, in order that the two may be joined with balsam, thus avoiding, as much as possible, reflection at these surfaces; the remaining surface to be determined by the conditions of focal length and the avoidance of spherical and chromatic aberrations.

These conditions having been fulfilled by the makers, notwithstanding the most careful blackening of the tube and the use of diaphragms, the amount of light coming back to the eye from the lens was found to be almost fatal to the usefulness of the instrument. But as all the surfaces of the lens, except that nearest to the slit, are of necessity curves of short radius, the light which can reach the eye must evidently come from a very small portion of them. It was only necessary, then, to cover this portion with a small blackened screen in order to escape all annoyance from this cause. The loss of light which the small screen cuts off from falling on the grating is very trifling,—not to be compared, in fact, with the inconvenience of the reflection which occurs without it.

The performance of the instrument as it now stands is quite equal to that which would be secured by one having the usual construction, with telescope and collimator mounted separately.

With a Rutherfurd grating of 17,000 lines to the inch, it can easily show many of the Fraunhofer lines, which the maps of Kirchhoff and Ångström lay down as single, to be composite.

Princeton, May 12, 1882.

8. *Relation between galvanic polarization and the surface tension of mercury.*—Many investigators have occupied themselves with the study of capillary phenomena presented by mercury, and the changes in these phenomena produced by electricity. Lippman has invented an electrometer whose action depends upon polarization produced by electrical currents at the surface of separation between mercury and dilute sulphuric acid. Lippman has also maintained that the magnitude of the capillary constant is modified by the difference of potential between the two liquids at the surfaces of which the phenomena are studied. A controversy upon this point has ensued between Lippman and Quincke, and Helmholtz suggested to Arthur König to complete an investigation which had already been begun in the Physical Laboratory, at Berlin. The experiments of Lippman were repeated and were extended to various acids and solutions of salts. In order to avoid the adhesion to glass surfaces, a form of apparatus was employed by means of which the mercury surface was bounded by a minimum surface of glass. The surface of the mercury was immersed in the solution employed and was observed by means of an opthalmometer. The ingenious arrangements by means of which the measurements of the change of shape of the mercury surface were made are given at length. Although the apparatus was placed upon a pier, the position of

the Berlin Physical Laboratory—in the midst of jars and tremors from the neighboring streets—interfered seriously with the work. It was found that with different fluids and with different values of potential, the surface tension had a certain maximum value—which subsided to a lower value—thus confirming the result of Quincke that a strong negative charge on the quicksilver resulted in a diminution of its surface tension. A careful study resulted in showing that the phenomena observed were due to electrical effects upon the mercury, produced by sudden rise in potential, and were not due to chemical change at the surfaces considered, thus confirming Helmholtz's views in regard to the influence of the layer of electricity (*doppelschicht*), upon the surface tension. The article of König contains some remarks of Helmholtz upon the electrical work done at the surface of separation between liquids, which results in diminishing the surface tension. —*Annalen der Physik und Chemie*, No. 5, 1882, pp. 1–38.

J. T.

9. *The change of color tones of spectrum colors and pigments with decreasing light.*—Certain observers, among whom is Dr. A. Chodin, have maintained that there is a close analogy between the colors of pigments and the colors of the spectrum. The latter maintained that with diminution of light yellow, orange and green impress the eye more than blue and violet. On the other hand Purkinje states that pigments with diminishing light become colorless, and that blue continued to impress most. Dove noticed in a picture gallery that blue could be perceived with insufficient illumination better than red. E. Albert examines the subject anew and comes to the following conclusions: The analogy between the changes in spectral colors and in pigments does not exist. From the change of a homogeneous color no conclusion can be drawn concerning the change of the corresponding pigment, but the change of the latter is the result of the changes of the component homogeneous colors. The behavior of homogeneous colors under diminution of light is explained by the Young and Helmholtz theory, with the following addition: a reduction of the intensity of different colored lights betokens a diverse great lessening of sensitiveness in this wise, that for rays of smaller wave lengths, in whatever part of the spectrum they belong, it decreases more slowly than for waves of greater wave length.—*Annalen der Physik und Chemie*, No. 5, 1882, pp. 129–160.

J. T.

10. *Specific resistance of Mercury.*—A new determination of the relation between the B. A. unit and the Siemens mercury unit has been made by Lord Rayleigh and Mrs. H. Sidgwick. According to Siemens' experiments—

1 mercury unit = 0·9536 B. A. units; and according to Matthiessen and Hockin,

1 mercury unit = 0·9619 B. A. units. Lord Rayleigh finds that

1 mercury unit = 0·95418 B. A. units.

Combining the result of the determination of the mercury unit with the value of the B. A. unit obtained by the same experimenter the following value results:

1 mercury unit $= 0·94130 \times 10^9$ C. G. S.—*Proceedings Royal Society*, May 4. J. T.

11. *Eclipse of* 1882.—The following collective note of the results obtained was agreed upon by Lockyer, Tacchini and Thollon: "Photographs of the corona and of its complete spectrum were obtained by Schuster on Abney's plates, H and K being the most intense lines. A study of the end of the spectrum, of the corona and prominences was made by Tacchini. A comet which was very near the sun, and a very striking object, was photographed and observed with the naked eye. Bright lines were observed, before and after totality, of different heights, by Lockyer, and with intensities differing from the Fraunhofer lines by Lockyer and Trèpied. An absolute determination of the place of the coronal line at 1474 of Kirchhoff's scale was made by Thollon and Trèpied. The absence of dark lines on the corona spectrum was noted by Tacchini and Thollon with very different dispersions. Many bright lines in the violet were observed in the spectrum of the corona by Thollon, and were photographed by Schuster. Hydrogen and coronal lines studied in grating spectroscope by Paiseux, and in direct-vision prism by Thollon. Rings observed with grating by Lockyer, first, second and third orders. Continuous spectrum relatively fainter than in 1878, and stronger than in 1871. Intensity of absorption observed in group A, at the edge of the moon, by Trèpied and Thollon."—*Nature*, June 1, 1882. J. T.

12. *Diffraction gratings.*—Professor H. A. Rowland, in a preliminary notice contained in the Johns Hopkins University Circular, No. 16, gives some results of a new dividing engine. Owing to a new method of manufacture a very perfect screw was obtained, and by means of this, diffraction gratings with 43,000 lines to the inch were obtained. Surfaces $6\frac{1}{4} \times 4\frac{1}{4}$ inches can be ruled by the machine. The screw is practically perfect and has been tested to $\frac{1}{100000}$ of an inch without showing any appreciable error. A flat grating 1 inch square with 43,000 lines to the inch divides the 1,474 line in the first spectrum. A flat grating $2 \times 3\frac{1}{4}$ inches, with 14,438 lines to the inch, shows the Z line, wave length 8,240, and as much below the A line as the B line is above the A line. Lines were also ruled on concave surfaces. These gratings allow the observer to dispense with a large part of the telescopic arrangements of a spectroscope. A concave grating $3 \times 5\frac{1}{2}$ inches, 17 feet radius of curvature, 28,876 lines to the inch, showed more in the first spectrum than was ever seen before. It divides 1,474 and E very widely and shows the stronger component of Ångström 5,275 double. J. T.

13. *On the methods for calibrating Thermometers;* by M. Thiesen, Berlin, Germany. (Communicated.)—I take this opportunity to call attention to an inaccuracy in two papers recently published

in this Journal by Mr. Russell (xxi, 373) and by Mr. Holman (xxiii, 278). In them reference is made to the papers of mine in Carl's Rep., xv, 285 (and 677) and in the Zeitschr. d. oesterr. Ges. f. Meteor., xiv, 426 as simply giving Neumann's method for calibrating thermometers. This method is given, in the papers referred to, quoted from Wild and Dorn, but there are also given amplifications and improvements of it by myself, which were indeed not difficult to find, but are now become a matter of importance.

In Holman's paper it is asserted that some of the advantages of Neumann's method are offset by the considerable error arising from taking readings with an end of the thread apparently just at the line of the scale. This method of taking readings, often recommended it is true, is by no means an essential part of Neumann's method nor was it adopted by myself; that will be seen from the examples given in the papers quoted. In the thermometers used in Germany it is not necessary to avoid particularly the coincidence of top and line, since they allow the top of the mercury to be seen *before* the lines of the scale.

I shall venture to add some remarks on the methods of calibrating thermometers, a matter too often disregarded, and about which there seems now to be some interest felt in this country. I think I am acquainted with all the important and many of the unimportant papers on this subject, but I have never found a method that is not superseded by one of the three methods I have described in the paper in Carl's Rep., viz:

1. The method of Lambert or Gay-Lussac, the oldest and simplest one, but not permitting very great accuracy. The method proposed by Holman does not differ materially from this. 2. The methods of Hällström requiring a greater number of observations and a more tedious calculation but which will answer in all ordinary cases. 3. The methods based on Neumann's principles requiring a great number of observations but giving the best results with little trouble.

By employing the method of least squares instead of No. 3 (a method which I may call Hansen's method, though Hansen proposed it for another matter) the labor of calculation is increased rather more than the accuracy; moreover, there is not always occasion for employing this method and it is not easy for everybody to be so acquainted with it as to be always ready to employ it.

To the famous method of Bessel and its modification by Oettingen, to-day only a historical value can be attributed.

II. Geology and Mineralogy.

1. *Abstract of a Report upon the Geology and Mining Industry of Leadville, Colorado;* by S. F. Emmons, Geologist-in-charge Rocky Mountain Division U. S. Geological Survey. 290 pp. 4to, with two colored plates. Washington, 1882. Extr. from Ann. Rep. Director Geol. Surv. of 1881.—The subject of the Report of which an abstract is here given is one of great interest, and the

character of it, as the abstract shows, is every way calculated to satisfy the reader. It is topographical, lithological, geological and economical in its range, and enters into full details under each of its subdivisions. It has many illustrations in the text and an Atlas of fourteen plates. The abstract, by the author, Mr. Emmons, gives a general review of the whole subject, and from it we make out the following brief sketch.

In the latitude of Leadville, 39° 15′, the Rocky Mountain chain includes (1) the Front or Colorado Range on the east; (2) the Mosquito or Park Range with peaks over 14,000 feet, next west—which slopes gently to the eastward and abruptly westward; and (3) farther west, the broader Sawatch Range equally high. Between the latter two ranges is the Arkansas Valley, 60 miles long and 16 wide; and on its eastern side, on the western flank of the Mosquito Range, is situated the city of Leadville, in longitude 106° 17′ W. and 10,150 feet above the sea "between Big Evan's and California Gulches at the base of Carbonate Hill." The first discovery of ore was made in 1860. In 1877 its population was less than 200, its opened mines *three,* and there were surface scratchings; in 1880 it was a city of 15,000 inhabitants, and its producing mines numbered over thirty.

The Paleozoic rocks of the Mosquito Range have a thickness of 4050 to 5600 feet and are more or less folded and faulted. They comprise (1) 200 feet of Cambrian or Primordial, chiefly quartzytes; (2) over these, 200 of Silurian (*white* or dolomitic limestone and quartzyte); and (3) 3700 to 4200 of Carboniferous, which last have 200 feet of limestone, called the *blue* limestone, at base and 1000 to 1500 at top (Upper Measures), with grits (Weber grits), sandstones and shales, partly calcareous, between. In the Kanab section on the Colorado, the Paleozoic has about the same thickness (85 feet of it referred to the Permian); but in the Wahsatch section cited, the thickness is 30,000 feet, 12,000 referred to the Cambrian, 3400 to the Silurian and Devonian, 15,000 to the Carboniferous and 650 to the Permian.

Besides these there are eruptive rocks—porphyries and diorytes—mostly Mesozoic in age. The common kind is the white porphyry, an evenly granular rock, consisting of quartz (70 per cent), feldspar (the latter occasionally in small rectangular crystals), black mica or biotite, and some muscovite. The rock is partly decomposed, and the muscovite "is the result of the decomposition of the feldspar." Other kinds of porphyry, more granite-like, consist of quartz, two feldspars and biotite, and in one variety hornblende is present. The dioryte is a porphyritic crystalline-granular variety. The white porphyry occurs to the south of an east-and-west line through Leadville, and the other kind north of this line. The main sheet of the former which lies upon the surface of the blue limestone forms, at the 4-mile Creek where is its principal vent, the larger portion of a hill 2000 feet high, and thence spreads southward reaching nearly to Buffalo Peaks. On Iron and Carbonate hills it has a possible thickness of over 1000 feet; but along Evan's Gulch it will scarcely average 100, and even thins out entirely. Other sheets occur between lower strata, and there is a local sheet in the lower quartzyte or Cambrian. The intrusive masses of the other porphyries have a wider vertical distribution, "extending up to the Jurassic and possibly even to the Cretaceous." A single section exhibits "fifteen sheets, many several hundred feet thick, between the blue limestone and the top of the Carboniferous." The various sheets of porphyry form an integral part of the sedimentary series; they never reached the surface, but were spread out and cooled between deep-lying strata—laccolith-like, before the mountain-building epoch at the close of the Cretaceous, and therefore before the associated strata were folded or faulted. Archæan rocks make large parts of the Sawatch Range on the west, and of the Front Range on the east, and their areas must have been great islands in the Paleozoic seas. "The Paleozoic and Mesozoic beds are a littoral deposit around the Sawatch Archæan Island and were consequently formed in comparatively shallow waters."

Of later formations, the region contains only the Quaternary; what have existed of Mesozoic strata—probably not less than 10,000 feet—having been removed by erosion and abrasion.

Several faults occur, the more prominent of which have the strike of the rocks, or about N. 60° W. and the upthrow on the east side; and, of these, the Mosquito fault, west of the main crest of the Mosquito Range, amounts on the north to 5000 feet or more. Besides these there are many cross faults.

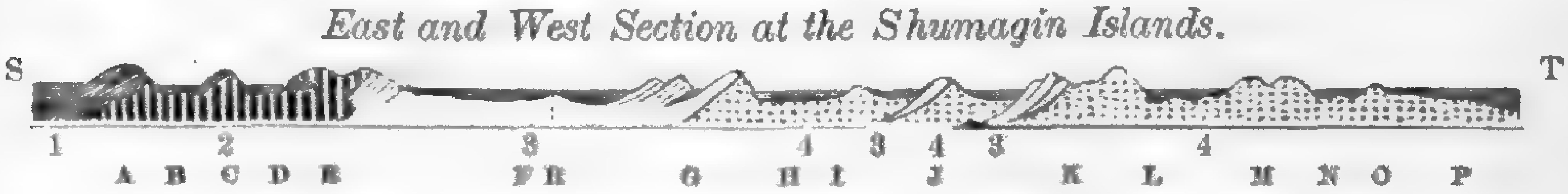
The ores occur underneath a porphyry sheet and chiefly in cavities penetrating the lowest member of the Carboniferous formation—the *Blue* limestone—but occasionally also underneath the same porphyry in the *White* or Silurian limestone, and the Cambrian quartzyte. The ore deposits penetrate into the limestone to varying depths from its plane of contact with the overlying igneous rock, sometimes following courses of natural joints or cleavage planes.

The ore is principally argentiferous galena and its secondary products lead carbonate, silver chloride, and, less abundantly, lead sulphate or anglesite, pyromorphite, minium, zinc blende and calamine. The gangue, or material mixed with or holding the ore, consists of hydrated iron oxides or manganese oxides, silica and clay, all secondary products, the clay coming from the decomposed porphyry. The cavities in the limestone were made by the eroding solutions which introduce the ores; the action commenced at the top of the limestone adjoining the sheet of porphyry, and from this plane worked downward into the limestone. The materials of the ores were taken from "circulating waters, which, in their passage through the various bodies of eruptive rocks, took up certain metals in solution, and, concentrating along bedding planes, by a metamorphic or pseudomorphic action of replacement, deposited these metals as sulphides along the contact or upper surface, and to greater or less depth below that surface, of beds generally of limestone or dolomite but sometimes also of siliceous rocks." Dikes intersecting the ore-bearing formation "seem to favor the concentration of rich ore-bodies or bonanzas in their vicinity;" but the planes of faults afford no deposits of importance, and evidently for the reason that "their origin is later than that of the original ore-deposits." Thus the intrusion of the igneous sheets preceded the production of the ore-deposits and of the cavities containing them; and the production of the ores antedated the era of great disturbance which closed the Lignitic period or the Cretaceous, and which has continued to be followed by feeble movements until the present time, even since the opening, according to some evidence, of the Leadville mines.

Mr. Emmons's abstract of his Report is, like all his geological writings, clear and precise in style, and of the best kind of science whether the subject is purely scientific or practical.

2. *Note on Alaska Tertiary Deposits;* by WM. H. DALL, U. S. Coast Survey. (Communicated in reply to a letter from J. D. Dana.)—Our present knowledge of the existence of Miocene deposits in northern Alaska depends on the identification by Dr. Newberry of certain leaf-bearing strata from Norton Sound and the Yukon River. All along the coast of Alaska there is a series of brown sandstones with marine fossils, which appear to be the same as the brown marine sandstones of the vicinity of San Francisco and Monterey. They are not of course *continuous*, but are found here and there in the same position relative to the conglomerates and shales under them which bear vegetable remains. The California sandstones are called Miocene, though they contain numerous shells chiefly of still-living mollusks. The shells in the northern strata are not characteristic, and belong to *Crepidula*, *Mytilus*, *Ostrea*, and some indeterminate Gasteropods, all extinct species as far as I have noticed, except in one deposit on St. Paul Island which may be of later origin. These brown sandstones are the top-rock in the Yukon valley at Nulato, where they cover a comparatively small area (say thirty miles along the river at most), the bluish underlying leaf-bearing shales and gritty slates covering a very much greater area, and extending to the coast at Cape Tolstoi on Norton Sound north of St. Michael's (which is later

East and West Section at the Shumagin Islands.



1. Tertiary; 2. Lavas; 3. Metamorphic; 4. Granite.

A. West peninsula of Unga Island.
B. Unga North Harbor.
C. East peninsula of Unga Sound.
D. Popoff Strait.
E. Popoff Island.
F. Strait between Unga and Nagai.
R. The submarine Ridge.
G. Island of Nagai.
H. Strait east of Nagai.
I. Twin Rocks.
J. Spectacle Island.
K. Big Koniushi Island.
L. Little Koniushi Island Strait.
M. Little Koniushi Island.
N. Twelve-fathom Strait.
O. Simeonoff Island.
P. Off shore fishing ground.
S.T. Sea-level.

basaltic rock, a formation appearing low down on the Yukon also). They are also the top-rock at the Shumagin Islands, where we have a very pretty section down to the Triassic or Jurassic syenites, which are the base rock of the country nearly every where.

(1) The marine brown sandstone with *Crepidula*, whale vertebræ, oysters, and fossil teredo-bored wood.

(2) Conglomerates brown and iron-stained with thin sandy layers bearing Sequoia and other vegetable remains.

(3) Bluish sandy slates and shales with *Platanus* leaves interstratified with conglomerates and layers of silicified wood and lignite beds. (This is the Miocene of Newberry and Heer.)

(4) Quartzites much metamorphosed but conformable.

(5) Syenites (or granites without mica).

Through all the later strata (1–4) irregular ejections of basaltic lavas.

The sketch of the Shumagin section, herewith sent, was made ten years ago. It is typical of the general sequence in many parts of the territory. At Bering Strait there are no fossiliferous rocks. The Diomedes are granitic domes, rounded and weathered into irregular shapes, but domes of "massive eruption" on Richthofen's hypothesis. The rocks of the Asiatic side are nearly all syenitic (at least so wherever I have landed). The American side is mostly the metamorphic quartzites and hard blue slates not fossil-bearing, with occasional patches (as in Kotzebue Sound) of lava and basalt of late origin. Northward we have the great ground-ice formation broken here and there by hills of Paleozoic age with characteristic fossils and coal of good quality.

On Aliaska Peninsula we have fossiliferous strata from the Jura up, with the same syenitic basis and superimposed Tertiary rocks. The Miocene plant and marine strata, as here considered, have not been noted northwest of the east coast of Norton Sound on the seacoast, nor much north of Nulato on the Yukon. Leaving them and going east on the river, we come upon quartzites and conglomerates, and strike the syenite at the junction of the Yukon and Tananah Rivers; farther eastward the region is probably Devonian, but covered by alluvial deposits near the river; the Devonian rocks actually come out near Fort Yukon, on the Porcupine River.

The general depression of the Alaska region indicated by the Tertiary beds probably could not have exceeded 1500 feet, and was perhaps less. But how to reconcile the general absence of marine tertiary strata over the region *adjacent to the strait* with a submergence there I do not quite clearly see. There was a depression farther east, of course, and farther south, but *at* and *near* the straits it seems more doubtful.

3. *Origin of Jointed Structure*; by J. H. KINAHAN. (From a letter to J. D. Dana, dated, Geological Survey of Ireland, April 15, 1882.)—Mr. G. K. Gilbert and Professor J. LeConte's articles on the "Origin of Jointed Structure in undisturbed Clay and Marl Deposits" are of considerable interest to me. For years I

have believed that many geologists give much less credit to "shrinkage fissures" than they are entitled to. This cause is advocated in my "Valleys and their relations to Fissures, Fractures and Faults," especially in chapter ii; also in different memoirs to accompany the maps of the geological survey of Ireland. In Connemara or West Galway many of the narrow deep gorges I believe to be due nearly solely to the drying and contraction of the rocks after they became dry land; while in different places in the county of Clare there are, under the basal Carboniferous conglomerate sandstone and shales, peculiar siliceous or calcareous rocks that send down dykes into the underlying Cambro-Silurian rocks; and these dykes and other intrusions, as stated in the memoirs, I believe to have filled "shrinkage fissures" in the older rocks. Similarly, in the counties Mayo and Galway, the basal bed of the Silurians (or Lower Old Red Sandstone) intrudes downward, filling fissures in the metamorphosed Cambro-Silurians. In the coals of the Coal-measures many of the "troubles" or "horses" were filled from above, and anciently were "shrinkage fissures;" while in other places it appears to me many dykes of "fault-rock" are the filling in from above of "shrinkage fissures."

4. *American Geological Society.*—The proposal to organize an American Geological Society was brought up at the last meeting of the American Association, and a committee was appointed to consider the advisability of it and report at the next meeting. This committee consists of N. H. Winchell of Minneapolis, Minnesota, John H. Proctor of Frankfort, Kentucky, H. S. Williams of Ithaca, N. Y., John Collett of Indianapolis, G. C. Swallow of Columbia, Missouri, Wm. J. Davis of Louisville, Ky., and S. A. Miller, of Cincinnati, Ohio. The chief objection to it, offered at the time of proposal, was that the American Association included as one of its essential parts a geological association, and offered all the advantages needed by geologists in case the society was to have only annual meetings and no permanent place of meeting; and the objection appears to be good. The division would weaken the American Association without any necessary compensating advantage. The establishment, however, of an American Geological Society at some central city, for monthly meetings, might promote greatly the progress of the science, if it should have men and money to sustain it. Money would be freely needed in order that all memoirs offered might be fully illustrated.

5. *Catalogue of the Fossil Foraminifera of the Collection of the British Museum* (Natural History); by Professor T. RUPERT JONES, F.R.S., F.G.S., etc. 100 pp. 8vo. London, 1882.—This catalogue is of value to investigators and collectors outside of England. It is prepared by one who has published largely on the subject, and is recognized as high authority in the department; it is both stratigraphical and geographical in arrangement; and contains references to many of the works and articles treating of the species.

6. *Brief Notices of some recently described minerals.*—HIERATITE—Occurs at the fumaroles of the crater of Vulcano, one of the Lipari Islands. It forms a part of stalactitic concretions of a grayish color, generally of spongy texture, rarely compact and vitreous. These concretions consist of very small crystals of the new mineral, lamellæ of boracic acid, and are veined with selensulphur, arsenic sulphide, etc. An analysis of the octahedral crystals, separated from the aqueous solution, showed them to have the composition of a potassium fluo-silicate, $2KF+SiF_4$. The concretions also contain potassium alum, and cæsium and rubidium alum, with small quantities of thallium. The name is given from *Hiera*, the Greek name of Vulcano.—Cossa in *Trans. Acad. Linc.*, III, vi, 141.

GUNNISONITE—A massive substance of a deep purple color, intimately mixed with calcite. H. about 4. G.=2·85. An analysis, after the deduction of 12·75 p. c. of admixed calcite, yielded CaF_2 74·89, CaO 11·44, SiO_2 6·87, Al_2O_3 5·95, Na_2O 0·85=100. From the neighborhood (20 miles south) of Gunnison, Colorado. The describers, Clarke and Perry, suggest that it may be an alteration product of fluorite, or a mixture of that species with a silicate, though the mineral seemed to be homogeneous. The name is only given provisionally, but it is to be regretted that it was not withheld until the very serious doubt as to the homogeneity of the substance under examination was decided.—*Amer. Chem. Journ.*, iv, 140.

URANOTHALLITE.—Schrauf has given this name to a uranium carbonate from Joachimsthal, partially described by Vogl, and analyzed by Lindacker (see Dana, Syst. Min., 5th ed., p. 717). Schrauf makes the crystals, which form confused aggregates, orthorhombic with an axial ratio near that of aragonite. An analysis on 0·15 gr. gave him results agreeing with those of Lindacker, viz: CO_2 22·95, UO_2 36·29, CaO 16·42, H_2O 23·72=99·38, for which he calculates the formula $UC_2O_6+2CaCO_3+10$ aq. *Zeitsch f. Kryst*, vi, 410. Schrauf has also studied the minerals occurring in the serpentine region near Budweis in Southern Bohemia. He describes in detail the method of association both of the original minerals and those produced by alteration. In the course of his development of the subject, he introduces a number of new names for intermediate varieties allied to serpentine; the names, however, seem rather unnecessary as the substances named are certainly not distinct species; they are KELYPHITE—a serpentinous substance coating altered crystals of pyrope; ENOPHITE—a chloritic variety of serpentine; hallite of Cooke is related; LERNILITE—in composition near the vermiculite of Lerni (Cooke), hence the name; SILICIOPHITE—the result of continued alteration, yielding from the serpentine (formed the chrysolite) a heterogeneous substance remarkable for its high percentage of silica; HYDROBIOTITE—a hydrated biotite from the granulite adjoining the serpentine (this name was previously used by Lewis in connection with his description of philadelphite); BERLAUITE—a chloritic substance filling cavities between the granite and serpentine near others of the vermiculite group; SCHUCHARDTITE—the so-called chrysopraserde from Gläserndorf, Silesia. (Syst. Min., 5th ed., p. 510, H_2O =21·03, not 31·03). Schrauf uses the name PARACHLORITE for these substances whose constitution can be expressed by the general formula $m(Al_4Si_3O_{12})+n(R_2SiO_4)+p$ aq; also, PROTOCHLORITE for those corresponding to $m(Al_2SiO_5)+n(R_2SiO_4)+p$ aq.—*Zeitsch. f. Kryst.*, vi, 321.

MOLYBDOMENITE, COBALTOMENITE.—The remarkable copper selenite from Cacheuta, Argentine Republic, called chalcomenite by Descloizeaux and Damour, has been described in this Journal (xxii, 155). To this new group of minerals Bertrand has added two others from the same locality, a lead selenite and a cobalt selenite. The first, *molybdomenite* (*μολυβδος lead*, and *μήνη* moon), occurs in very thin white lamellæ, with a vitreous luster and nearly transparent; crystalline system orthorhombic, cleavage in two directions. Affords lead oxide and selenious oxide; some varieties have a greenish color and contain a little copper. The *cobaltomenite* is associated with the other mineral in the midst of the selenides of lead and cobalt. It occurs in very minute rose-red crystals resembling erythrite, but differing from it optically. Associated with these minerals is another which appeared to be pure selenium dioxide, entirely volatile.

7. *Statistics of the Production of the Precious Metals in the United States;* by CLARENCE KING. Tenth Census of the United States, Francis A. Walker, Superintendent. Department of the Interior. 94 pp. 4to.—This is a very carefully prepared report, covering all the divisions of the subject connected with the production of the precious metals in the different States and Territories. Mr. King in his "letter of transmittal" observes that this statistical statement is presented in advance of his report on the production of the precious metals, because of "its immediate interest to legislators, financiers and metallists."

8. *Supposed organic remains in meteorites.*—The fanciful conclusions of Dr. Hahn (vol. xxiii, p. 156), that meteorites of the chondrite class contain many distinct fossil remains, have found a supporter in Dr. D. F. Weinland, of Esslingen. In a brief pamphlet published recently, he describes and names some sixteen different genera and a large number of species; most of these he refers to the polycystines, sponges and foraminifera, with a few corals and crinoids. It is to be regretted that the extended study of the microscopic structure of meteorites, here recorded, should not have been directed by sounder judgment.

9. *Notes on the Mineralogy of Missouri*, by ALEXANDER V. LEONHARD.—Mr. Leonhard has given a brief descriptive catalogue of the mineral species of Missouri and a list of the important mineral localities. It would be well if the same work could be done with equal care for every State in the Union.—*Trans. St. Louis Acad. Sci.*, vol. iv, No. 3.

III. Botany and Zoology.

1. *Characeæ Americanæ Exsiccatæ, distributæ* a T. F. Allen, M.D.—Fasc. I was issued some time ago; fasc. II and III we have just now received. Thus far 30 species or varieties are represented by admirable specimens, carefully mounted, with printed tickets, giving needful details. The sets, as we understand, are not put on sale, but are presented by the author to those, among others, who will contribute for the continuation of the work about 100 specimens of any desired species or variety, properly prepared. Parallel with the issue of the *Exsiccatæ* we may expect further papers, like those recently issued, with creditable illustrations, in the Bulletin of the Torrey Club for April and the American Naturalist for May last. And at length we may have the "American Characeæ" illustrated in systematic order and with the completeness of fuller knowledge. A. G.

2. *Versuch einer Entwicklungsgeschichte der Pflanzenwelt insbesondere der Florengebiete seit der Tertiärperiode*, von Dr. Adolf Engler. Part I, 1879, Part II, 1882. Leipsic (Engelmann).—The first part of this History of the development of the Vegetable Kingdom since the Tertiary period, which is concerned with the flora of the northern hemisphere, fills 202 octavo pages; the second, which treats of the southern hemisphere and the tropical regions, fills 386 pages, including a very full index. There are two maps, one for the Tertiary period, one illustrating the present distribution of plants. A very important work, which we can here only announce, but which we may hope before long to give the account of which it well deserves. A. G.

3. *The Genus Isoëtes in North America;* by Dr. George Engelmann.—We must announce this essay, though we have not room for an abstract of it. It is separately issued, in 33 pages, 8vo, from the fourth volume of the Transactions of the St. Louis Academy of Science, to which it was communicated in February last. The author, with customary thoroughness, gives the history of the genus as to this country, from the time of Pursh, who found what he took for *Isoëtes lacustris* in Oswego River, down to the present memoir, in which he fully characterizes fifteen species, the latest (*I. Howellii*) discovered in 1880, and discusses the morphology, biological characters, systematic arrangement, distribution, etc. Several of our botanists are naturally desirous of helping on the science by doing some special original work. Let them take this paper as a model. A. G.

4. *Flore de la Gironde;* par A. Clavaud. Paris, Masson; Bordeaux, Feret. 8vo.—We have received the first part of this new Flora of the Bordeaux district, containing the *Thalamifloræ*, in 222 pages, issued in 1882, and we perceive that it is a work of real character. It is wholly in French, gives full descriptions, also keys both to genera and species, and in both the more diagnostic characters are italicized after the manner of Koch and of

Gray's Manual. What adds to the value of the work is, first, that the descriptions are not only drawn from the plants themselves, but exclusively from the plants of the district; and, secondly, grades of relationship are very carefully exhibited. We have first the *species* in the Linnæan sense, and as we should regard them, although the author in his preface prefers to call them *stirpes*, regarding them rather as the stocks of species. The more strikingly differentiated portions of such a group, the sub-species of other authors, he designates as the *species*, and arranges them under the more generalized *stirps* in full-faced type. The less marked or subordinate forms, or varieties proper, have the names printed in italic type. The author refers to Braun as his sole predecessor in this mode of representation; but he might have mentioned Ball's Spicilegium of the Marocco flora. But both Ball and Braun keep to species, sub-species and variety, as botanists who deal with plants over wide regions may be expected to do.

There is an accompanying atlas of figures, after the manner of Cosson's Flora of the Environs of Paris. Eight plates of this atlas accompany the first installment of the Flora. They illustrate very neatly the sub-genus *Batrachium*, critical forms of *Fumaria*, *Viola*, *Polygala*, *Cerastium*, etc. A. G.

5. *Beitrag zur Kenntniss der Ustilagineen;* by M. WORONIN.—This paper of 35 quarto pages forms the fifth portion of De-Bary and Woronin's Beitræge zur Morphologie und Physiologie der Pilze, and rapidly follows part four, which was recently reviewed in this Journal. The greater part of the article is devoted to the development of *Tuburcinia Trientalis* B. & Br., which is parasitic on *Trientalis europæa.* In the spring and early summer it forms whitish spots on the leaves and young stems, due to the conidia, which are pear-shaped bodies borne on stalks that project through the epidermis. The conidia were formerly described by Berkeley under the name of *Ascomyces Trientalis.* In the autumn the *Tuburcinia* forms black spots in the leaves, in which a microscopic examination shows an abundance of the aggregated spores characteristic of the genus. The author describes in detail the germination of the conidia, and the formation and germination of the aggregated spores. The latter arise from swollen portions of the hyphæ; but the process is soon obscured by a growth of lateral hyphæ which completely hide the spores in the later stages of formation. Each one of the aggregated spores can germinate singly and produce a promycelium, at whose tip is a whorl of sporidia which usually, but not always, connect with one another by a series of conjugating processes, as in *Tilletia.* But *Tuburcinia* differs from the last named genus in that the upper part of the promyceluim, which is separated from the basal part by a cell-wall, drops from its attachment together with the attached sporidia, and therefrom grow the latter secondary or even tertiary sporidia, and ultimately a mycelium is formed. Woronin then describes the development or more particularly the germination of several species referred by different writers to

Sorosporium, *Thecaphora*, *Entyloma* and *Melanotænium*. *Sorosporium Junci* Schr., he makes the type of a new genus *Tolyposporium*. In this connection is the only direct reference to American species, viz: *Sorosporium Astragali* Peck and *S. Desmodii* Peck are referred to *Thecophora* in consequence of the structure of their spores. The article ends with a synopsis of the genera of *Ustilagineæ*, and is illustrated by four partly colored plates, which, as is always the case in Woronin's articles, are beautifully executed. W. G. F.

6. *Salmon Disease.*—The existence of an epidemic disease in the Salmon of some Scottish and British rivers (a disease existing also in North America and Siberia), led to the appointment of Commissioners in 1879 to examine the facts. Prof. Huxley has a paper on the "Pathology of the epidemic known as the Salmon disease" in the Proceedings of the Royal Society for March 2, 1882, from which the following facts are taken. He observes that "the evidence taken by the Commissioners* leaves no room for doubt that the malady is to be assigned to the large and constantly increasing class of diseases which are caused by parasitic organisms. It is a contagious and infectious disease of the same order as ringworm in the human subject, muscardine among silkworms, or the potato disease among plants; and, like them, is the work of a minute fungus. In fact, the *Saprolegnia*, which is the cause of the salmon disease, is an organism in all respects very closely allied to the *Peronospora*, which is the cause of the potato disease.

It is a very curious circumstance, however, that while the *Peronosporæ* are always parasites—that is to say, depend altogether upon living plants for their support—the *Saprolegniæ* are essentially saprophytes; that is to say, they ordinarily derive their nourishment from dead animal and vegetable matters, and are only occasionally parasites upon living organisms. In this respect they resemble the *Bacteria*, if the results of recent researches, which tend to show that pathogenic bacteria are mere modifications of saprogenic forms, are to be accepted."

The disease covers the skin of the salmon, wherever it is attacked, with a "papyraceous slough-like substance," which is a *mycelium* or felt-like fungus; and the *zoospores* set free are the source of the contageousness of the disease. Prof. Huxley made experiments on the transplantation of the *Saprolegniæ* of the living Salmon to dead animals.

"The body of a recently killed common house-fly was gently rubbed two or three times over the surface of a patch of the diseased skin of a salmon and was then placed in a vessel of water, on the surface of which it floated in consequence of the large

* "Report on the Disease which has recently prevailed among the Salmon in the Tweed, Eden, and other Rivers in England and Scotland." By Messrs. Buckland, Walpole, and Young, 1880.

See also the three valuable communications to the "Proceedings of the Royal Society of Edinburgh," made by the late Mr. A. B. Stirling in 1878–79.

quantity of air which a fly's body contains. In the course of forty-eight hours, or thereabouts, innumerable white cottony filaments made their appearance, set close side by side, and radiated from the body of the fly in all directions. As these filaments had approximately the same length, the fly's body thus became inclosed in a thick white spheroidal shroud, having a diameter of as much as half an inch. As the filaments are specifically heavier than water, they gradually overcome the buoyancy of the air contained in the tracheæ of the fly, and the whole mass sinks to the bottom of the vessel. The filaments are very short when they are first discernible, and usually make their appearance where the integument of the fly is softest, as between the head and thorax, upon the proboscis, and between the rings of the abdomen. These filaments, in their size, their structure, and the manner in which they give rise to zoosporangia and zoospores, are precisely similar to the hyphæ of the salmon fungus; and the characters of the one, as of the other, prove that the fungus is a *Saprolegnia* and not an *Achlya.* Moreover, it is easy to obtain evidence that the body of the fly has become infected by spores swept off by its surface when it was rubbed over the diseased salmon skin. These spores have in fact germinated, and their hyphæ have perforated the cuticle of the fly, notwithstanding its comparative density, and have then ramified outwards and inwards, growing at the expense of the nourishment supplied by the tissues of the fly."

"Having infected dead flies with the salmon *Saprolegnia*, once from Conway and once from Tweed fish,* I was enabled to propagate it from these flies to other flies, and, in this manner, to set up a sort of garden of *Saprolegniæ.*"

"Whether the zoospores are actively locomotive or not, they are quite free when they emerge from the zoosporangia; and, from their extreme minuteness, they must be readily carried away and diffused through the surrounding water. Hence, a salmon entering a stream inhabited by the *Saprolegnia* will be exposed to the chance of coming into contact with *Saprolegnia* spores; and the probability of infection, other things being alike, will be in proportion to the quantity of the growing *Saprolegnia*, and the vigor with which the process of spore-formation is carried on. At a very moderate estimate, a single fly may bear 1,000 fruiting hyphæ; and if each sporangium contains twenty zoospores, and runs through the whole course of its development in twelve hours, the result will be the production of 40,000 zoospores in a day, which is more than enough to furnish one zoospore to the cubic inch of twenty cubic feet of water. Even if we halve this rate of production, it is easy to see that the *Saprolegnia* on a single fly might furnish spores enough to render such a small shallow stream as salmon often ascend for spawning purposes, dangerous for several days. But a large fully diseased salmon may

* And since this paper was read once more from the North Esk fish. (March 8, 1882.)

have as much as two square feet of its skin thickly covered with *Saprolegnia.* If we allow only 1,000 fruiting hyphæ for every square inch, we shall have 288,000 for the whole surface, which, at the same rate as before, gives over 10,000,000 spores for a day's production, or enough to provide a spore to every cubic foot of a mass of water 100 feet wide and 5 feet deep and four miles long. Forty such diseased salmon might furnish one spore to the gallon for all the water of the Thames (380,000,000 gallons per diem) which flows over Teddington Weir. But two thousand diseased salmon have been taken out of a single comparatively insignificant river in the course of a season.

It will be understood that the above numerical estimate of the productivity of *Saprolegnia* has been adopted merely for the sake of illustration; that I do not intend to suggest that the zoospores are evenly distributed through the water into which they are discharged by the zoosporangia; and that allowance must be made for the very short life of those zoospores which do not speedily reach an appropriate nidus. Nevertheless, the conclusion remains arithmetically certain that every diseased salmon adds immensely to the chances of infection of those which are not diseased."

The author shows that the hyphæ penetrate the true skin, but obtained no evidence that they "break up into toruloid segments (as in the case of *Empusa muscæ*), and thus give rise to general septic poisoning or fungoid metastasis." The epidermis is destroyed, and its place is taken by a thick, felted mycelium, which entangles the minute particles of sand that are suspended in the water, and this no doubt constitutes a very irritating application to the sensitive surface of the true skin." Death results without any other organ being affected, and is "the consequence partly of the exhaustion of nervous energy by the incessant irritation of the felted mycelium with its charge of fine sand, and partly of the drain of nutriment directly and indirectly caused by the fungus."

The *Saprolegnia* has not been observed on decaying bodies in salt water; and there is only one case on record of any fungus occurring on a fish in salt water.

IV. Miscellaneous Scientific Intelligence.

1. *Bibliographie générale de l'Astronomie* ou Catalogue méthodique des ouvrages, des mémoires et des observations astronomiques publiés depuis l'origine de l'imprimerie jusqu'en 1880, par J. C. Houzeau et A. Lancaster. Tome second: Mémoires et notices insérés dans les collections académiques et les revues; quatrième fascicule, columns 1548–2225. Brussels, April, 1882.—The part, now issued, forms the conclusion of the second volume of this most valuable work. It contains the following heads: history and study of astronomy; biographies of astronomers; spherical astronomy; theoretical astronomy; celestial mechanics; physical astronomy; monographs on the solar system. The vol-

ume concludes with an alphabetical index of the authors whose works are mentioned in this volume. It is the complete methodical catalogue of astronomical memoirs and is indispensable to astronomers. The first and third volumes of the *Bibliographie* will contain books and astronomical observations.

2. *Life in Hawaii, by the Rev. Titus Coan.* 340 pp. 12mo. New York: A. D. F. Randolph & Co.)—This autobiographic sketch of mission life and work, besides its deep interest on account of the great successes of the author's labors among the Hawaiian people, has a value also to science from his various explorations of the Hawaiian volcanos. Mr. Coan has been since 1840, as the readers of this Journal are aware, the chief source of information with respect to the eruptions. He has made at least "a hundred" visits to Kilauea, studying its phases, and has traced the courses of its eruptions and also of those of the summit crater, one of the latter from a height of 12,000 feet. His vivid descriptions, the last little over a year old, have given the world a large part of what has hitherto been known about the movements of the two craters. This volume will therefore always have a place among works of original observation on volcanic phenomena.

3. *Studies in Science and Religion;* by G. FREDERICK WRIGHT, author of the "Logic of Christian Evidences." 390 pp. 12mo. Andover, 1882 (W. F. Draper).—The author of these "Studies" understands well both sides of his subject—the arguments which come from recent developments in science, including their bearings on theories of evolution, and those which proceed from the subordination of the natural to the theistic. All classes of readers may derive profit from his able discussions with respect to evidence from nature and Darwinism on the one side and religion or Christianity on the other. One of the later chapters is an essay on prehistoric man, in which known facts are briefly reviewed, and the special facts from America; and those of the Trenton Gravel are given with more detail, the latter largely from Mr. Wright's personal investigations.

4. *Knight's New Mechanical Dictionary*, in four sections, large 8vo. Boston (Houghton, Mifflin & Co.) A description of tools, instruments, machines, processes, and engineering with indexical references to technical journals, by EDWARD H. KNIGHT, A.M., LL.D.—Knight's Mechanical Dictionary is a work well known and whose value is thoroughly appreciated. It gives in three volumes, aggregating 2,831 pages, a very complete digest of mechanical appliances in science and the arts. It was completed in 1876, and the publishers now announce that the remarkable progress which has been made during this time in the department of the mechanical arts and the application of science to industrial uses, has induced them to undertake the issue of a supplementary volume. This will continue the record from the date of the former work, and give in alphabetical order a discussion of each topic included under the general head, with a large number of illustrations. The volume will also contain a complete index to technical literature,

giving under each subject a list of all the articles which have appeared from 1876 to 1880 inclusive, in the pages of English and American technical journals. The work is to be published in four sections of 240 pp. each, to be ready every second month, commencing with June.

5. *Report of the Board of Regents of the Smithsonian Institution for* 1880.—The Report of the Secretary, Professor Baird, on the organization of the Institution and its work and progress, in its various departments, during the year 1880, is followed by a General Record of Scientific Progress for the year: in Astronomy by Professor E. S. Holden; in Geology and Mineralogy by G. W. Hawes; in Physics and Chemistry by Professor G. F. Barker; in Botany by W. G. Farlow; in Zoology by T. Gill; and in Anthropology by O. T. Mason. It also contains a paper on the Luray Cavern from an examination made under the auspices of the Institution in July, 1880; a discussion of Professor Snell's barometric observations by T. H. Loud; an investigation of illuminating materials by the late Secretary, Professor Henry (reprinted from the Report of the Light House Board for 1875); Synopsis of the scientific writings of William Herschel, by E. S. Holden and C. S. Hastings; and Reports of Astronomical observatories.

6. The *British Association* meets, August 23d, at Southampton, C. W. Siemens, Esq., President; the *French Association*, August 24th, at La Rochelle, M. Janssen, President; and the *Helvetian Association*, September 11th, at Linthal, in the Canton of Glaris, Dr. F. Kœnig, President.

OBITUARY.

William Barton Rogers, President of the National Academy of Sciences, and long one of the ablest of American men of science, died suddenly at Boston, May 30, while in the act of delivering an address before the Massachusetts Institute of Technology, of which he was the founder and the first president. The occasion was the graduation exercises of the Institute. Professor Rogers was announced for a short address, at the close of the exercises. His appearance was the signal for prolonged and enthusiastic applause which deeply moved him. He commenced speaking with deep emotion, when suddenly he fell lifeless to the floor without a struggle.

Professor Rogers was born in Philadelphia, in 1805, and was the second son of Dr. P. K. Rogers. His father was Professor of Physics and Chemistry at the college of William and Mary, in Virginia, from 1819 to 1829, when he was succeeded by his son William, who held the position until his removal to the University of Virginia, in 1835. He discharged there with distinguished ability the duties of the Chair of Physics, and also of instruction in mineralogy and geology until 1853, when he removed to Boston. The writer has a vivid memory of a lecture on the resultant of force which he heard Professor Rogers deliver at the University of Virginia in the autumn of 1835, when the lecturer was in the prime of his manhood, at thirty years, and had already developed those charming qualities of method and discourse which always made it a pleasure to follow him, even on subjects of no more than ordinary interest.

In 1835 Professor Rogers organized a geological survey for the State of Virginia, but after several years of a struggling existence and the publication of some annual reports of progress, in 1842, the effort was abandoned for want of any adequate support from the State. The materials accumulated for a final report have never been published, but Professor Rogers united with his brother, Henry Darwin Rogers, geologist of Pennsylvania, in the authorship of a memorable memoir on the structure of the Appalachians in Pennsylvania and Virginia. This paper was jointly presented by the two brothers, at Boston, in the autumn of 1842, before the session of the American Association of Geologists and Naturalists. It excited the greatest interest among geologists and physicists on account of the novelty of its views, supported as they were by ample data and numerous sections, and the eloquence with which the whole subject was set forth. This was the first important contribution to dynamical and structural geology which, up to that time, had been brought forward in this country. With it appeared, also for the first time, the notation and nomenclature of the Appalachian system of rocks, now so familiar, through the Reports of the Geological Survey of Pennsylvania. An important paper on the "Connection of Thermal Springs in Virginia with Anticlinal Axes and Faults," by Professor William B. Rogers, was presented at the same meeting, and both papers were published in the Transactions of the Association for that year.

But probably the most important life work of Professor Rogers was that connected with the Massachusetts Institute of Technology at Boston, an institution which owes its existence, mainly, to his zeal and untiring industry, through which, in 1860, 1861, he secured for it the support of the State and of individual founders. The work was crowned with success, and in 1862 Professor Rogers was made president of the institution, an office which he held until 1868, when his health failed him owing to overwork.

In 1878, upon the death of Professor Joseph Henry, Professor Rogers was elected to the presidency of the National Academy of Sciences, the duties of which he has discharged with eminent ability. He presided at the stated session of the Academy, in April, of this year, at Washington, with his accustomed urbanity and tact, sustaining the work, which is not small, with cheerfulness, but not without some signs of exhaustion. On this last occasion he occupied the entire morning of one of the public sessions in pronouncing eulogies upon several of the deceased members of the Academy whose deaths had not been previously memorialized.

In November of last year at the meeting of the Academy at Philadelphia, President Rogers delivered a discourse in which he reviewed with critical care some of the more important contributions to Physics which had appeared in the previous year. It was in work of this description and in his extemporaneous discourses upon scientific topics that the breadth of his views, the accuracy of his knowledge, the charm of his diction, were most conspicuous.

His public lectures before the large audiences gathered at the Lowell Institute in Boston, on various departments of physics, are remembered with pleasure by all who heard them in 1862, and subsequently. No one excelled him in the neatness and originality of his experimental demonstrations on these occasions. A writer for a Boston paper said well, on the day of his funeral: "The hundreds of men, young and old, on whom his influence bore, think of him gratefully and affectionately. All testimony is alike as to the power of his personality. He was the creator of the Institute of Technology, the inspirer of its teachers and pupils. His direct influence through contact has been very great. But fortunately the value of men to their fellows is not limited by personal acquaintance. This limitation, however, is the fate of almost every instructor. The work of teaching swallows up energy so completely that most who follow it are limited to personal influence. As one of these hard-working men, President Rogers had no time to become the public apostle of his immortal idea. But whenever he did appear as the representative of his beloved school, his voice used to ring with the utterance of it like the voice of a prophet, and his face to glow with a light which no one who saw it could ever forget. He stood for loyalty to absolute truth. He gave himself to this thought with an intensity and consecration which made it like a religion. To hear him speak of his great idea was to realize something of the divine right of science."

Professor Rogers published many original papers in various lines of research, in physics, in analytical chemistry, and in geology. A list of his chemical papers, both alone and in company with his brother, Robert E. Rogers, will be found in the writer's address at Northumberland, in 1874.* A full list of his contributions to the various departments of science remains to be compiled.

President Rogers was married, after his removal to Boston, to the only daughter of the late Judge James Savage, of that city, who survives him. B. S.

Dr. AUGUSTUS A. HAYES, for many years State Assayer of Massachusetts, the author of papers in Chemistry and Mineralogy, has died at the age of 76 years.

Dr. GEORGE W. HAWES, Curator of the Mineralogical Department of the National Museum at Washington, died on June 22 at Manitou Springs, Colorado. A notice of Dr. Hawes and his work in Science will be given in another number of this Journal.

* American Contributions to Chemistry, pp. 83–84.

POSITION OF RAIN AREAS

PLATE I.

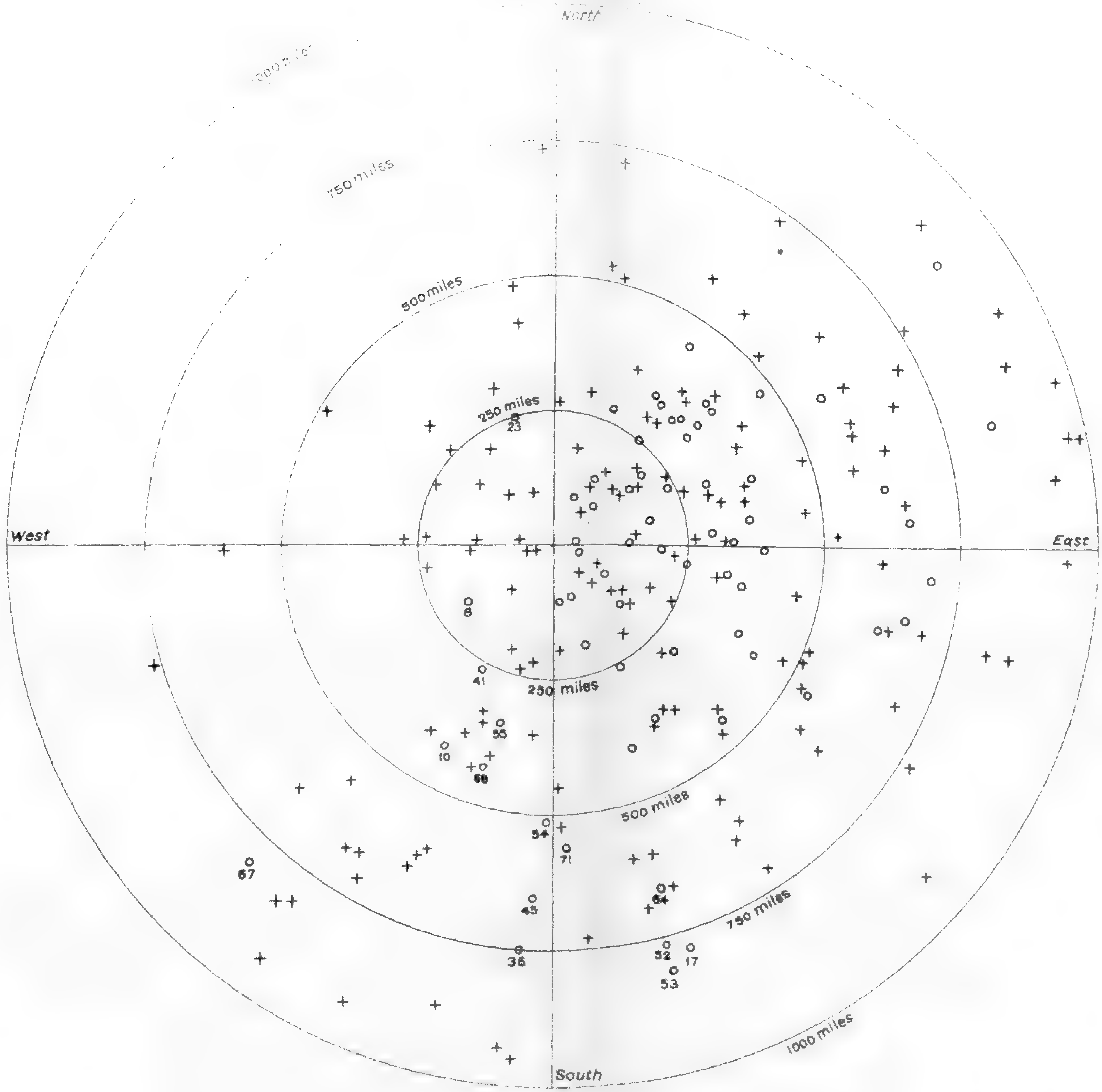
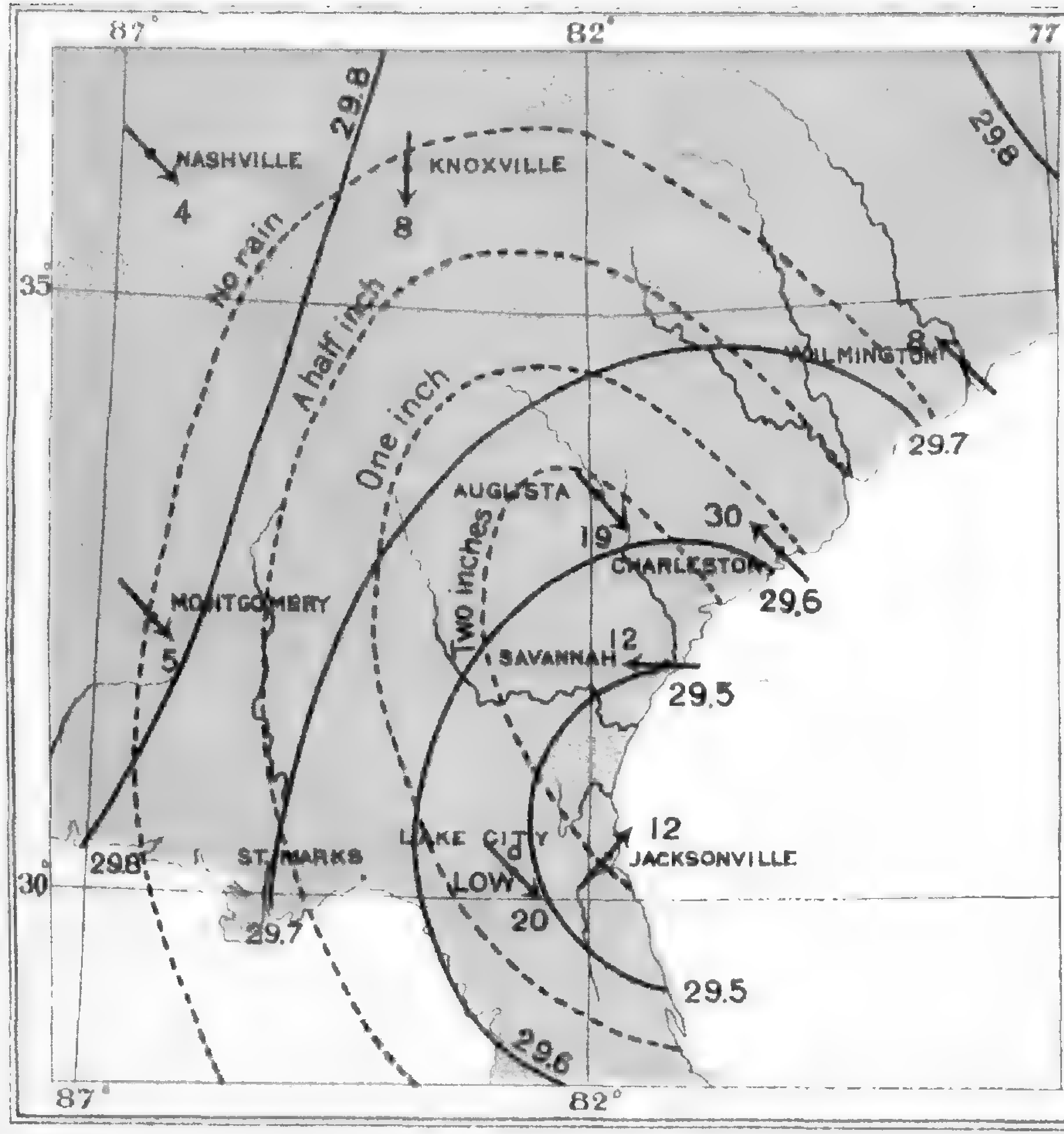


PLATE II.

RAIN AREA 1874 SEPT 28th 7 35 AM.



RAIN AREA 1877 APRIL 13th 7 35 A M.

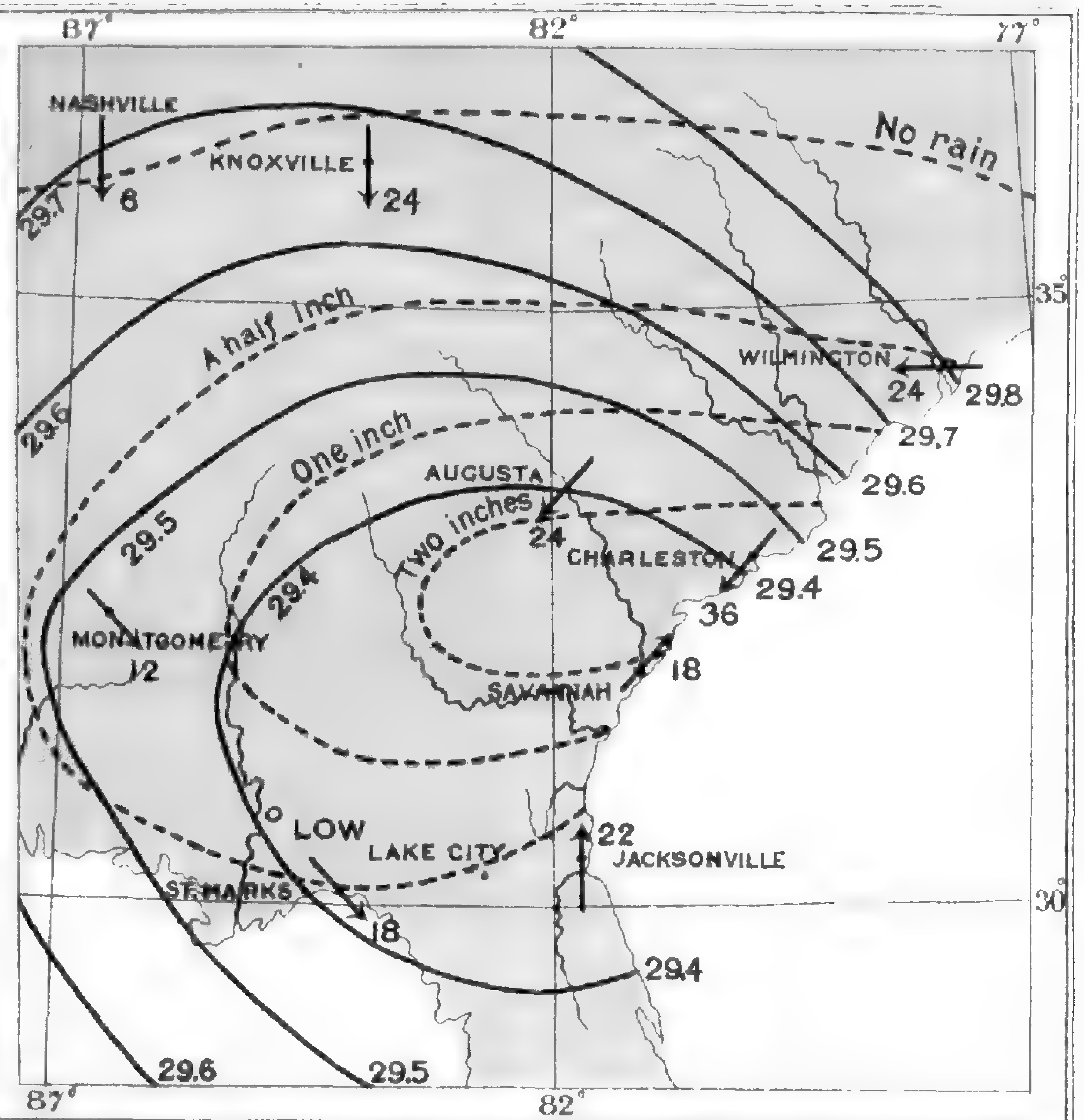
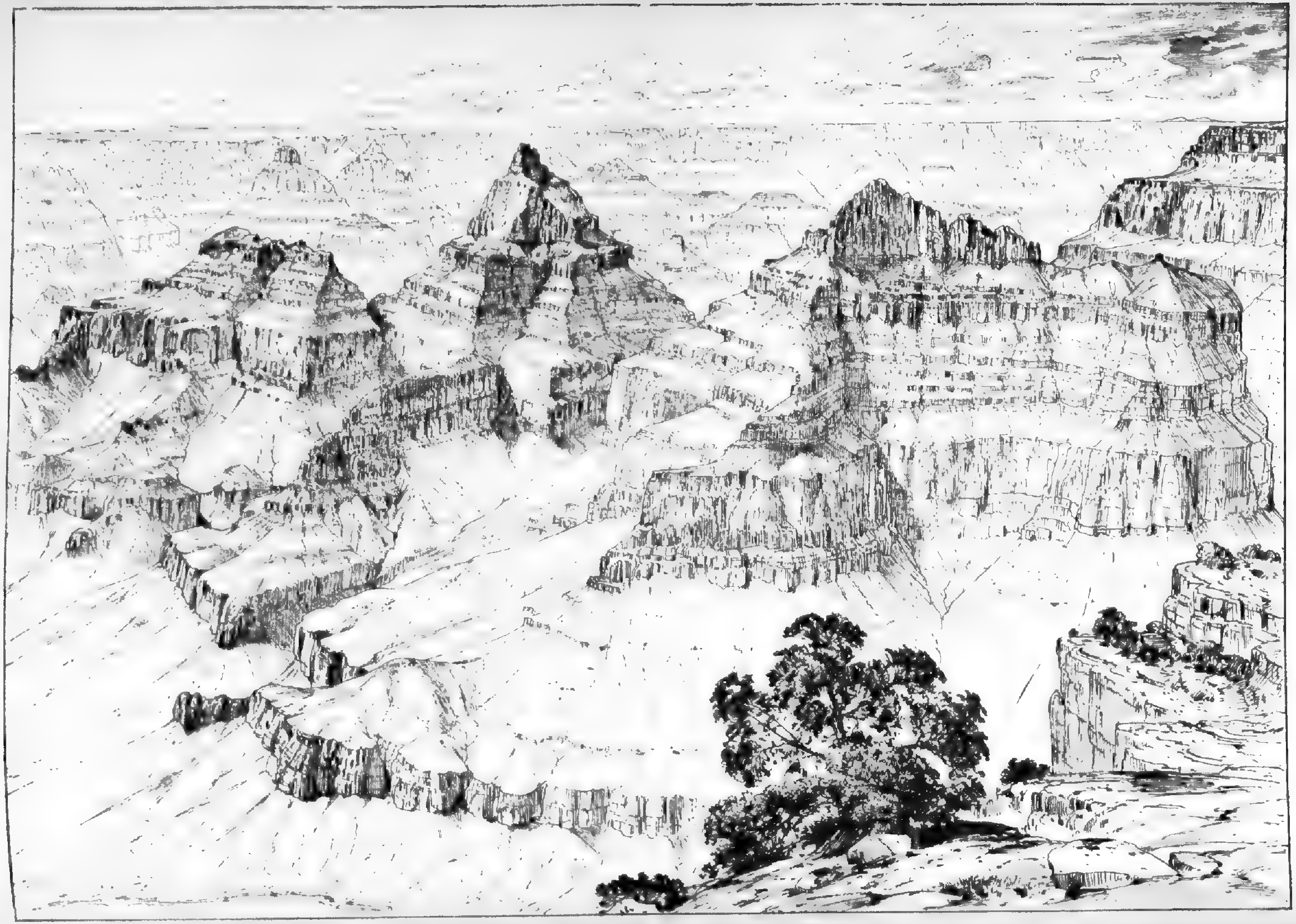


PLATE II.

LTH. L.S. PUNDERSON, NEW HAVEN, CONN.



Vishnu's Temple, Colorado Cañon.

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. IX.—*Tertiary History of the Grand Cañon District;* by CLARENCE E. DUTTON, Captain of Ordnance, U. S. A., 4to, with folio atlas. U. S. Geological Survey, CLARENCE KING, Director. Washington, 1882.—With plate IV.*

THE features of the Grand Cañon of the Colorado and its varied illustrations of river erosion first began to be appreciated after the descriptions and views given in the Report of the Expedition under Lieutenant J. C. Ives in 1857–58, with which Professor J. S. NEWBERRY was associated as Geologist. Major POWELL'S Reports and the photographs made by the Expedition under his direction added greatly to our knowledge and appreciation of the facts, making accepted truth of what had seemed to many to be almost beyond belief.

Captain DUTTON'S Report, just now published, still further illustrates the features of the region, portraying the magnificence of its various parts by remarkably effective views and word-pictures, besides describing its geological structure and history. In the course of the latter the author takes the reader on several excursions through the Grand Cañon among the castellated and cathedral-like peaks and ridges two to five thousands of feet in height which stand over its bottom and project from its deeply alcoved borders; and gives explanations along the way with regard to the peculiar features of the different rocks, the water-sculpturing process, the long and profound faults of the region, the many volcanic cones and outflows, and the era and extent of the great erosion.

These several topics are further discussed in separate chapters, treating of the physical history and evolution of the

* This notice has been prepared from advance sheets placed in the hands of the writer by the author.

various cañons of the district, their excavation, and the origin of special details.

In a previous Report on the High Plateau District of Utah, published in 1880, Captain Dutton had described with like fulness the country immediately north,* and the two Reports relate really to different parts of the same great plateau area. Between the parallels of 40° and 40° 30′, the Great Salt Lake comes to its southern end. Just east, in the same latitude, the Wasatch Mountains, rising in points to 13,000 feet, begin their north-and-south course. Farther eastward are spread out the tamer Uinta Mountains, a great plateau, 150 miles from east to west, and averaging 10,000 to 11,000 feet in height, yet reaching at one place a height of 13,694 feet. To the south, below the parallel of 40°, the Wasatch range falls off into the "High Plateaus" of Southern Utah, the Wasatch, Pavant, Awapa, Aquarius, Paunságunt and Markágunt plateaus, ranging from 10,000 to 11,600 feet in height, which are the subject of the former Report. These plateaus have together a length from north to south of 175 miles, with a breadth of 25 to 80 miles. Eocene beds, of lacustrine origin, are widely distributed over the summits with also extensive streams of trachytic and basaltic lavas of still later origin; and Cretaceous, Jurassic, Triassic, Permian and Carboniferous rocks come to view successively on descending into the intersecting gorges or valleys.

Passing south and southeast of the southernmost of these High Plateaus, the Markágunt and the Paunságunt, a series of great steps commences leading down, over successive cliffs and broad plateaus, from the Eocene table-land of the summit to, finally, the depths of the Grand Cañon—and with the account of this majestic "stairway" the new Report begins.

These successive steps to the cañon, along with the plateaus below them, cover a region on the north side of the river averaging 75 miles in breadth. The plateaus which this border area of the Grand Cañon include, beginning to the eastward, are the Kaiparowits, Paria, Kaibab, Kanab, Uinkaret, and Sheavwits plateaus.

The first step down from the Eocene of the summit is over Cretaceous rocks, for 4000 to 5000 feet—a vast series of sandstones and shales, of pale yellow and light brown to gray shades, rather brilliant in effect. The Kaiparowits plateau, the easternmost, is wholly Cretaceous at top, almost to the margin of the Colorado; and similar Cretaceous mesas cover nearly all northeastern Arizona and reach indefinitely eastward. The second step downward is over the Jura-Trias—first a descent of 300–500 feet over red shales with fossiliferous calcareous layers containing Jurassic fossils; then a great stratum of

* See for a notice, vol. xx, p. 63, 1880.

white sandstone, conspicuous for its cliffs and its massive architectural projections with few horizontal lines, a marked feature in the landscape along the Virgen. Below the "White Cliffs" come the "Vermilion Cliffs" of the Trias, mostly 1200 to over 2000 feet in height, generally thin-bedded, often presenting southward "a majestic front richly sculptured and blazing with gorgeous colors." The Paria plateau consists of the Trias at top. Below the Trias, and in some parts making the lower step of the great stairway, lies the Permian, consisting of evenly bedded sandy shales with thin layers of limestone, of deep and rich coloring—often chocolate, purple, red-brown between horizontal patches of violet, lavender and white.

Below all these, lies the Carboniferous. It is the floor of all the plateaus above enumerated except the two eastern, the Paria and Kaiparowits; and covers also a wide region south of the Colorado at the same level.

The thickness of rock passed over in descending from the top of the Eocene of the High Plateaus to the Carboniferous is 5000 to 6000 feet. But the Eocene thickens toward the Uinta Mountains to 4000 and 5000 feet, making the whole thickness of the formations overlying the Carboniferous about 10,000 feet. The Carboniferous has a small dip to the northward. The overlying beds partake of this dip in some degree, especially at their free southern borders. The beds thin somewhat to the eastward and most markedly so the Triassic in contrast with the Tertiary which thicken in that direction.

The Grand Cañon, 5000 to 6000 feet in depth, is cut out of the Carboniferous and lower formations, the Carboniferous making 4000 to 4500 feet of the whole, and the Archæan, with in some parts Silurian and Devonian strata, constituting the rest. The higher beds of the Carboniferous for 700 to 750 feet are of limestone; next below are red and gray sandstones and shales for 1000 to 1500 feet; and again below, for 1800 feet, mostly limestones, with other sandstones underneath.

The channel of the cañon has (1) an upper portion or story which is 4 to 5 miles wide, and about 2000 feet deep, and (2) an inner chasm cut through the floor of the upper to a depth of 3000 feet or more. The lofty walls of the upper portion, set back 2 to 3 miles from the profounder chasm and stretching along interminably (more than 100 miles), up and down the stream from east to west, are wonderful in architectural features, and add immensely to the grandeur of the landscapes. The so-called inner chasm is not a narrow cleft with perpendicular walls, and a slender strip of water half hid away in the dark depths. It has nowhere a width less than its depth and is generally of much greater width; and over part of the broad area are crowds of mountain towers and temples, 3000 to 5500 feet in height, with combinations of amphitheatres, alcoves, buttresses and towers along the sides; and all is open to the sunlight.

The scenic effects of the out-cropping formations depend greatly on the horizontal bedding; but also largely on the unequal spacing of the beds, the variations in hardness tending to make cliffs to alternate with taluses, at longer or shorter intervals; and on the diversities in shade and brilliancy of coloring. The architectural forms, though on a mountain scale, are literally architectural, and different in type for the different formations. We quote a few paragraphs from the descriptive part of the Report.

"Each of the greater sedimentary groups of the terraces, from the Eocene to the Permian inclusive, has its own style of sculpture and architecture; and it is at first surprising and always pleasing to observe how strongly the several styles contrast with each other. The elephantine structure of the Nile, the Grecian temples, the pagodas of China, the cathedrals of western Europe, do not offer stronger contrasts than those we successively encounter as we descend the great stairway which leads down from the High Plateaus. As we pass from one terrace to another the scene is wholly changed: not only in the bolder and grander masses which dominate the landscape, but in every detail and accessory; in the tone of the color-masses, in the vegetation, and in the spirit and subjective influence of the scenery. Of these and many strong antitheses, there is none stronger than that between the repose of the Jura and the animation of the Trias.

"The profile of the Vermilion Cliffs is very complex, though conforming to a definite type and made up of simple elements. It consists of a series of vertical ledges rising tier above tier, story above story, with intervening slopes covered with talus, through which the beds project their fretted edges. The stratification is always revealed with perfect distinctness and is even emphasized by the peculiar weathering. Northwestward of the southern promontory at Pipe Spring, the cliffs steadily increase in grandeur and animation, and also assume new features. Near the summit of the series is a very heavy stratum of sandstone, which is every where distinguishable from the others. This member is seen at Kanab with a thickness of about 200 feet. It increases westward, becoming 400 feet at Pipe Spring. Beyond that it still increases, reaching a thickness of more than 1200 feet in the valley of the Virgen. It has many strong features, and yet they elude description. One point, however, may be seized upon, and that is a series of joints nearly vertical with which the mass is every where riven. The fissures thus produced have been slowly enlarged by weathering, and down the face of every escarpment run the dark shadows of these rifts. They reach often from top to bottom of the mass and penetrate deeply its recesses. Wherever this great member forms the entablature—and west of Pepis Spring it usually does so—its crest is uneven and presents towers and buttresses produced by the widening of these cracks. Near Short Creek it breaks into lofty truncated towers of great beauty and grandeur, with strongly emphasized vertical lines and decorations, suggestive of cathedral architecture on a colossal scale. Still loftier and more ornate become the structures as we approach the Virgen. At length they reach the sublime. The altitudes increase until they approach 2000 feet above the plain. The wall is recessed with large amphitheatres, buttressed with huge spurs and decorated with towers and pinnacles. Here, too, for the first time, along their westward trend, the Vermilion Cliffs send off buttes. And giant buttes they verily are, rearing their unassailable summits into the domain of the clouds, rich with the aspiring forms of Gothic type, and flinging back in red and purple the intense sunlight poured over them.

"As we moved northward from Short Creek, we had frequent opportunities to admire these cliffs and buttes." * * * "In an hour's time we reached the crest of the isthmus, and in an instant there flashed before us a scene never to be forgotten—that of the temples and towers of the Virgen. At our feet the surface drops down by cliff and talus 1200 feet upon a broad and rugged plain cut by narrow cañons. The slopes, the winding ledges, the bosses of projecting rock, the naked, scanty soil display colors which are truly amazing. Chocolate, maroon, purple, lavender, magenta, with broad bands of toned white, are laid in horizontal belts, strongly contrasting with each other, and the ever-varying slope of the surface cuts across them capriciously, so that the sharply defined belts wind about like the contours of a map. From right to left across the farther foreground of the picture stretches the inner cañon of the Virgen, 900 feet in depth and here of considerable width. Its bottom is for the most part unseen, but in one place it is disclosed by a turn in its course, showing the vivid green of vegetation. Across the cañon, and rather more than a mile and a half beyond it, stands the central and commanding object of the picture, the western temple, rising 4000 feet above the river. Its glorious summit was the object we had seen an hour before, and now the matchless beauty and majesty of its vast mass is all before us; yet it is only the central object of a mighty throng of structures wrought up to the same exalted style, and filling up the entire panorama. Directly in front of us a complex mass of white towers, springing from a central pile, mounts upward to the clouds. Out of their midst, and high over all, rises the dome-like mass of the temple which dominates the entire landscape. It is almost pure white, with brilliant streaks of carmine descending its vertical walls. The towers which surround it are of inferior mass and altitude, but each of them is a study of fine form and architectural effect. They are white above, and change to a strong, rich red below. Dome and towers are planted upon a substructure no less admirable. Its plan is indefinite, but its profiles are perfectly systematic. A curtain wall, 1400 feet high, descends vertically from the eaves of the temples, and is succeeded by a steep slope of ever-widening base-courses leading down to the esplanade below. The curtain wall is decorated with a lavish display of vertical mouldings, and the ridges, eaves, and mitred angles are fretted with serrated cusps. This ornamentation is suggestive rather than precise, but it is none the less effective. It is neither repetitive, nor symmetrical. But though exact symmetry is wanting, nature has here brought home to us the truth that symmetry is only one of an infinite range of devices by which beauty can be materialized."

The illustrations of the report, both in the text and atlas, are admirable, and more than sustain the author's descriptions. Those from the drawings of Mr. Holmes are like photographs in accuracy of detail and aerial effect. Plate IV is a reduced copy of a plate in the text, representing "Vishnu's Temple," one of the architectural masses in the Cañon south of the Kaibab plateau, *having a height from its base of* 5500 *feet.* For others, and a continuation of the descriptions of this region of nature's architectural marvels, the reader is referred to the report itself.

The following are some points in the geological history of the region which the report brings out:

While Silurian and Devonian rocks (the latter paleontologically identified in the Kanab Cañon by Mr. Walcott) occasionally occur, the Carboniferous, for the most part, rests directly on the Archæan. Between the Carboniferous and the underlying Paleozoic beds there is always unconformability, both through the greater or less dip of the latter and the erosion of the surface; and the same is true through the Sierra country of central and western Arizona, and of Nevada and western Utah. But from the bottom of the Carboniferous to the top of the Cretaceous the beds are one continuous conformable series. The beds of this long range appear to have been deposited horizontally; the thick lower limestone of the Carboniferous was probably made in moderately deep water, and the rest of the formations—mostly sandstones and shales—near mean-tide level, as proved by ripple-marks and other evidences. From this fact is drawn the important conclusion that a gradual subsidence was taking place as the depositions went forward; and since the Cretaceous contains lignitic or coal-bearing beds throughout, and at short intervals alternating in the upper part with brackish-water instead of marine beds, it is inferred that there were alternations of emergence and submergence going on during its progress also, ending finally in widely-extended estuary and terrestrial conditions. The Cretaceous seas probably stretched across from the Gulf of Mexico to the Pacific, with interruptions only of narrow emerged areas—that of the Great Basin being one of these, and another in Arizona. Between these two areas, or along the parallels of 34° and 37°, "we can now travel from the Mississippi to the Pacific without being at any time more than fifty miles distant from some known mass of Cretaceous beds;" and "every indication we now have raises a presumption in favor of a complete connection." The distance is nearly 2,000 miles.

"At the close of the Cretaceous, important vertical movements were inaugurated, and around the borders of the Plateau province some important flexures were generated." This epoch, the close of the "Lignitic" or "Laramie" formation, was that, it is supposed, of the making of the Wasatch Mountains. A great area, from the Aquarius plateau to the Colorado, must have been denuded at this time of the Cretaceous, so that the Tertiary over it was laid down on the Jurassic beds; and similar facts occur at other points indicating that "the Cretaceous closed amid important disturbances. Still the deposition of strata was not ended." The depositions of Eocene beds went forward in *fresh* waters until 1200 to 5,000 feet of strata were added to the series, the facts showing that a single lake extended from the Uinta Mountains southward over the Plateau region; that the elevation was sufficient, and sufficiently persistent to make great lake-basins; and evincing, also, since the beds are successively of shallow water origin, that, as before, a subsidence was going on over the Eocene lake region to as great a depth as the thickness of the beds. The earlier subsidence had been greatest in the line of the Wasatch Mountains; the later was most so farther to the north-eastward, in the region of the Uinta Mountains, where Eocene beds have a thickness of 5,000 feet and the great Eocene lake made its final disappearance, only the lower Eocene occurring over the Plateau District.

The Miocene depositions followed, but it is difficult to find "in this district any epoch separating the later Eocene from the Miocene; and of the Pliocene nothing is known from any beds or fossils. Both eras were no doubt eras of gradual emergence; at the close of the Miocene an uplift took place of probably 2,000 to 3,000 feet, and at or near the close of the Pliocene a greater upheaval of 3,000 to 4,000 feet."

The making of the great north-and-south faults of the plateau region—first described by Powell—some of which extend northward over the region of the "High Plateaus" far toward the Wasatch Mountains, began, according to the author, at the close of the Miocene, and went on for some of them during the

Pliocene. Among them the largest is the Hurricane fault, following the west side of the Uinkaret plateau, along which the displacement in the south wall of the Grand Cañon is 1500 feet; and farther north, near the Virgen River, 6,600, it making the Hurricane bluff 1200 to 1600 feet—ten miles farther north probably over 12,000 feet, the Eocene being on one side and the Carboniferous on the other—that is, if, as is probable, the Permian and Mesozoic beds, which there are now absent, were once in the series as they are elsewhere; and, farther north, it extends into Utah, along the west side of the Markágunt plateau and the southwest flank of the Tushar range, where it finally ends its course of 200 miles beneath great lava floods. Another is the Kaibab fault which outlines the Kaibab plateau on the west, and extends to the northward about as far as the Hurricane fault. The Kaibab fault is referred to the Pliocene and the Hurricane to later Pliocene.

The numerous volcanic cones and wide spread streams of lavas add greatly to the geological interest of the region. They cover much of the Uinkaret plateau, and descend from it for 1500 to 2000 feet into the upper portions of the Grand Cañon, and thus prove that the eruptions took place after the great faulting and after a large part of the erosion. But beyond this, some of the streams make a further plunge to the depths of the cañon; and in places over the bottom also there are cones and widely spread sheets of lavas. The Miocene, or its close, was the era of the earlier volcanic out-flows; but a large part were of Pliocene date; and some are of quite recent time, their scoriaceous lavas looking as if of recent ejection, perhaps dating but a few centuries back.

In the history of the erosion, Captain Dutton observes that the first channeling along the line of the Grand Cañon occurred in the early Tertiary or at the close of the Cretaceous. The removal of Cretaceous beds that once covered the borders of the Colorado Cañon south of the Aquarius plateau, leaving a surface of Jurassic beds, was part of the earlier erosion. The emergence was small in the Eocene, the climate moist, and, during its latter part "the degrading forces no doubt made progress in removing the Mesozoic deposits that originally covered the region;" and this work went on through the Miocene, completing nearly the denudation of the Tertiary, Cretaceous and Jura-Trias; that is, sweeping off large parts of these upper formations down to the Permian. The cutting of the Grand Cañon through the Carboniferous is stated to have gone on after the uplift closing the Miocene; at this time "the outer chasm of the Grand Cañon was cut" through the Permian and the upper part of the Carboniferous, and although it must at first have been narrow, it finally reached a width of some miles.

Then after another rise, "most probably near the close of the Pliocene," "the faults increased their displacement, the volcanic vents reopened," and the Colorado River resumed the operation of sinking its channel; and, as time went forward it made the inner chasm with all its grand features. The erosion made quite rapid progress owing to the high pitch given the surface by the new elevation; it has now almost ceased, the river having nearly reached a level of slight change by erosion or what is here called its base-level,—a base-level nearly for the stream at the present state of elevation of the land and ordinary annual floods. Captain Dutton observed that the Glacier period intervened between the Pliocene and the present time—a rainy rather than an icy era for that district—increasing the depth of the Cañon and making some new channels; but, he adds—limiting the effects more than some others might do, in view of the fact that the head waters of the Colorado drain the wide mountain region of the Rocky mountain summit for a breadth from north to south of more than 300 miles,—"The Glacial period appears to have been of too brief duration to have achieved any very great results in this district."

J. D. D.

ART. X.—*The relative Temperatures of the two Hemispheres of the Earth;* by WILLIAM FERREL.

IT was once thought, and the idea still prevails almost universally, that the southern hemisphere of our globe is colder than the northern. This first arose from the comparison of Dove's thermal charts for the two hemispheres. The observations upon which that of the southern hemisphere was based extended only as far south as the parallel of 40° S. The comparison, therefore, between the two hemispheres could be made for the portions only between the equator and the parallels of 40°, and so far as this comparison extends, the mean temperature of the southern is really greater than that of the northern. It was, however, first suggested by Dove, and rendered still more probable by the researches and theoretical considerations of Hopkins, Sartorius von Waltershausen, Forbes and others, that the conditions may be reversed in the higher latitudes, and the mean temperature there be greater in the southern hemisphere than in the northern.

With a view of settling this question, and that of the equality or inequality of the mean temperatures of the two hemispheres, Dr. Hann of Vienna* has recently undertaken a

* Ueber die Temperature der südlichen Hemisphäre. Sitzb. der k. Akad. der Wissensch., B. lxxxv, 1882.

new discussion of the subject, availing himself of all the more recent observations made in the lower latitudes of the southern hemisphere, especially of those made by the Venus expeditions to the islands of Kerguelen, Auckland and St. Paul. . With the aid of these additional observations he obtained as an expression of the mean temperature of the southern hemisphere, in centigrade degrees,

$$T=26^\circ{\cdot}0+6^\circ{\cdot}94 \sin \varphi-42{\cdot}28 \sin^2 \varphi$$

in which φ is the latitude.

By the integration of the temperature, given by this expression, over the whole surface of the hemisphere, the average is found to be 15°·4. From a comparison of this with the result obtained by the writer* for the northern hemisphere, 15°·3, Dr. Hann concludes that the mean temperatures of the two hemispheres are probably exactly the same.

Using exclusively only ocean stations of observation, he obtained, instead of the expression above, the following:

$$T=26^\circ{\cdot}0+10^\circ{\cdot}03 \sin \varphi-47{\cdot}13 \sin^2 \varphi$$

From this expression the mean temperature of the southern hemisphere was found to be 15°·2, very nearly the same as found from the other

The comparison of the temperatures, given by the first of the preceding formulæ for the several latitudes, with those obtained by Forbes for the northern hemisphere, is as follows:

Latitude,	40°	45°	50°	55°	60°
S. hemisphere,	13·0	9·8	6·5	3·3	0·3
N. hemisphere,	13·6	9·7	5·8	2·3	−1·2
Difference,	−0·6	+0·1	+0·7	+1·0	+1·5

It is seen from these differences that, at about the parallel of 45°, the southern hemisphere begins to be warmer than the northern, and as Dr. Hann now considers the temperatures at the latitudes 40° to 50° to be pretty well determined, he thinks it leaves the result with scarcely a doubt. It seems, therefore, to be now well established that, although the temperatures of the lower latitudes of the southern hemisphere are less than those of the same latitudes of the northern hemisphere, yet it is the reverse in the higher latitudes, and that there is no sensible difference between the mean temperatures of the two hemispheres.

The reason of this becomes clear when we consider that if the surface of the earth were all land, the difference between the temperatures of the equatorial and polar regions would be much greater than if the whole surface were water. In the former case there would be no transfer of heat by means of

† Meteorological Researches, Part I; U. S. Coast Survey Report, 1875.

ocean currents from the equator toward the poles, while in the latter the well-known gradual interchange of water between the equatorial and polar regions, arising from a difference of temperature, conveys a great amount of heat from the former to the latter, diminishing the temperature in the lower latitudes and increasing it in the higher ones. It has been estimated that the heat transferred from the torrid zone to higher latitudes by the Gulf Stream alone amounts to about one-twelfth of all the heat received by the earth from the sun between the equator and the tropic of Cancer, and that transferred by the Kuro-siwo to more than twice as much more. If all the heat received by the torrid zone had to be disposed of by radiation back into space, of course the temperature there would be higher, since by the law of radiation, where greater radiation is required, there must be a higher temperature of the radiating surface. On the other hand, if no heat were received in the polar zone, or higher latitudes, except that received directly from the sun, the temperature at which the radiating surface would have to stand to dispose of the heat received would be less. We see the effect upon temperature of this transfer of heat from equatorial to polar regions in the relative mean temperatures of land and water in the northern hemisphere. In the lower latitudes mean ocean temperatures are lower, and in the higher latitudes greater, than on land. And the differences would be still greater, if much of the heat conveyed by ocean currents to the higher latitudes were not transferred to the land by the general eastward motion of the air in those latitudes.

Since the amount of transfer of heat from equatorial to polar regions must be somewhat in proportion to the amount of ocean surface, the amount of this transferrence must be greater in the southern than in the northern hemisphere. Hence the difference between the mean temperature of the equatorial and polar regions must be less in the southern than in the northern hemisphere. If the mean temperatures of the two hemispheres are equal, as has been shown, it is readily seen that the effect of this must be to make the temperature of the lower latitudes colder, and that of the higher latitudes warmer, in the southern hemisphere than in the northern.

It is well known that the annual amount of heat received from the sun by each hemisphere is precisely the same. A number of hypotheses have therefore been devised to account for the supposed difference of temperature between the two hemispheres. Poisson supposed it was due to the greater heat-absorbing power of land than of water, which, on account of the greater proportion of land in the northern than in the southern hemisphere, would cause the temperature of the former to be a little the greater. But if the principle of the equality of the absorbing and radiating powers of all bodies is true, which is generally conceded, thus a greater absorbing power, if it is accompanied by a proportionately greater radiating power, cannot give rise to a higher temperature, and to account for any difference in the temperatures of the two hemispheres, it would be necessary to suppose that the absorbing and radiating powers are different, either in a land-, or in a water-surface, or in both.

The establishment, therefore, of the equality of the mean temperatures of the two hemispheres seems to confirm the principle of the equality of the absorbing and radiating powers of bodies, since this seems to be the case with regard to water, and land with all its variety of surface. If this were not true for any considerable part of the earth's surface, it would affect the equality of the mean temperatures of the two hemispheres.

ART. XI.—*An Air-thermometer whose indications are independent of the Barometric Pressure;* by ALBERT A. MICHELSON.

THE appearance of an abstract of a paper by Pettersson* on a new air-thermometer, has led me to publish, sooner than I had contemplated, a notice of an instrument far simpler and more manageable than that which is there described, and which likewise retains the important advantage of giving indications which are independent of the external pressure.

The instrument consists of a glass bulb and stem, the former about 40^{mm} and the latter about 2^{mm} in interior diameter. The bulb contains dry air at a pressure of about 100^{mm} of mercury, and this air is separated from the upper portion of the tube by a column of mercury about 100^{mm} in length. The mercury remains above the air, notwithstanding the large diameter of the bore, owing to the resistance to deformation of the meniscus. The space above the mercury is a vacuum.

Thus the pressure of the air in the bulb is constant and is equal to that of the column of mercury above it. If the bore of the stem is not of uniform section the length of the column will change—but this length is easily read off and gives at once the true pressure.

The pressure need not be limited to 100^{mm}, but if it be much greater the instrument becomes inconveniently long.

The only precaution to be observed, beyond what is used in an ordinary mercury thermometer, is that the stem must be kept vertical.

Case School of Applied Science,
Cleveland, O., July 5th, 1882.

* Annalen der Physik und Chemie (Beiblätter), No. 5, 1882.

ART. XII.—*The Bearing of some Recent Determinations on the Correlation of the Eastern and Western Terminal Moraines;* by Professor T. C. CHAMBERLIN.

FOR several years a group of geologists of the interior have been engaged in tracing out an extensive range of terminal moraines. This may be said to have become a definitely organized movement, and to have already accomplished, so far as the interior is concerned, its main purposes, though many details remain to be worked out. The character and brevity of this note forbid any attempt to set forth in detail the respective parts played by the different investigators who have contributed to this work. In a paper entitled, "On the Extent and Significance of the Wisconsin Kettle Moraine," presented to the Wisconsin Academy of Sciences, in February, 1875 (printed in 1878), the writer attempted to collate and duly accredit everything published at that time having any specific bearing on the subject, whether definitely recognized as such by the authors or not. To a considerable extent the correlation and interpretation of the investigations of others were based upon personal visitation of characteristic and significant portions of the formation in the seven interior States traversed by the moraine. Of the much more considerable work which has been done since, the writer hopes to find an early opportunity to speak fully.

The result of these investigations has been the determination of a morainic belt of extraordinary extent and character. It traverses portions of Ohio, Indiana, Michigan, Illinois, Wisconsin, Minnesota, Iowa and Dakota, and extends a distance, as yet undetermined, into the British Possessions. Presumably it crosses the continent. It will be convenient to speak of this as a single moraine, though in reality it is a complex range, formed of two principal and one or more subordinate morainic ranges, which sometimes coalesce and sometimes separate, so as to embrace a belt twenty or thirty miles in width.

It is important to our present purpose to observe three salient facts that characterize it.

1. Instead of pursuing a somewhat direct course across the country *it is disposed in large loops which have for their axes the great valleys of the interior.* These loops represent the margins of great glacial lobes that fringed the greater ice-sheet of the north. Of the ten great lobes now determined, one occupied each of the following valleys, viz: of the Dakota River, of the Minnesota River, of the western projection of Lake Superior, of the Chippewa River, of Green Bay, of Lake Michigan, of Saginaw Bay, of the Maumee, of the Scioto, and of the Grand

River, the special interest of this discussion attaching to the last.

2. *The moraine does not lie upon the margin of the glaciated area*, but is distant from it at considerable, though varying distances.

3. *The moraine marks a second glacial advance separated from the former by a considerable interval of time.* From the consideration of several distinct lines of evidence, the impression has been gained that the interval which separated the earlier from the later glaciation, was equal to, or greater than, that which has elapsed since the latter. But the correctness or otherwise of this is unimportant to our present purpose.

Somewhat later a similar attempt was made by eastern geologists to trace out an analogous moraine in the coast region. The result of their investigations was the determination of a massive morainic belt traversing northern New Jersey, the entire extent of Long Island, and the smaller islands lying to the eastward, striking the Atlantic on the peninsula of Cape Cod. Concerning this it is likewise essential to note two characteristics and a negation.

1. Unlike the western moraine, *it is not disposed in conspicuous loops*, as now delineated. This is the more to be remarked, since the surface inequalities of the region lying north of it are greater than those of the interior.

2. *This moraine marks the southern limit of the drift-sheet.*

3. It has not yet been determined whether this moraine represents the limit of the earlier or later glacial advance.

Notwithstanding their differences, the characteristics of the eastern and western moraines are so strikingly similar, that their tentative correlation as portions of a single moraine presented itself on the first appearance of Professor Cook's results, and was given expression to in the paper above cited. The correct correlation of these moraines and the decisive determination as to whether the coast member belongs to the earlier or later period of glaciation, are manifestly questions of great interest, and the purpose of this paper is to make a preliminary contribution toward their solution. The hypothesis of their unity is somewhat strengthened by the fact that thus far no similar moraine has been traced along the margin of the drift in the interior. It may be, however, unsafe to assume the absence of such moraine until the region shall have been critically examined with especial reference to this question.

During the past year Professors Lewis and Wright, of the Pennsylvania Survey, have been engaged in tracing a marginal moraine from the western terminus of the New Jersey range, across Pennsylvania. Their results are not yet published, and will be awaited with interest.

Meanwhile the investigations of the writer, which have been pursued, though with considerable interruption arising from the pressure of other duties, since 1873, have developed some evidence having an important bearing on the correct correlation of the eastern and western moraines. In the paper above referred to attention was called to the fact that, while in the immediate Mississippi valley the kettle moraine lies some hundreds of miles back from the drift margin, in Ohio it approaches it much more closely, and this fact was adduced in support of the presumption that the kettle moraine might become marginal to the drift area somewhere farther east.

In the reports of the geological survey of Ohio a series of peculiar drift accumulations, consisting largely of gravelly hills, are described as occupying the water-shed between the Ohio and Lake Erie. The identification of these with the kettle moraine made* on the basis of the descriptions of the several geologists who have taken account of them, interpreted in the light of some personal observation, is in the main confirmed by further investigation. But, whatever may be true of the kame-like gravelly hills, the course of the moraine diverges quite widely from the summit line of the water-shed. In conformity to its habit, it is disposed in loops, one of which has for its axis the Maumee valley, another the Scioto, and a third, in eastern Ohio, with which we are more especially concerned, the Grand River valley. It is worthy of note that these axes correspond to the three hydrographic sections of Lake Erie, as marked by its surface outline, but more significantly by the soundings of the Lake Survey.

The interest which attaches to the eastern loop in its bearing upon the correlation of eastern and western moraines lies in the fact that in its southern portion it constitutes the margin of the drift-bearing area. Its geography may be briefly sketched as follows: Beginning with the eastern marginal moraine of the Scioto lobe, in the southwestern corner of Stark Co., it pursues a north-northeasterly course to the northern part of Portage Co. In this portion, the moraine attains a more pronounced development than in adjacent regions, and has been made the basis of the descriptions and illustrations of Dr. Newberry † and Colonel Whittlesey.‡ In this it conforms to a law observed to be widely prevalent in its westerly extension, viz: that the reëntrant portions lying between two glacial lobes have a stronger development, and are more especially characterized by the knob-and-basin features, and gravelly constitution, than those portions which were simply marginal

* Paper cited, pp. 21-25. † Geol. Survey of Ohio, vol. ii, pp. 41-46.

‡ On the Fresh Water Glacial Drift of the Northwestern States, Smithsonian Contributions, p. 6.

to the glacier. The northerly part of this belt is such an intermediate moraine, formed between the Scioto and Grand River glaciers. The moraine proper to the Grand River glacier diverges from this common intermediate one in the north central part of Stark Co., from which point it curves rapidly to the eastward, and passes into Columbiana Co. in West and southern Knox townships. Thence it passes eastward in an undulating course through the northern portion of Columbiana Co., from which it enters Pennsylvania. The latter state being under investigation, the course of the moraine was not pursued by me further than to determine its general northeasterly direction and persistence. This latter portion marks the left hand margin of the glacial lobe.

These determinations are thoroughly in harmony with, and bring into rational unity the interesting observations of Mr. M. C. Read,* on the direction of glacial striation in northeastern Ohio. Indeed my working hypothesis was based upon them. These striations show a remarkable divergence from the axis of the Grand River valley toward the high lands that form its rim, and, as it proves, toward the margin of the glacial lobe that gave rise to them. This conforms to the law of divergent internal movement, first demonstrated by myself in respect to the Green Bay glacier, and since shown to be a general character of the glacial lobes of the interior, and will doubtless prove to be a uniform feature of glaciers deploying in an open country. That the southern extremity of this lobe reached the margin of the drift area is affirmed by the observations of Dr. Newberry, on Columbiana Co.,† who asserts that the drift is confined to the northwestern portion of the county, and of Professor J. J. Stevenson on Carroll Co.,‡ who says that after diligent examination, no drift was found except a few doubtful specimens in the northeast, and that the boundary line of drift influence lies to the north and northeast of the county.

The outer margin of the moraine, according to my determination, approaches to within less than three miles of the northern line of Carroll Co., and I observed no apparent evidence of glaciation south of it. A little farther east, however, drift was observed from three to four miles south of the apparent margin of the moraine. Whether this was formed contemporaneously with the moraine or during the earlier glacial epoch, seems to me uncertain, but the general fact that the moraine here reaches the essential limit of the drift-bearing area, is satisfactorily determined. This removes one of the

* Geol. Survey of Ohio, vol. i, p. 531.

† Geol. Survey Ohio, vol. iii, p. 90. ‡ Ibid, p. 179.

apparent distinctions between the moraines of the coast and interior.

While, however, this distinction has been removed, the remaining one has been intensified, for it is shown that the lobate character of the glacial margin prevailed thus much farther east, and as that character is manifestly due to topographical features, it becomes all the more remarkable that in the more diversified region of the east, the glacial outline should become more nearly uniform and rectilinear, as determined by the geologists of that region.

In New York, morainic accumulations identical in character with the class under consideration have an extensive development, but their relations and connections are not yet fully determined. The more pronounced character of the topography manifestly made itself felt upon the margin of the ice, and gave rise to local modifications, and seemingly to independent local moraines that increase the difficulties of a safe interpretation. But it is certain that, in part, the main morainic accumulations are considerably removed from the margin of the drift, and indicate that alternate divergence and approach may be found to characterize the region lying east of the point of first contact. In view of the fact that the wide separation in the Mississippi Valley is entirely closed in eastern Ohio, the suggestion that the later advance actually passed beyond the earlier in the coast region, may be worthy of entertaining as a working hypothesis. It may be further remarked that if there be alternating contact and divergence of the margins of the two glacial sheets, that a considerable belt lying back from the drift limit requires investigation.

In view of the further fact that the great moraine of the interior is found throughout the wide extent through which it has been traced, to be persistently disposed in loops, the presumption of a similar outline, attended by reëntrant angles and intermediate moraines, ought only to be dismissed when found unsupported by evidence after diligent search.

It is hoped that the foregoing suggestions at this stage of the investigation, while yet final conclusions are unformed and opinions still plastic, may not be without service to the increasingly large number of workers in this somewhat new field.

Art. XIII.—*On the Flood of the Connecticut River Valley from the melting of the Quaternary Glacier;* by James D. Dana.

[Concluded from p. 373, volume xxiii.]

6. *The question as to the Elevation of the Land.*

The remaining question in connection with the discussion respecting the Connecticut Valley during the era of the great flood is that relating to its apparent depression at the time:—Whether the change in pitch, which was proved to have been a fact, was due to a change in land-level, or only to a change in sea-level.

To understand the events of the Glacial era and that following and reason correctly on the facts, we should know which of these views is right, and, in order to know, take evidence from the region.

Toward this end, we may first compare the requirements of an hypothesis which refers the change to a change in sea-level with the facts observed. If the facts do not accord with the demands of such an hypothesis, we are then free to adopt the other view—that the depression of the land was actual and not merely apparent.

It should be understood, in advance, as a fact in terrestrial physics, that any rise in the ocean's level increasing northward produced by a change in the position of the earth's center of gravity would be,* effectively, a change (1) in the height of the land; and (2) a change in the pitch of its surface; and, New England, like the rest of the globe, being within the area so affected, it would be a change in pitch for the Connecticut Valley and the region around, as well as for the coast region. For, the ocean's surface is the reference-plane of horizontality as well as elevation, and the attraction determining its level would affect not only the land adjoining but also all instruments used over it for obtaining horizontal or perpendicular lines.

Only one source of a change in the position of the earth's center of gravity has been suggested in this connection—that from the forming of a polar ice cap of great thickness, during a glacial era in one hemisphere or the other, as in the hypothesis of Adhemar, adopted by Croll and others, this cause leading to an increased pole-ward accumulation of the oceanic waters in the ice-covered hemisphere.

The following are among the facts bearing on this subject.

(1.) There is no correspondence between the amounts of change deduced from observations and those required by the

* Assuming that the earth is so far rigid that it would not suffer deformation—or a depression of the crust—from the weight of the ice resting on its surface.

hypothesis. Since the amount of the apparent depression, that is, of the rise in the earth's curving water-surface which would follow from such a change in the position of the center of gravity, would increase northward very nearly in the ratio of the sine of the latitude, it follows that if the amount at Montreal were 520 feet, as the facts reported show, they should have been about 507 feet at Lewiston, Maine, 491 feet at Point Shirley, Mass. (near Boston), and 480 feet along the north shore of Long Island Sound. But, instead of the amounts 507, 491 and 480 feet, the actual levels observed are 200, 75 or 80, and 25 to 15 feet.*

Further, the hypothesis,—calculating again from the Montreal level, 520 feet,—would give hardly 730 feet for the region about the North Pole, and 720 for latitude 81° to 82°, or that of Grinnell Land and Northern Greenland; while in the latter region, Feilden and De Rance found sea-shells (*Pecten Grœnlandicus, Astarte boreale, Mya truncata, Saxicava rugosa,* etc.) in beach-made deposits at different levels up to 1000 feet.† But this is not all the divergence of the facts from Greenland terraces. For, in the part of Danish Greenland called Southern Greenland (between the parallels of 60° and 67° 40′), the part best known, no heights of terraces or elevated beaches have been reported above 350 feet. Dr. Rink, one of the Greenland explorers as well as Government Inspector for many years of Southern Greenland, mentions, in his latest work on Danish Greenland (1877), the occurrence, in this part of the semicontinent, of terraces at a height of 100 feet, rising in some places to 200 feet, and nothing of higher level. Mr. A. Kornerup, Geologist of Lieutenant Jensen's Expedition of 1878,‡ observed terraces at several points, and describes a series, near the parallel of 63° 10′ N., to the north of Fiskernaes, the highest of which was 101 meters, and another in 63° 5′ N., of 106 meters (348 feet) as the maximum height. Nordenskiöld, in connection with his exploration in the vicinity of Jakobshavn, in 1870,§ observed shell beaches up to a height of 100 feet near 69° 10′ N. Hayes, in his "Open Polar Sea," gives (p. 402) 110 feet as the height of terraces at Port Foulke, near 78° 10′ N., north of Cape Alexander. Kane describes, in volume ii of his Arctic Explorations (p. 80) a series of terraces in 78° 40′, the highest of which was 480 feet above the sea. Three degrees in latitude north of the last region occur the beaches at 1,000 feet, mentioned above. The discrepancy is

* The height of the beds at Point Shirley is made 75 or 80 feet by Professor Shaler in his recent quarto volume on Glaciers forming the first volume of his proposed "Illustrations of the Earth's Surface."

† Quart. J. Geol. Soc., xxxiv, 563, 1878.

‡ Meddelelser om Grönland, 196 pp. 8vo, Copenhagen, 1879.

§ Geol. Mag., 1872, p. 400.

thus increasingly great on going southward along the Greenland coast.

It may be said that the facts from Greenland are only partially known; and, again, that a depression is now going on in Southern Greenland which has increased, and may have occasioned, the discrepancy. But, connecting them with the facts from the Atlantic borders in more southern latitudes, the evidence against the hypothesis is decisive.

(2.) The idea of a polar ice-cap of the extent claimed is an assumption opposed to known meteorological laws and observed climatal facts. For the position of the region of maximum ice would have depended very largely on that of the area of greatest precipitation; and, as the writer, accordingly, some years since suggested,* and Mr. W. J. McGee has formally demonstrated,† the ice would have diminished toward the pole as well as to the northwestward. The eastern ice-range, located in this way between the Atlantic Ocean and points not far west of the Winnipeg line of lakes, 1000 miles in width at base, presented an immense surface for condensing the moisture of the Atlantic winds and diminishing the amount carried northward, so that the ice in Greenland would have had hardly half the height of that to the southwest, and more northern polar regions still less;—Mr. McGee's calculations making the thickness in Greenland in 60° N., 5728 feet, and in 70° N., 2800 feet, while south and southeast of Hudson's Bay on the Canada water-shed, it was probably not less than 12,000 feet.

In accordance with these conclusions, the ice, at the present time, is reported by Arctic travelers to be less thick in the northern part of North Greenland than in the part to the south, and also in the lands west of Greenland than on Greenland itself. Messrs. Feilden and De Rance (loc. cit., p. 567) speak of the paucity of glaciers in Grinnell Land, lying just west of Greenland, stating that north of 81° N. on this more western land, no glaciers descend to the sea-level although they do on the coast opposite of Greenland, the situation of Greenland against the Atlantic rendering it a region of more precipitation than that to the west; and so it would have been under the more favorable conditions for precipitation of the Glacial era. As to the height of the Greenland ice in the Glacial era we have the observations of Mr. A. Kornerup, of Jensen's Expedition,‡ that, near the parallel of 64° N. about the Ameralik and Buxe fiords, there are glacial scratches at a height of 1260 meters

* This Journal, III, v, 206, 1873, ix, 312, x, 385, 1875, xiii, 79, 1877, xv, 250, 1878.

† Proc. Amer. Assoc., xxix, 1880, on Maximum Synchronous Glaciation; a portion of which paper on the particular point above referred to is cited in vol. xxii. of this Journal, p. 264 (1881). Mr. McGee gives for the thickness at 50° N. only 8213 feet.

‡ Loc. cit., pp. 109–113.

(4134 feet), a level almost 3000 feet above any glaciers now in that vicinity, and near the parallel of 63° N., in the vicinity of Kuvnilik and Björnesund, at heights of 940 to 1100 meters (the latter 3609 feet); but none on the upper part of Nukagpiarsuak, northwest of Kuvnilik, whose height is 1520 meters (4987 feet). Mr. Kornerup also states that in the era of extreme glaciation when the glacier was 3000 feet higher than now, the movement of the ice was nearly *east-and-west*, but subsequently, as the scratches at lower levels show, it followed the direction of the fiords or valleys:—a change evidently due to the thinning of the ice, the pitch of the upper surface being great enough when the glacier was at its maximum to cause ice to move independently of the courses of valleys or depressions beneath, and not so after the thickness had been much reduced. This fact had its parallel all over glaciated North America.

(3.) In addition, the hypothesis makes the submergence of the Coast region (indicated by elevated beaches) to have taken place *during the Glacial period, and to have passed its maximum in the height of the period;* when, according to the facts, whatever the condition in the Glacial era, the submergence was a prominent feature of the era when melting was going forward and the ice finally disappeared—the Champlain period. This point needs no special remark after the descriptions already given of the Connecticut River terraces, and the explanations in the following part of this paper.

(4.) But the Glacial era was not for the higher latitudes generally one of *less* elevation in the land than now, and was probably one of somewhat greater elevation for large portions.

The arguments in favor of such elevation I here briefly review, in order to test them by a reference to recent discoveries.

(*a*) One of these arguments is based on the depth to which many river channels are excavated below the present bed of the stream. It has been strongly urged by Dr. Newberry and others. The facts supporting it have been drawn from New England and the States of New York, Pennsylvania, Ohio, Indiana, Illinois, Wisconsin, and from British America; and new cases are annually becoming known. The Pennsylvania Geological Report for 1881 by Mr. I. C. White, treating of Erie and Crawford Counties (among the western counties of the State), remarks that a boring for oil on French Creek, below Meadville, descended *for 285 feet through the drift;* and another, in Conneaut Creek valley, 180 feet in drift; and in connection with his account of these and other cases, he speaks of it as a general fact that "the present water courses meander along the upper surfaces of drift-deposits which fill the ancient valleys to various heights above the old rock beds." Other similar facts from western Pennsylvania are presented in the report of Mr. J. F. Carll, for 1880. During 1881, Mr. J. W. Spencer published facts respecting a buried channel between Lake Erie and Lake Ontario, which entered the latter lake along the steeply escarped Dundas Valley.* He states that in this valley the drift has been penetrated to a depth of 227 feet below *the level of the lake* without reaching a rocky bottom, and that the depth of the drift is probably as much as 1,000 feet. He also points out that the channel of Lake Ontario, which has its greatest depth abruptly near the southern side and gradually shallows northward, is a channel of erosion and probably of cotemporaneous erosion with that of the Dundas Valley.

Reported examples of this kind are so numerous that they are regarded now as representing a general fact. Such excavations could not have been made by running water while the land was at its present level; and much less could they have been made when the land was lower than now. Their origin was hence before the Champlain period in *Glacial* or *pre-Glacial* time.

The accounts speak of these deeply-eroded valleys as filled with *drift;* and if with true *northern drift,* as is implied by the language—a point which in all cases needs special examination—they were open to their bottom to receive the drift during the Glacial era. For otherwise they would be found filled in each case with the sand and gravel of the drainage-area instead of with material from a more northern source. And if open in the Glacial era, the land was at a higher level than in the Champlain period, or that of great deposition; high enough for a flowing stream to have kept the trenches clear of deposits. Many of these valleys, like that of Dundas Valley, have a different course from that of the movement of the glacier, and hence, no aid could have been afforded by the glacier in the excavation if the level was as now; and the aid would have been ineffectual whatever the course.

The facts thus prove that if the material filling these buried valleys is true drift, the land in the Glacial era was higher than now; and *much* higher, if the drift of the Dundas Valley is 500 to 1,000 feet deep. The valleys may have been pre-Glacial in origin, but their depth would have reached its lowest limit from the latest erosion or that of the Glacial era.

The argument from the deep river-made channels intersecting sea-border regions, and now occupied by the sea—that is from long bays and fiords 100 to 3,000 feet or more in depth of water—which characterize the shores in the higher latitudes on all the continents, north and south, still stands good so far

* Proc. Amer. Phil. Soc., 1881, and Proc. Amer. Assoc. Adv. Sci., 1881.

as this at least, that if, as is probable, antedating in first origin the Glacial era, the final deepest erosion took place at that time. Being proof of water erosion, they are proof of the emerged state of lands where now are seas 1,000 to 3,000 feet deep. But they do not prove that there may not have been several successive emergences and Glacial eras concerned in their production.

(*b.*) Again, there are deserted water-courses which appear to owe their desertion to a change of level which took the flow from the waters. In many cases the desertion was due simply to a decline of the flood, and a filling of channels by the depositions. But in other cases, like that of the discharge of the St. Lawrence from the Great Lakes, an appeal to diminished southward pitch in the land is necessary to account for the depositions of the Champlain period, and also for the present condition of the lakes as to outlet.

(*d.*) An argument for the probability of a greater elevation in the Glacial than Champlain period I have based, in earlier papers, on the progressive elevation of the continent which was going on during the preceding Tertiary era; and this has lost none of its force by recent discovery. The elevation of the Rocky Mountain region from Mexico on the south to the Arctic seas, and which amounted to 10,000 and 11,000 feet in the higher portions of the United States, was not completed until the close of the Pliocene—the vast Pliocene fresh-water lakes proving this; and the close of the Pliocene was the beginning of the Glacial era. Besides this upward movement in the western two-thirds of the continent, a smaller took place in its eastern portion, as geologists have inferred from the absence of marine Tertiary either above or at the sea-level north of Cape Cod, and of Pliocene Tertiary to a large extent south of it. Thus the Tertiary changes of level were, in the main, upward to the end of this age.

It is evident, too, that these changes of level in the Tertiary were changes of land-level. For changes due to a transfer of the ocean's water meridionally would have been alike on the two sides of the continent.

It is deserving of consideration also that an elevation of large portions of the Arctic regions would be favorable to the production of Glacial conditions, for it would diminish the depth of the arctic seas, and consequently would diminish the volume of arctic currents flowing southward, and of tropical waters reaching the arctic; and it would hence increase the cold of arctic seas and lands and of the lands south, and the warmth and rate of evaporation of the North Atlantic in temperate latitudes.

The evidence reviewed thus shows that there were real changes of land-level and not simply a change of ocean-level connected with the coming on and disappearance of the ice of the Glacial era; and that the level during the Glacial era was not below the present, like that of the era following, but at least as high as the present, and probably, in many portions of the colder latitudes, somewhat higher than now.

It thus follows that a change of level of very wide continental range introduced the era of depression or Champlain period—a change so great and so marked in its effects that it is reasonably recognized as a time-boundary in Quaternary history; and as the Champlain period was one of ameliorated climate, it may have begun with the beginning of the melting. As I have shown in the earlier part of this memoir, the depression was certainly a fact during the great flood, and began before the melting had far advanced. The fact of a warmer climate in the Champlain period is manifested in the distribution of the quadrupeds and forest trees of America, Europe and Siberia, as now generally admitted. It is most strikingly demonstrated among the lands of the Arctic seas, where, on Banks's Land (74° 48′), Prince Patrick's Island (76° 12′ N.), and elsewhere, unaltered trunks of modern fir trees, single and in forest-like accumulation, exist.

But the facts as to amount of change of level are not so well known that we can mark off the limits of the areas of elevation and depression over the higher latitudes. They do not enable us to decide whether there were not, extending northward, a series of upward and downward flexures, with only a greater general emergence than now in the Glacial era and a greater general submergence in the era following. The heights of terraces on the coast of Greenland seem to be an indication as to one in this series of flexures. In any case the facts do not sustain the ordinary assumption that the amount of depression in the Arctic regions was approximately alike in all parts, and they leave it to be proved that all portions participated in the subsidence.

The cause of the depression of the land, or of the previous elevation, this is not the place to consider.

ART. XIV.—*On the Retardation of the Maxima and Minima of Air-pressure at High Stations;* by H. A. HAZEN, A.M.

[Communicated by permission of the Chief Signal Officer of the United States Army.]

IN his tenth paper, published in the number of this Journal for January, 1879, Professor Loomis advanced certain evidence to show that, apparently, the progress of a storm center was much more rapid at the surface of the earth than at elevations above it. Many arguments have been advanced by others for and against this theory. It is the purpose of this article to put forth certain facts which have come to light, and which it is hoped will tend to elucidate the subject.

Many years ago it was noticed from hourly observations at Zurich and at the summit of the Rigi, that while the morning maximum, in the diurnal range of air-pressure, occurred at the lower station at ten, it did not occur at the summit of the mountain until two P. M. Professor Loomis writes (this Journal, January, 1879, pp. 11 and 12): "Over the United States both the maxima and minima" [of accidental fluctuations] "of atmospheric pressure generally occur first near the surface of the earth, and they occur later as we rise above the surface, the retardation amounting to one hour for an elevation of from nine hundred to thirteen hundred feet." He says again (pp. 13 and 14): "The diurnal movements of the barometer exhibit a peculiarity similar to that found for the accidental fluctuations. The principal maximum occurs at the base at half past eight, but on the summit it does not occur until noon, being a retardation of three and a half hours, which is almost identically the same as we have found by a comparison of the accidental fluctuations." He says further (p. 19): "The low center at the height of Mount Washington sometimes lags behind the low center at the surface of the earth apparently as much as two hundred miles."

The Rev. Clement Ley, of England, in a paper published in the Quarterly Journal of the Meteorological Society for July, 1879, adopts this statement advanced by Professor Loomis in support of his hypothesis that the storm center lags behind at elevations as shown by his own observations of cirrus clouds. Mr. Strachan in discussing this point as brought out by Mr. Ley has shown that, taking the average velocity of a storm center as twenty miles per hour, and a retardation of one hour per each thousand feet of ascent, the axis of the storm center must be inclined 89°·5 to the vertical, or, in other words, lie almost parallel with the earth's surface.

Professor Ferrel, in his paper, "Meteorological Researches for the use of the Coast Pilot, Part II," has advanced the theory that a storm center lags behind at the earth's surface, and, speaking of the apparent contradiction of the researches of Professor Loomis, says: "These results of Professor Loomis show too much for this hypothesis" [that the axis of a "low" is retarded at elevations], "for they show that there is a similar retardation of just about the same amount in the times of the maxima and minima of the diurnal changes of barometric pressure at the summits of mountains, and we cannot reasonably explain this by means of cyclones with reclining axes. When we shall have a satisfactory explanation of this retardation in this latter case, we shall probably have one in the other."

In discussing the probable cause for this retardation, the influence of high winds and of variations in temperature will be considered, and the theory that it can be caused by the lagging of the axis of a "low" abandoned as untenable, for this, if for no other reason, that, unless a secondary force acts, it is exceedingly difficult to conceive how any fall of pressure at the summit of a mountain would not make itself felt at the same time at the base through the superincumbent atmosphere.

If a strong current of air can produce a depression of the mercurial column of a barometer, as has been shown by using a blower for the air current and an air-tight receiver for the barometer (a condition of things, however, which, it should be be borne in mind, can never occur in nature), then why may not the high wind which nearly always accompanies a storm cause a fall in air-pressure, which shall continue as long as the wind is strong at the summit and some time after the storm center has passed the base?

It is exceedingly desirable that special experiments be made under natural conditions, directly testing the influence or non-influence of high winds on the indications of the barometer. In the absence of such experiments we may indirectly ascertain such influence by comparing observations made at the same moment of time at the summit and base of mountains. The materials for such comparison exist in manuscript copies of hourly observations at the base and summit of Mount Washington during May, 1872, which I have been allowed to consult through the kindness of the Chief Signal Officer of the Army; and in the hourly observations of May and June, 1873, made at the same stations. The latter have been published in the annual report of the Chief Signal Officer for 1873. These stations lie three miles apart in a horizontal direction, and hence we may compute with a near approach to accuracy, from the observations for pressure and temperature, the difference of level between them, by the use of Guyot's hypsometric formula.

In order to show that varying temperature does not appreciably affect the relative results of such computation, the following comparisons are given.

At a recent meeting of the Washington Philosophical Society, Professor G. K. Gilbert, of the United States Geological Survey, gave a method for determining differences of elevation where air-pressures are observed at three or more neighboring stations having different heights, which may be outlined as follows: Let P, P′ and P″ represent the observed air-pressure at stations A, B and C, then will the formula,

$$H = C(\log P - \log P')f(t)f(O)f(m) \qquad (1)$$

express the difference in height between A and B, and

$$H' = C(\log P - \log P'')f(t)f(O)f(m) \qquad (2)$$

the same for A and C; dividing (1) by (2) we have

$$\frac{H}{H'} = \frac{\log P - \log P'}{\log P - \log P''} + D:$$

if now we have either H or H′ given, we may compute the other, without referring to temperature, latitude or moisture.

During the month of June, 1873, hourly observations were made at the base and summit of Mount Washington and at two intermediate stations. Considering forty-three cases taken at random, I find twenty-three of them in which the mean height of the summit above the base is too small, by Gilbert's and Guyot's formulæ, forty-six and fifty-five feet respectively; while the remaining twenty cases give a value too great by fifty-one and forty-eight feet. We may therefore, in comparing relative heights, neglect the effect of varying temperature as introduced by computations with Guyot's formula.

If the wind affects the pressure directly, we would expect that the computed difference of level would be the same as the true difference when there was no wind, and would gradually increase as the wind increased, unless there were some causes beside pressure, temperature and wind affecting the computation. I have grouped these computed differences in elevation according to the force of the wind, as may be seen in Table I.

In the following table, for May, 1872, all winds under ten and above forty miles per hour are included, and in May, 1873, all the cases except a few which were omitted because of serious errors in the observations. The table shows this remarkable peculiarity, that, though with winds above sixty-one miles per hour, the mean computed difference in height is too great by sixty-six feet; with winds under ten the mean difference is too small by thirty-five feet. We conclude, then, that some other cause must produce the results or must act in conjunction with the wind. Taking winds above sixty-one miles per hour I have found ten cases in which the height was too small by about fifteen feet; also, a great number of cases in which though the wind continued strong from the same direction, yet the computed height continually became less, showing that the wind does not produce a direct effect upon the indications of the barometer.

TABLE I.

Mean amount to be added to the true difference in height between the summit and base of Mount Washington to give the computed difference.

	Wind force in miles per hour.													
	0 to 10.		11 to 20.		21 to 30.		31 to 40.		41 to 50.		51 to 60.		Above 61.	
Date.	Cases.	Amt.	C.	A.	C.	A.	C.	A.	C.	A.	C.	A.	C.	A.
May, 1872.	77	−27′·1	25	−18′·6	30	−3′·1	43	+13′·8	65	+10′·5	32	+33′·9	50	+51′·4
May, 1873.	104	−43·5	134	−22·0	183	+4·1	135	+15·6	99	+34·9	61	+52·4	27	+80·1

On projecting the curves of pressure in connection with the computed elevations, we find that there is a striking uniformity in the occurrence of small and large differences of elevation with the maxima and minima of pressure, the least coinciding with high pressure and the greatest with low. Grouping a second time, then, with respect to the maxima and minima of pressure we have Table II.

TABLE II.

Mean amounts to be added to the true difference in height between the summit and base of Mount Washington to obtain the computed difference.

		Maxima of Pressure.		Minima of Pressure.	
Date.	Locality.	Cases.	Amount.	Cases.	Amount.
May, 1872	Mt. W. and base	81	−32′·5	70	+ 57′·4
May, 1873	Mt. W. and base	102	−61·6	137	+ 67·3
Jan., Feb., Mar., Oct., Nov., Dec., 1880	Mt. W. and mean of B. and P.	119	−29·1	120	+127·0

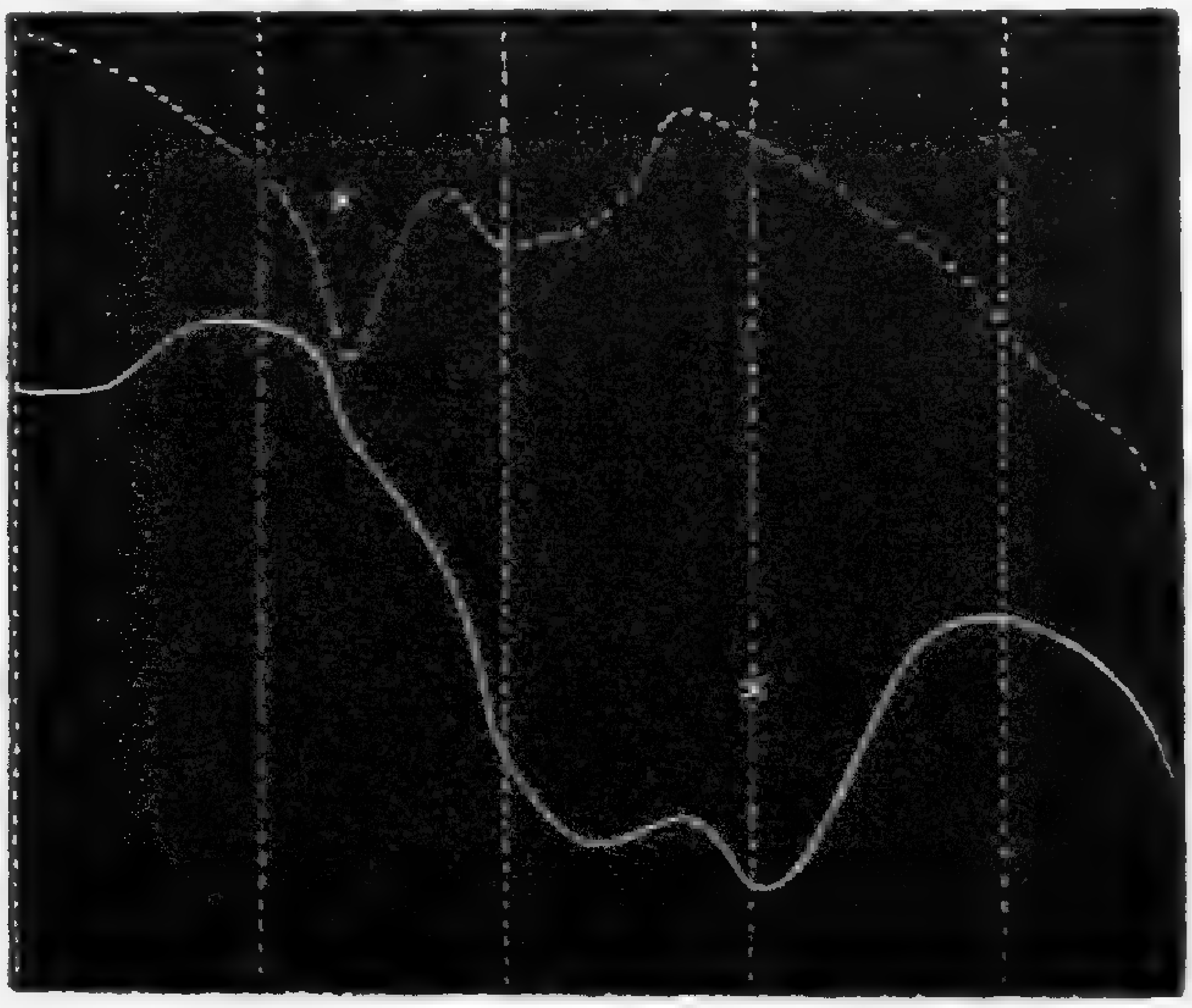
In the above table, as the first two horizontal rows of figures apply only to observations for the month of May, I have added a third set of figures for the summit of Mount Washington compared with the mean of Burlington and Portland as the base, and computed for observations taken at 7 A. M., 3 P. M. and 11 P. M., Washington time, during Jan., Feb., Mar., Oct., Nov. and Dec., 1880. Burlington and Portland, near sea-level, lie on opposite sides of Mount Washington and at distances altogether too great to give the best results; if, however, we take the mean of the two we shall obtain an approximate value for the base of the mountain.

It is evident from Table II that during the prevalence of relatively high pressure, elevations, computed barometrically, will in general be too small, and, on the other hand, when the pressure is low the computed heights will be too great. This fact also explains the coincidence of too great computed heights with high winds, for the reason that the highest winds always occur with relatively low pressure; on the contrary, when the wind is light the pressure is generally high. We may conclude, then, that the same cause which produces the maxima and minima of pressure, controls also the different values of computed elevations, and that high winds are rather an accompaniment than a direct cause of the same variations.

May not the apparent lagging of the axes of "highs" and "lows" be due to the effect of varying temperature. The general tendency of high temperature being to expand the air and force it from the lower levels, above the summits of mountains, and of low temperature to produce an opposite effect, we should expect at elevated stations high pressure with high temperature and low pressure with low temperature. This principle is well illustrated by the Signal Service observations of pressures on Mount Washington and Pike's Peak. In January the mean pressures are 23″·393 and 17″·512 at the two points respectively, while in July they are 23″·894 and 18″·078. The same results would follow the accidental fluctuations, whenever there might be a steady, gradual rise or fall in temperature for a sufficient period of time. When a "low" has passed a station at sea-level, the temperature frequently falls steadily with a west wind and the result is a contraction of the air, which causes its withdrawal from the upper atmosphere and a further fall in pressure there. This process will continue until the fall caused by the low temperature is counterbalanced by the rise due to the advancing high. The reverse of this may take place at the passing of a "high." In order to ascertain the influence of varying temperature as suggested above, I have projected the pressure curves for a singular case at Pike's Peak, in which the minimum occurred forty hours earlier at Denver than at Pike's Peak; also, for a case in which the minimum for Burlington and Portland occurred twenty-four hours earlier than on Mount Washington.

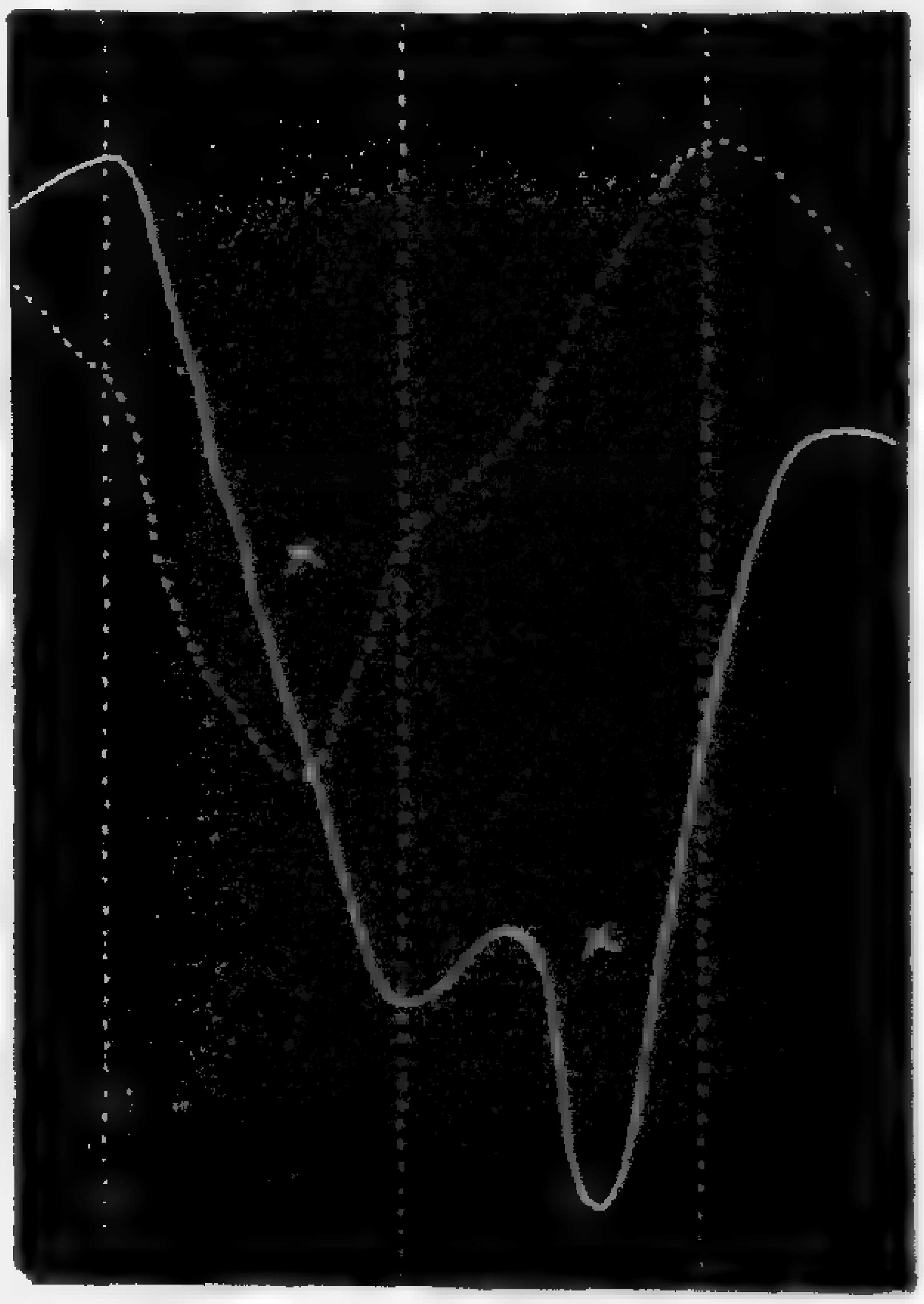
Referring to the curves and the temperatures at Pike's Peak, we see that on November fourteenth, at the 7 A. M. observation, the mean temperature of the air column was comparatively low and the pressure at a maximum at Denver; the temperature gradually increased to three P. M. of the fifteenth, and though there was a steady fall in pressure at Denver, yet it rose on Pike's Peak until seven A. M. of the fifteenth; from this point

Retardation of the minimum of pressure at Pike's Peak, Nov. 15 *and* 16, 1880.



Curves of Air-pressure.

Mt. Washington and mean of Burlington and Portland, Nov., 1880.



Curves of Air-pressure.

the pressure rose steadily at Denver under the influence of an extraordinary cold wave; this same cold wave reduced the pressure on Pike's Peak, which did not reach its minimum till seven A. M. of the seventeenth, or forty hours later than at

Denver. On a comparison of the curves at Mount Washington, we see another illustration of the same nature.

If now we apply the same reasoning to the maxima and minima of the diurnal range of pressure, at the base and summit of mountains, we shall find that it affords a satisfactory explanation of the retardation at the summits. For the purpose of comparison I have taken the hourly observations at Mount Washington and base in May, 1872 and '73, and in June, 1873; also, a manuscript copy of hourly observations made by the observers of the United States Signal Service at Pike's Peak and Colorado Springs during August and September, 1874. The means for each hour have been embodied in Table III. The difference in level between the base and

TABLE III.

Diurnal range of air pressure, and the mean temperature of the air column at Mount Washington and Pike's Peak.

Hour of day.	May, 1872.			May and June, 1873.			Aug. and Sept., 1874.		
	Air pressure.		Mean T.	Air pressure.		Mean T.	Air pressure.		Mean T.
	Mt. W.	Base.	Air col.	Mt. W.	Base.	Air col.	Pike's P.	C. Sp'gs.	Air col.
1 A.M.				23″·760	27″·165	37°·2			
2				·757	·161	38·8			
3				·751	·158	38·4			
4				·746	·160	38·0			
5				·753	·165	37·8			
6	23″·675*	27″·098†	36°·2	·756	·173	38·6	17″·982	24″·201	47°·1
7	·670	·100	37·4	·762	·180	40·1	17·988	·202	51·8
8	·671	·101	38·7	·767	·181	42·2	17·995	·204	55·0
9	·674	·103	39·6	·773	·181	44·0	18·002	·205	58·0
10	·683	·098	40·6	·781	·180	45·1	18·009	·198	60·4
11	·689	·096	41·9	·784	·176	46·6	18·009	·188	62·8
Noon	·690	·093	42·6	·787	·169	48·0	18·007	·176	64·3
1 P.M.	·690	·085	43·3	·785	·163	49·0	18·005	·164	65·0
2	·687	·081	43·6	·783	·157	49·0	18·002	·150	64·4
3	·689	·082	44·0	·777	·152	48·8	17·998	·144	63·3
4	·688	·078	43·8	·775	·150	48·6	17·994	·142	61·2
5	·683	·066	44·0	·771	·150	47·6	17·992	·146	60·1
6	·691	·084	43·2	·771	·155	46·2	17·992	·152	58·2
7				·772	·163	44·3	17·997	·165	55·5
8				·773	·166	42·4	18·001	·180	53·5
9	·680	·102	38·5	·779	·171	41·7	18·003	·188	52·3
10				·775	·171	41·0			
11				·770	·171	40·2			
Midn.	·676	·095	37·4	·765	·167	39·8			

	Mt. W.* Uncorrected Barometer.	Att. Ther.	Base. Att. Ther.
6 A.	23″·730	55°·1	50·4
7	·730	57·8	49·5
8	·739	60·7	49·4
9	·750	64·6	49·7
10	·762	65·7	49·8

summit of Mount Washington is 3590 feet, and between Pike's Peak and Colorado Springs it is 8100 feet.

The figures in this table, in the fifth and sixth columns, were taken from Professor Loomis' tenth paper; the remaining columns I have computed from the original observations. Unfortunately the hourly observations of 1872 and '74 were continued only during the day hours; they, however, give satisfactory results for the principal morning maximum and afternoon minimum. A marked peculiarity will be noticed in column two in the means of the observations for seven and eight A. M., namely: a steady fall during these hours. This is due not to natural causes at all, but to the fact that at the midnight observation the barometer was pushed into its case and locked up. In this position the temperature indicated by the attached thermometer was lower than that of the room, consequently, by the time of the second observation the next morning, after the barometer had been suspended for an hour in the room, the temperature of the air in the room would be indicated by the attached thermometer, while the mercury and scale of the barometer would change their temperature much more slowly, and the correction for temperature being too great, the readings of the barometer were made too small, until the different parts of the instrument had attained a common temperature. The attached thermometer at the base indicates that the observations there were not made in the living room, or else that the fire in the room was very low. (See note at foot of Table III.) It will be noticed that in each case after the morning maximum of pressure was reached at the base, the mean temperature of the air column was rising, and in consequence, the pressure did not begin to fall at the summit till some time had elapsed. For the afternoon minimum a reverse of the conditions and effects is noticeable. One interesting circumstance should not be overlooked: while at Mount Washington the lagging in the morning was three hours and a half for 3590 feet, or one hour to each thousand feet, at Pike's Peak it was only two hours for 8100 feet, or one hour to 4000 feet. This is due in part to the fact that after the morning maximum the fall in pressure was much more rapid at the lower western station than at the eastern, and this counterbalanced the rise in pressure at the summit due to the increase of temperature.

Again, we see that in the single case we have of observations through the night, there is little or no retardation in the morning minimum and night maximum. This is precisely what we might conclude from the fact that during this time the temperature changes only slightly, though little stress can be laid upon this because the oscillation is correspondingly small.

Another cause for a portion of the retardation may be considered to be the sluggishness in action of the summit barometers, or again, to be the slowness with which the air at the maxima and minima of pressure would enter and leave the room where the observations were made, undoubtedly less accessible to the atmosphere at the summit than at the base. These last two causes, however, would be of little consequence in producing the results noted.

May we not be enabled, by a sufficient number of carefully conducted observations, extending over a year, at the base and along the side of Pike's Peak or some other isolated mountain, to determine the cause of the diurnal range of air pressure, which has been characterized as the most persistent of all meteorological phenomena and never as yet satisfactorily accounted for? If the above discussion assigning varying temperature as the cause of the apparent retardation of the axis of a "low" at high stations prove satisfactory, it will also show the great difficulty which inevitably attends any attempt made in comparing pressures observed at elevations above the earth with those observed at the same time at sea-level.

Acknowledgment is due to Professor Abbe for suggestions in the final construction of this paper.

ART. XV.—*On the General Principles of the Nomenclature of the Massive Crystalline Rocks;* by A. WENDELL JACKSON.

INTRODUCTION.

THE objects of the present paper are, first, to suggest the complete separation of rock-nomenclature from rock-classification, and, second, to investigate and to establish, as far as may be, the principles upon which any system of nomenclature for the massive crystalline rocks should be based. Throughout my paper the term "nomenclature" is to be understood as referring to the names of the rocks themselves and not of the larger groups recognized in rock-classifications.

The existing confusion in rock-nomenclature is due to several causes, not the least of which is the admission of classification as a controlling feature in nomenclature, and the tendency seems to be more and more in this direction. This principle is even directly advocated in a recent able work (Dutton, "Geology of the High Plateaus of Utah," Chap. iv). Its general recognition can only result disastrously to the science. The true function of present systems of classification is to express relations between the objects classified. The true function of a system of nomenclature is to furnish each of these objects with a name that shall be as little subject to change as possible, for change produces confusion.

Classifications are constantly changing and if our rock-names are made dependent upon them, an element of confusion in nomenclature is introduced that is both undesirable and unnecessary. Our only remedy lies in a complete divorce of nomenclature from classification such as has long been recognized in zoology, botany and mineralogy.*

In the following pages I wish to discuss the principles of nomenclature as considered thus entirely distinct from classification; it goes without saying that the chemical, mineralogical, and geological considerations which I discuss with reference to the irbearing on *nomenclature* are entirely open to a re-discussion with reference to their bearing on *classification;* and one may arrive at diametrically opposite conclusions as to their value for classification from my own as to their value for nomenclature without in the least invalidating the results reached in the present paper.

In the first chapter I state and explain the principles which I conceive should guide us in the formation of rock-names and I then examine the considerations at our disposal to determine how far they may be used in conformity with the principles laid down. In the second chapter I explain why I hold it to be inexpedient to formulate a system of names in accordance with the principles suggested and give reasons for adopting provisionally a different system of names.

Chapter I.

I conceive the fundamental principles to be borne constantly in mind in the formation of a system of nomenclature to be three: I. *Uniformity*, II. *Stability*, III. *Adaptability.* I shall examine each of these and indicate its bearing upon the question at issue.

I. *Uniformity.* No one will for a moment dispute the desirability of having but *one* name for each rock. There is something of a tendency toward the formation of "schools" in this respect. That is all wrong however; all geologists should call the same rock by the same name. Zoologists, botanists and mineralogists recognize this principle in their respective sciences. Indeed it is so evident that one who will dispute it is not to be reasoned with.

II. *Stability.* By a "stable" nomenclature, I mean one that is not subject to change. A rock that has once received a definite name should continue to be known by it. This principle is second in importance only to the first. If *all* geologists would agree to change any given name, there would of course

* For a more extended discussion of this topic see the reprint of this paper in the Proceedings of the California Academy of Sciences. Volume for 1882.

be no objection to the change; uniformity would still be preserved. This principle as well as the first has been frequently violated in petrography.

III. *Adaptability.* In considering this principle it is desirable to bear in mind the peculiar nature of a rock as distinguished from a mineral. A mineral is a definite homogeneous chemical compound and one usually has no difficulty in recognizing it and applying at once the name that has been agreed upon for that particular compound. But a rock is usually a mechanical mixture of two or more minerals, admitting considerable variation in the relative amounts of the different constituents, remaining in the estimation of the geologist substantially the same rock. By the "adaptability" of a name I mean that it should adapt itself to this variation. A change in the relative amount of the constituents within certain not all-too-broad limits should not necessitate the use of a new name.

It is here that I conceive some may take issue with me as to the practicability of upholding this principle. It will be contended that rocks grade off into each other by insensible transitions and that the *transitional forms* are just as common as those we may choose to set up as *typical forms*; that a name consequently cannot be made to adapt itself to this indefinitely shifting mixture of minerals. The answer to this has been so finely stated by Rosenbusch (Massige Gesteine, p. 25) that I cannot refrain from quoting it in full, premising that I have fully experienced the truth of his statement.

He says: "In the same way that insensible transitions from one rock to another are brought about by change in the mineralogical composition, so also is it true that similar transitions are sometimes the results of a change in texture. I believe myself justified in the statement that every thoughtful petrographer will have passed through three stages of development in his scientific views, with increasing experience in this direction, stages which possess more than a personal interest, from the fact that they are likewise recognizable as three stages in the development of the science itself. In the first of these stages, one is a fanatic for a *simple system*; one recognizes a series of well characterized types and no transitional forms. In the second stage, the conviction presses itself gradually upon the mind that nature cannot be fitted into so exact and rigid a frame; the well characterized rock-types become fewer and fewer, the transitional forms more and more numerous. One turns away from the rigid system and becomes an inspired advocate of the uninterrupted series, of the gradual development of one rock from another, of the insensible transitions which bind together and totally obliterate the types of the first stage. Finally, in the last stage, one begins gradually to discover certain fixed points in this vague and indefinite mass of transitional forms; or, to express myself petrographically, in the formless magma of our views crystallization-centra begin to appear, about which homogeneous material begins to deposit itself concentrically with gradually decreasing density as we recede from the center. Thus arise rock-groups whose central types are well-defined and distinctly separated from one another, while their peripheries tangent and in many ways coalesce. One now returns to the definite system which no longer possesses however the rigidity and dead immobility of the first period."

One who believes there is no such thing as a definite rock-type, finds himself in the second stage of his development and only needs a more extended range of experience to discover the rock-types and to view them in their true relations; and he will then perceive the true significance of this principle of adaptability and will recognize the importance of conceding to it a high degree of influence in the construction of rock-names.

Mr. Darwin has demonstrated the necessity of recognizing this principle in the organic natural sciences and the mineralogist has to bear it constantly in mind.

Were the necessity at all incumbent upon us to form a system of nomenclature for material that had reached a *perfect* natural classification, I should certainly add a fourth principle to the three thus suggested, namely, that a name should be constructed so as to suggest the relation of the rock to all allied rocks; in other words I would seek to construct a complete *systematic* nomenclature that should be an exact expression of the *systematic* classification.

As such a system has not yet and may never be reached, it is certainly unwise to allow this principle to enter largely into the determination of present nomenclature. It would at once conflict with the first two principles of uniformity and stability. To a slight extent it may perhaps safely be done; we shall consider such cases later.

Having thus laid down certain principles to guide us, I will now examine the considerations that might influence our selection of rock-names. In so far as these considerations are in accord with these principles, they will be endorsed; in so far as they are in conflict, they will be rejected.

I claim, first, as of fundamental importance that *facts*, and facts alone, should determine names and that *speculations*, *hypotheses* and *theories* should be entirely ignored. Facts are susceptible of demonstration, and a nomenclature founded upon them is sure to be uniform and stable, while speculations, hypotheses and theories admit of differences of opinion, and if our names are to be influenced in any way by them, we at once admit an element of nonuniformity and instability. Although it is in a general way true that the theories of one generation become the facts of the next, it is equally true that *most* of the theories of one generation *fail* to become the facts of the next; and so long as they remain in the condition of a theory they should be totally ignored in forming rock-names. The value of a fact in this connection is to be measured by its generality; facts of local value should be reserved for local distinctions.

The kinds of facts which are more immediately accessible to the geologists are three: *chemical*, *geological* and *mineralogical*. I will indicate what I conceive to be the value of each class for the formation of names.

1. *Chemical.* Perhaps the most striking evidence of the impossibility of basing nomenclature upon chemical composition can be presented in the fact that during all of the years preceding the use of the microscope in petrographical investigation, chemistry was unable to discover distinctions that become evident with the first glance into the microscope. Rocks are not minerals and have not the same well-defined stochiometric composition that minerals have. On the contrary, rocks that are mineralogically identical show considerable variations in chemical composition, while the same bulk-analysis may be true for rocks of widely different mineralogical composition. It is to be observed from this that knowing the analysis one is not able to predict mineral composition while the converse is *not* true; if we know the mineral composition we can predict always qualitatively, and to an approximation quantitatively, the chemical composition. It would seem then that the fact of mineral composition is of a higher order of utility than the fact of chemical composition. The latter is a function of the former and a nomenclature based upon mineralogical facts will necessarily express sufficiently clearly the chemical facts, without the inconvenience of determining the chemical composition in each case before deciding what name shall be applied.

Again, it is held by some (Scheerer, Jahrbuch der Mineralogie etc., 1864, 385, and others) that the chemical composition of a rock is a fact of the first importance and should be made the leading element in classifying (and naming?) because it gives us a clear conception of the nature of the original fluid material out of which the rock crystallized; and that it is this original fluid material which constitutes the true "rock-type" about which all of our interest centers. Now, while I fully admit the value of this conception and appreciate the significance of the results to be gained by tracing different rocks back to a common magma, still I hold that a rock is something more than a certain chemical mixture, it is a chemical mixture *with a history that is equally interesting.* It has been subjected to various physical conditions of temperature and pressure that have determined its rate of crystallization and that, equally with the original magma, have determined the precise minerals which we now find in the rock itself. It is true we do not yet know enough of the relations between varying conditions of temperature and pressure, and the resulting minerals to be able to reason backward from the minerals themselves to the conditions of which they are the (partial) expression; some progress has been made in this direction and certainly more is to be expected.

The mineral composition of a rock will give us a conception, then, not only of the original chemical composition of the magma from which it was derived. but also (particularly with *texture*, see p. 19) of the physical conditions which have prevailed during the process by which the rock acquired its present appearance; it suggests both chemical *and* physical conditions while the chemical analysis suggests only the former. Whence I conceive that the use of chemical facts in constructing rock-names is superfluous.

The inconvenience of making a quantitative chemical analysis before deciding the name of a rock is certainly not the least objectionable feature of the plan.

Geology must always remain more or less of a natural history science and the field geologist will always need a name that will convey some conception of the *appearance* of a rock, such as a mineralogical name will give him.

2. *Geological.* The geological facts that might be used in this connection are *form, age* and *origin*. *Form* has been used to some extent, but it is now so generally recognized that the same rock can occur as dyke, bed, sheet, stream, or stock, that it has properly ceased to have any significance so far as name is concerned. Not so, however, with *age*. The continental geologists divide the massive crystalline rocks into two classes which they call "older" or "younger" according as the rock was formed *before* or *after* the inception of the Tertiary period; and based upon this distinction, the same mineral aggregate is provided with two different names according as it is of Pre-Tertiary or Post-Cretaceous age. Thus I have held in my hand two specimens that could not be distinguished from each other even in thin sections under the microscope. Both contained quartz and sanidine porphyritically developed, the groundmass of both was crypto-crystalline throughout and yet the one was "quartz-porphyry" because Pre-Tertiary, and the other was "quartz-trachyte" because Post-Cretaceous. For the same reason melaphyr is separated from basalt, with which it is otherwise identical; hornblende porphyrite from hornblende

andesite; augite porphyrite from augite andesite; orthoclase porphyrite from trachyte; and diabase from dolerite.

Those who hold to this distinction do not indeed deny the frequent mineralogical identity of the rocks thus separated; but they hold that it is *desirable* to express thus the difference in age of the same mineral aggregate. With Prof. J. D. Dana* I must confess myself unable to see the value of this distinction for the nomenclature of the science. It appears to me much more rational to call a certain mineral aggregate "quartz porphyry" or "liparite" (use which name one will) and to recognize the fact that the rock thus named is sometimes of Silurian, sometimes of Carboniferous, sometimes of Permian, and sometimes of Post-Cretaceous age. We find no difficulty in mineralogy of uniting the quartz of the Pre-Tertiary quartz porphyry with the quartz of the Post-Cretaceous quartz-trachyte (or liparite, or rhyolite) under one species, in spite of the fact that geological periods separated the dates of their formation. One who would advocate their separation into two species would be properly ignored and yet the geologist makes a similar unnecessary and unphilosophical distinction daily.

Moreover those who insist upon this distinction are not consistent. They separate quartz porphyry from liparite, but they fail to separate the Paleozoic granite of the Harz Mts. from the Mesozoic granite of Cornwall; and they fail to separate certain Triassic quartz porphyries of Germany from Silurian quartz porphyries of England. In other words, the line is drawn between Mesozoic and Cenozoic but not betweeen Mesozoic and Paleozoic. The reason for this (Roth, Beiträge zur Petrographie der plutonischen Gesteine in den Abhandlungen der Akademie der Wissenschaften zu Berlin, 1869, p. 74) probably lies in the fact that the earlier geologists were led, through the study of the Mesozoic rocks of Central Europe, to the conception that a period of comparative quiet separated the widespread igneous activity of the Azoic and Paleozoic ages from what appeared to be a renewal of this activity in a different form in Tertiary and Post-Tertiary times. It appeared as though the nature as well as the products of this renewed activity were different. The pronounced absence of volcanoes, lava streams, and tufas seemed to indicate that Pre-Tertiary activity was *subterranean* while *recent* activity finds expression *at the surface* in the form of volcanoes, lava streams, tufa eruptions, and such tremendous sheet overflows as those of Utah, and of Washington Territory, Oregon, and Northern California.

The results of more recent and more widely extended researches do not seem to favor this idea. Paleozoic volcanoes, lava streams, and even tufas have been found and we should

* J. D. Dana. On some points in Lithology. This Journal, iii, p. 336.

certainly expect *à priori* that they would have been formed then as now; but in the tremendous lapse of time that has intervened they would necessarily have become either greatly modified in form by erosion or in appearance by subsequent metamorphism so as to become unrecognizable as such, or indeed entirely obliterated. It would require peculiarly favorable conditions to preserve a Paleozoic tufa in a recognizable condition to the present day. On the other hand, it is now conceived that granitic rocks are forming in the subterranean depths at the present time. The differences that do exist between so-called "older" and "newer" rocks may be due then not to their difference in age, but to the difference in the physical conditions of their crystallization, conditions which held equally in Paleozoic times and in Tertiary times, only the Paleozoic superficial formations have been mostly swept away and the deep seated rocks of that age exposed by the removal of thousands of feet of superincumbent strata while the superficial rocks of Post-Cretaceous times, the trachytes, andesites, phonolites, basalts, etc., are preserved to us because of their recent origin and the granitic rocks *now forming* are too deep-seated to be exposed for observation.

I would oppose then this distinction of rocks into "older" and "newer" (for purposes of nomenclature) first, because the original grounds upon which it was made seem no longer tenable; second, because such distinctions as exist *in fact* between older and younger rocks can be accurately expressed by a purely mineralogical nomenclature; third, because the distinction is not and cannot be consistently carried out between rocks of Mesozoic and Paleozoic age; fourth, because of its great inconvenience. It is not always possible to tell the age of a rock; in the meantime its name must be held in abeyance or at least subject to change. More than one instance will suggest itself to the specialist where the name of a rock supposed to be Pre-Tertiary has been changed when subsequent study in the field has proved the rock to be Tertiary or Post-Tertiary. This element of uncertainty plays sad havoc with rock-names and should be set aside entirely.

The third geological consideration to be noticed is *origin*. The first objection to be urged against its use in rock-naming is the fact that the whole subject of rock-genesis lies too much within the region of theory and even speculation; whence for reasons previously indicated, it should be disregarded in this connection. But even if we could determine for each rock its exact mode of formation, even if we could attach definite conceptions to such terms as "metamorphism," "aqueo-igneous fusion," etc., the objection similar to that urged against "age" would still remain, namely, rocks with the same mineralogical composition would be provided with different names according as they were formed by one process or another. When actual differences in composition result from different modes of formation, such differences will find expression in a mineralogical nomenclature, and when no differences exist, it would seem far more rational to use but a single name. I would quote here. with additions of my own in italics, from Prof. J. D. Dana's Manual of Geology, 3d edit., p. 76. "Further, rocks, as objects in science, should be defined and named according to their kinds,—not according to the era of formation *nor the method of formation*,—since the same things are the same whenever made *and however made*." Fortunately there is no pronounced tendency to transgress in this direction.

3. *Mineralogical.* We come now to an examination of the mineralogical facts at our disposal, in the light of the three principles previously laid down. Under this head I propose to include both the *minerals* themselves and the manner in which they are combined together, in other words *rock-texture.*

First, with respect to the minerals themselves. They are susceptible of exact determination, there can be no differences of opinion as to what the essential constituents of a rock really are. The use of the microscope, the application of polarized light whereby the positions of optical planes can be accurately determined, Sorby's method for determining the indices of refraction of minerals in rock-sections, Thoulet's method of mechanically isolating rock constituents so that they may be quantitatively analysed if necessary, have all reduced the process of mineralogical determination of the constituents even of compact rocks to great exactness.

It may be conceived that the difficulty, rarely perhaps impossibility, of distinguishing between the different kinds of plagioclase * would interpose a serious obstacle in the way of a purely mineralogical nomenclature. But it should be remembered on the one hand that Descloizeaux' optical distinctions and Thoulet's method of mechanical isolation, together enable us, in most cases, to make the distinction with the greatest accuracy and, on the other hand, that the practical distinction between the different forms of plagioclase that occur as rock constituents is of secondary importance compared with the fundamental distinction between orthoclase and plagioclase, and this latter we have always been able to make with the greatest ease.

While it cannot be regarded as proved that albite and anorthite, the soda-plagioclase and lime-plagioclase, do not widely occur as rock constituents, still the results of investigations up to the present point in this direction. It is the intermediate

* I use the term "plagioclase" in its original sense, including the albite-anorthite series and excluding microcline.

members of the plagioclase group for which oligoclase and labradorite stand as types, that most commonly occur. No great element of uncertainty would be introduced into our nomenclature if we considered plagioclase a single mineral species, subject of course to variation in the amounts of soda, lime and silica, and in the future progress of the science, as the exact nature of the plagioclase for each individual case became determined, the name of this variety could easily be substituted for plagioclase in the name of the rock, or used as an adjective modifying the name, if a purely trivial one. We should have, e. g. "oligoclase-basalt" and "labradorite-basalt" in the place of "basalt" as now used. It must certainly be conceded (as indeed it is generally believed) that no weight can attach to the objection that the constituent minerals of a rock cannot be accurately determined.

Supposing, now, that our nomenclature is to be based upon purely mineralogical grounds, it becomes necessary to determine what minerals shall be utilized for this purpose. The mineral constituents of a rock have been divided into *primary* and *secondary* according as they are the product of immediate crystallization out of the original rock-magma before or at the final solidification of the rock; or are produced by changes in the rock subsequent to its final solidification brought about by atmospheric waters or local metamorphism. To these may be added such minerals and fragments as may have been mechanically enclosed during the process of eruption; I shall call such foreign minerals and fragments. With the fragments of course we have nothing to do.

Of these the secondary and foreign minerals should unquestionably be disregarded in naming the rock, as in fact has always been the practice. They are evidently purely adventitious and have nothing whatsoever to do with the rock as such. Their true nature can always be recognized and they consequently introduce no element of uncertainty to create confusion in names. There remain the primary constituents. Among these a certain liability to confusion may exist in the distinction between *essential* and *accessory* constituents. The accessory mineral of one rock is the essential mineral of another, and just where to draw the line is not always at once evident from the fact that an approximate quantitative estimate of the mineral has to be made. It is here that practice only can render skillful. From the nature of the case it can never be otherwise, and serious embarrassment is not to be feared from this source. It is to be presumed that geologists are to be educated and the ability to make such distinctions must be learned. He who runs cannot expect to read. On the other hand, it must be observed that mistakes arising from this source are liable only about the *peripheries* of the rock-groups, to take up Rozenbusch's figure once more; and the alternative is to place the rock in a closely allied group where the mistake, if it be one, can do the minimum of harm.

I have shown thus far that *uniformity* and *stability* would result from a purely mineralogical nomenclature; let us now examine the *adaptibility* of such names. I have already called attention to the variation within certain limits in the relative proportion of the essential constituent minerals of any rock. It is not worth while to express this variation in our nomenclature. In fact it is so irregular, so completely beyond the control of any known or conceivable general law that it would be altogether impossible to express it if we would. Names founded upon mineral composition would ignore this variation so long as it took place within the limits assigned for *essential* constituents. Such names would therefore completely adapt themselves to the natural conditions. They would have moreover even a higher order of adaptability than this. I have quoted Rosenbusch on the subject of rock-groups wherein he asserts the substantial unity of rock-types but of rock-types that are themselves united by transitions due to the gradual replacement of one or more constituents by other minerals, or by a gradual change of texture. Such names can be made to adapt themselves most perfectly to the expression of the relations between the different members of a rock-group and between each and the central type. *To this limited extent* the attempt could safely be made to be *systematic* in our nomenclature; for the relations between the closely allied rocks of each group both chemically and geologically as well as mineralogically are too evident ever to become questioned.

To illustrate with the granite group, Rosenbusch (Massige Gesteine, p. 18) following and developing the suggestion of Gustav Rose has divided and named the group in accordance with these principles. Quartz, orthoclase, and plagioclase are present in every granite; associated with these are muscovite, biotite and hornblende, sometimes one, sometimes two. When muscovite alone is present we have muscovite granite; when biotite alone, biotite-granite (or granitite); when hornblende alone, hornblende granite, when muscovite and biotite together, granite (in strict sense); when biotite and hornblende, biotite hornblende granite, or, more conveniently, hornblende granitite. Muscovite and hornblende do not occur simultaneously with the type constituents, but if they did it would be a simple matter to make a name for the rock.

The basalt group furnishes another good instance. From basalt as a central type (plagioclase, augite, olivine) we pass to nephelite basalt (−plagioclase + nephelite), or to leucite basalt

(—plagioclase + leucite), or to diallage basalt (—augite + diallage.)

In this way then our nomenclature could easily adapt itself to the special circumstances of each case. If it were considered desirable, purely trivial names could be given to each of these closely allied rocks; but my own preference would be for descriptive names so long as they could be formed by the use of a single mineral name as a modifier, such as "biotite granite," "leucite basalt," and for the reduction in number of the purely trivial names to a minimum.

In addition to the mineral constituents, many rocks contain more or less of the solidified magma-residuum that was not taken up by the crystalline elements before molecular freedom of motion was stopped by the final solidification of the rock. This varies in quantity all the way from 100 per cent (as in obsidian) down to 0 per cent as in granite. This evidently can not be disregarded; but the part it should play can be better discussed perhaps under the head of *texture*.

Rock Texture.—From the earliest times texture has been utilized for the purpose of naming rocks, and the desirability of continuing its use particularly for purposes of descriptive petrography is evident. It is none the less so from the fact that it is the expression, so far as we yet understand it even more perfectly than the minerals themselves, of the prevailing physical conditions during the process of cooling and solidification.

Can rock-texture be used in forming a nomenclature, without danger to our fundamental principles? Does it present itself in such forms as to be accurately and universally recognized? The accuracy with which Rosenbusch has defined (l. c. p. 70 et seq.) certain important forms of macro-, and micro-texture renders possible an affirmative answer to these two queries. I will reproduce his definitions. Ground-mass is the term applied to the compact portion of a rock as distinguished from the large, distinctly visible, disseminated crystals. It is entirely a macroscopic conception. Under the microscope this ground-mass may be developed entirely crystalline, i. e. anisotropic; or as a mixture of crystals and isotropic material called the *base;* or entirely isotropic. If entirely anisotropic, it may be either micro-crystalline, i. e. made up entirely of distinct crystalline granules; or cryptocrystalline, i. e. consisting of anisotropic material throughout but with the crystalline individuals altogether indistinguishable from one another. No sharp distinction can be drawn between these two; they pass by insensible transitions into each other.

If the ground-mass contains isotropic material, this material may be developed as a *microfelsitic base*, i. e. showing no polarization and no glass, but consisting entirely of granules, scales and thread-like forms; or as a *glassy base*, i. e. a glass with products of devitrification; or as a pure *glass* without any of these devitrification products.

I would not pretend to base any distinction in nomenclature upon differences between these three latter forms of ground-mass. They are exceedingly interesting and important as showing at precisely what stage molecular freedom of motion was arrested in the cooling magma; or if one will, the precise stage of subsequent molecular rearrangement in the "older" rocks. But the distinction cannot invariably be sharply drawn between them.

One can however at once distinguish sharply between the *presence* or *absence* of isotropic material in the ground-mass, and upon this a distinction in nomenclature can safely be based. Bearing in mind the terms thus defined, I will illustrate the use that can safely be made of rock-texture, by applying it to the series of rocks having obsidian at one extreme and granite at the other, including thus the liparites and quartz porphyries.

If the rock is to the unaided eye distinctly and completely granular, it would be "granite." If some of the constituents were developed in larger crystals than the rest it could be indicated by the term "porphyritic granite." If the size of the granules diminished until the rock became compact and the texture were micro-crystalline or crypto-crystalline, it could be called with Rosenbusch "microgranite," and if porphyritic, "porphyritic microgranite." If the ground-mass contained isotropic material it would be desirable to distinguish between two cases; first, where the crystalline portion is in excess (the "quartz porphyries"), second, where the isotropic portion is in excess ("the obsidian porphyries.") I would call the first kind "quartz porphyry" whether the base were microfelsitic, glassy or pure glass. Or the trivial name "liparite" could be used, with the understanding however that the name should always indicate the presence of base in the ground-mass with disseminated crystals in excess. The "obsidian porphyries" could be distinguished, if desirable, as "microlitic obsidian porphyry," "felsitic obsidian, porphyry" and "glassy obsidian porphyry" according as the base showed a microlitic differentiation (as in the "younger" pitchstones), a felsitic devitrification (as in the "older" pitchstones) or remained in a purely glassy state. Finally when no recognizable crystalline minerals were present, the term "obsidian" could be used, and, if desirable, we could also distinguish "microlitic obsidian" (trachyte pitchstone), "felsitic obsidian" (felsite pitchstone) and "glassy obsidian."

Subjoined is a table of the terms I have thus constructed, opposite to each the term Rosenbusch has applied to the same mineralogical and textural aggregate.

Jackson.	*Rosenbusch.*
Granite,	Granite. Granitic liparite (in part).
Porphyritic granite,	Porphyritic granite.
Microgranite,	Microgranite. Felsite fels.
Porphyritic microgranite,	Quartz porphyry. Granitic liparite (in part).
Quartz porphyry,	Liparite. Felsophyr. Vitrophyr (in part).
Obsidian porphyry, microlitic,	Trachytic pitchstone porphyry.
Obsidian porphyry, felsitic,	Felsitic pitchstone porphyry. Vitrophyr (in part).
Obsidian porphyry, glassy,	Obsidian porphyry.
Obsidian, microlitic,	Trachytic pitchstone.
Obsidian, felsitic,	Felsitic pitchstone.
Obsidian, glassy,	Obsidian.

In these names which I have thus suggested, the much abused term "porphyry" obtains a perfectly definite meaning; it indicates always the presence of determinable crystalline constituents and of a base, which is of course always isotropic. The term "porphyritic" would be used only in the macroscopic sense. These names are as much as possible descriptive; trivial names could be substituted throughout but, as I have said before, I think such names should never be coined where a convenient descriptive one will answer the same purpose. It will be observed that, following the principles previously laid down every possible textural aggregate in the series has received a name, that each has received but *one* name, that, consequently, the same name is never applied to aggregates that are objectively distinct, and finally that they are based upon distinctions about which there can be no differences of opinion.

In a similar manner these textural distinctions could be applied to every similar rock-series and perfect uniformity and consistency established throughout.

I have discussed in the present chapter only the most general considerations. Even if the principle of a strictly mineralogical nomenclature were accepted, the exact part which the different essential rock-constituents would play therein would still remain to be determined. The discussion of this question is premature, however, until the more fundamental proposition is recognized.

It seems to me clear that a rock-nomenclature founded upon purely chemical or geological or upon mixed chemical or geological principles either with each other, or with mineralogical principles, necessarily *must* lead, as it certainly *has* led, to much confusion in the science; and that we can only hope for a satisfactory, uniform and consistent nomenclature when based upon mineralogical grounds alone. It is only thus that an exact system of names can arise that can give worthy expression to the exact work that is now being done in this department of geology. Until some such uniform system is established we must continue to waste our energies in struggling to understand one another when the real difficulty is not with the *facts* but with the *terms* in which we express them. The energies expended in this effort would be far more profitably utilized in advancing our knowledge of the facts themselves.

Justin Roth says that Petrography as a descriptive science loses all significance.* True, but it must be remembered that the purely *descriptive* stage of a science must always precede the *scientific* stage; and that the latter stage is only possible after the former has become *exact*. Whatever conduces to exactness of expression in descriptive petrography will add greatly to the *scientific* usefulness of this branch of geology in helping to solve many of the profoundest problems that engage the attention of the geological thinker of the present day.

Chapter II.

It will be observed that I refrain from any attempt to frame a system of names in accordance with the principles I have laid down. I do this because I think that no new name should be introduced into a science unless it is tolerably sure of being accepted in the sense in which it is proposed. Names are used to promote *clearness* and not *confusion* and unless this end can be attained it is better to refrain entirely from their introduction. The reformation of the entire nomenclature of a science is a task that should be attempted only by one who has gained authority by long years of special work, by one who is universally recognized as fitted for the undertaking. There are but one or two men living who could hope to succeed.

All that can be hoped for under the circumstances is that every writer should use the *same* nomenclature; *uniformity*, even if based upon principles that all will not accept as valid, is of the first importance. It is better that each should forego the luxury of insisting upon individual idiosyncracies, which in the majority of cases can never hope to become currently accepted than that by so doing he should add to the existing confusion. Just as strongly as Capt. Dutton † would insist upon

* Gest. Anal., 1873, p. 90. Die Petrographie, welche nicht mit den beschreibenden Zweigen der Naturwissenschaft in einer Reihe gestellt werden kann, gewinnt nur durch die Unterordnung unter die geologische Forschung ihre Bedeutung.

† Geol. of High Plateaus, p. 85.

the duty of each to express his ideas in the form of a classification, just so strongly would I insist upon the duty of each to refrain from using a name in a different sense from that in which it was originally proposed, or from that which is already current.

In selecting a nomenclature, that one should be chosen which is embodied in a convenient form accessible to all, which is freest from inconsistencies, and which has already attained the widest recognition. No American author, nor English, nor French can pretend to claim that his names are authoritative even in his own country. Germany if not the mother is at least the foster-mother of petrography and the literature of every other country is small compared with her own. In Germany two men—Zirkel and Rosenbusch—have won the highest recognition for their contributions to this branch of geology. Zirkel's "Lehrbuch der Petrographie" (1866) while still the best for field petrography is already too old to represent the present condition of the science. Of more recent works, Zirkel's "Mikroskopische Beschaffenheit der Mineralien und Gesteine" (1873) and Rosenbusch's "Mikroskopische Physiographie der massigen Gesteine" (1877) are most worthy of being cited. The latter is later and goes more systematically over the entire field. I think Rosenbusch's names are better chosen and capable of better defense than Zirkel's, where they differ. I shall follow Rosenbusch in the series of papers which I propose to present to the Academy of Sciences of California on the rocks of the Pacific coast.

Summary.

Permanence of rock-names is desirable; hence names should not be dependent in any manner upon the system of rock-classification, for classifications change.

The names of rocks should be *uniform*, i. e., used in the same sense by all geologists; they should be *stable*, i. e., not subject to change; they should be *adaptable*, i. e., to the somewhat variable nature of each rock.

In forming rock-names both *facts* and *theories* offer themselves as determining elements. The latter should be rejected as they admit of honest differences of opinion. Of facts, we have chemical, geological and mineralogical at our disposal.

Both chemical and geological facts should be rejected in determining rock-names, because mineralogical (and textural) differences among massive crystalline rocks can be adequately expressed by a purely mineralogical (and textural) nomenclature, and where such differences do not exist, it is undesirable to have names based upon geological or slight chemical differences.

It is only by the adoption of names based upon purely mineralogical differences that we can hope to obtain a nomenclature that shall conform to the three fundamental principles of Uniformity, Stability, and Adaptability.

As it is not to be hoped that a sweeping reform in petrographical nomenclature can be carried out at once, the good of the science requires that at least the first and most important of these principles, viz: Uniformity, should be recognized and in conformity therewith that all should use some one published and easily accessible system of names until a *better* complete system of names can be offered with some chance that it may be generally adopted.

In the opinion of the writer, the nomenclature of Rosenbusch as recorded in his "Massige Gesteine, 1877," is the most widely recognized and the best now accessible.

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ART. XVI.—*Communications from the U. S. Geol. Survey, Rocky Mountain Division.* I. *On the Minerals, mainly Zeolites, occurring in the basalt of Table Mountain, near Golden, Colorado;* by WHITMAN CROSS and W. F. HILLEBRAND.

(Continued from page 458, vol. xxiii.)

4. APOPHYLLITE.

THIS mineral occurs in well-developed crystals of prismatic habitus, with *i-i* (∞P∞) and 1(P) predominating, while 0(0P) is in most cases quite subordinate, or wanting entirely. The larger crystals, which are occasionally half an inch in diameter, are often of a greenish tinge, sometimes quite pronounced, and possess more or less uneven surfaces produced by a repetition of the crystal faces, so that the termination is made up of a large number of small pyramids.

The prismatic surfaces are roughened by depressions or elevations, bounded by prism and pyramid planes. This feature is very prominent in all large crystals. The smaller ones are in contrast sharp and clear, with smooth, brilliant faces. Especially noticeable on these small and clear crystals, though not peculiar to them, is a replacement of the pole edge of the pyramid, by a small reëntering angle formed by pyramid faces. This angle is nowhere prominent, yet may be easily identified on all clear crystals both large and small. No corresponding irregularity of any kind could be detected on the dimetric prism of these crystals.

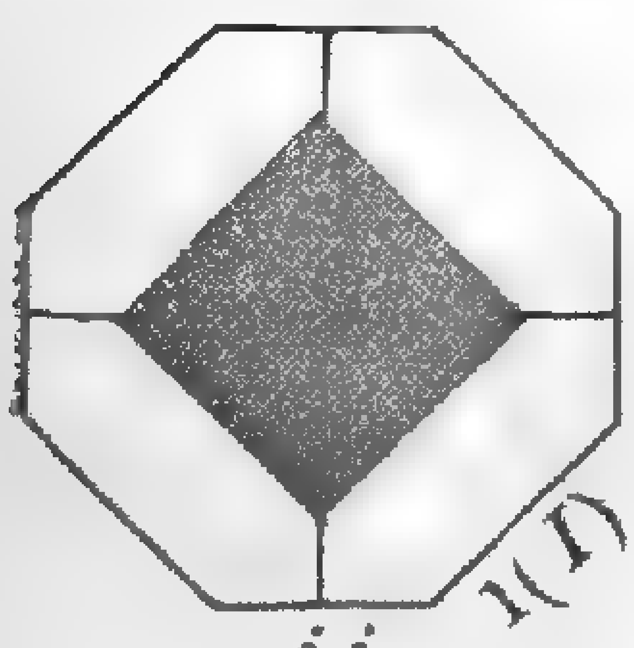
As a rule, the largest crystals occur in the small cavities, and their growth has been more or less hemmed by the walls, while the more perfect crystals are present in the large cavities, and are usually small and numerous.

In time of deposition apophyllite follows analcite. The optical properties of this apophyllite are noteworthy in so much as they seem to indicate very clearly the cause of the anomalous action, so often noticed in that mineral. No hypothesis of a complicated twin structure, such as that of Rumpf,* to cite the most recent, as well as the clearest and most consistent, can explain the phenomena observed in this apophyllite. While an extended description of the observed anomalies is impossible in this notice, the chief features will be given.

If from a small, clear crystal from Table Mountain a section be taken parallel to the base (0) and so situated that it cuts both pyramid (1) and dimetric prism (*i-i*), an eight-sided figure results (see fig. 1), in which the outlines of the pyramid will be referred to as those of the normal prism (*I*).

Such a section seen between crossed Nicols, whose principal sections lie parallel to the diagonals of *I* (position I), presents an appearance indicated by the diagram, fig. 1. There appears, namely, a dark square, whose sides lie parallel to the outlines of the prism (*I*), with dark lines running to the outlines of *i-i*, and perpendicular to the same, thus coinciding with the diagonals of *I*. The dark square and lines are well defined. The outer zone, divided by the dark lines into four segments, is in position I at its maximum of brightness.

1.



i-i

On revolving the section through 45°, or until the principal sections of the Nicols coincide with diagonals of *i-i* (position II), the whole field becomes equally dark, and the interference cross of the calcite plate suffers no distortion in any part of the section.

The dark square and lines revolve with the section, and the darkening of the outer zone is gradual. It is in but few cases, however, that the action of a crystal agrees entirely with the above. The variations can, however, be most easily described and best understood by comparison with that action as a basis.

In the first place, the outline of the dark figure is seldom that of a true square, its sides being usually more or less broken lines, even when the angles remain nearly or quite 90°. It may, too, resemble a rectangle rather than a square. The dark lines subdividing the outer zone are less frequently variable than the outlines of the figure. In proportion as the form of the dark figure approaches the square in regularity, so is the optical behavior of the space enclosed uniform. In one case observed,

* J. Rumpf "Ueber den Krystallbau des Apophyllits" Min. und petr. Mittheilungen von G. Tschermak, Neue Folge, ii, 369 (1879).

a section placed in position II was wholly dark, excepting at one of the angles of the square, where a faint light was visible, producing distortion of the calcite interference cross at this point. In another section, in position I, the dark figure was not completely dark, there being light enough to admit of the distinct appearance of two perfect black crosses, whose thick bushy arms lay parallel to the diagonals of prism I, and which, revolving with the section, disappeared entirely in position II. All but transmitted light must be excluded, in order to see these crosses distinctly, as the whole of the square is still very dark in contrast with the outer zone. In cases where the boundaries of the dark figure are much-broken lines, the space within is commonly divided into a number of irregular patches, each with its black cross, seen in position I. In such cases, too, the whole field does not become uniformly dark in any position. The size of the dark figure relative to that of the section varies greatly. In most cases the relation is similar to that of fig. 1; while in some prismatic sections the dark square is larger than can be inscribed within the prism, its angles being cut off by the outlines of *i-i.* Again, the dark figure becomes very small, though in no case yet observed has it been entirely wanting.

It is impossible to indicate all the irregularities observed, within the limits of this article, and the fuller description of these interesting phenomena must be reserved for the final report on the region embracing Table Mountain.

None of the sections thus far prepared, parallel to the prism *i-i*, have exhibited any marked abnormal properties.

It is thought that the degree of variation, in the optical properties, from the simplest form illustrated by fig. 1, stands in intimate relation to the degree of irregularity in crystal growth indicated by the faceted surfaces. Certainly no hypothesis, however ingenious, which considers the tetragonal symmetry of apophyllite as a result of intricate polysynthetic twin structure of rhombic or monoclinic individuals (that of Rumpf l. c.), can explain the present case with a tithe of the plausibility with which the theory of *inner tension** is able to do it.

It is hoped that further investigations will prove the direct applicability of this latter theory to the present instance.

* As leading instances of the application of this theory to the explanation of optical anomalies in minerals may be mentioned:—

(*a.*) C. Klein, "Ueber den Boracit," Neues Jahrbuch für Mineralogie, etc., 1880, ii, p. 209.

(*b.*) C. Klein, "Zur Frage über das Krystallsystem des Boracits," ibid., 1881, i, p. 239.

(*c.*) Alfredo Ben-Saude, "Ueber den Analcim," ibid., 1882, i, p. 41.

(*d.*) F. Klocke, "Ueber Doppelbrechung regulären Krystalle," ibid., 1880, i, p. 53.

F. Klocke * in a critical review of Rumpf's hypothesis (l. c.), advocated the theory of inner tension (Spannung) in explanation of the anomalous optical behavior of apophyllite. He also showed that Rumpf's hypothesis could not correctly explain phenomena in apophyllite much simpler than those above described.

In chemical composition this apophyllite is quite normal, the fresh substance yielding the following:

SiO_2	51·886
Al_2O_3	1·540
Fe_2O_3	0·130
CaO	24·513
K_2O	3·809
Na_2O	0·590
H_2O	16·523
Fl	1·700
	100·691
O for Fl	0·716
	99·975

Considering all potassium and sodium as combined with fluorine, the following oxygen ratios are afforded:

RO	SiO_2	H_2O
1	3·95	2·09

The theoretical proportion 1:4:2 would be still nearer approached were it not for a probable slight loss of silica and excess of water, scarcely to be avoided in analyses of silicates containing fluorine. The Fe_2O_3 is undoubtedly owing to minute particles of limonite, which could not be completely removed. The Al_2O_3 is much higher than in most analyses, and the condition in which it is present seems undeterminable.

Much of the Table Mountain apophyllite has suffered alteration to a snowy-white substance resembling that commonly known as *albine*. Knop † has proved, for many cases at least, that this latter substance is calcite. At Table Mountain, however, although the end product resembles albine, it is in reality of totally different nature.

Up to the present time it has been impossible to procure the alteration product, sufficiently free from fresh or partially decomposed apophyllite, to allow of its exact determination. From analyses made, it is certain that Fl, the alkalies and Ca decrease markedly, while the percentages of SiO_2, Al_2O_3 and H_2O increase greatly.

* F. Klocke, review of Rumpf's article, "Ueber den Krystallbau des Apophyllits," in "Neues Jahrbuch," etc., 1880, ii, p. 11.

† In Blum, "Die Pseudomorphosen, etc., Dritter Nachtrag," 1863, p. 41.

There is no calcite in the product at all. The substance is light, has a pearly luster, and is finely foliated parallel to the basal plane of the apophyllite. The alteration proceeds from without. Further data concerning the substance and the process of alteration will be given in the final report.

5. Calcite.

The carbonate of calcium has had three periods of deposition in the basaltic cavities of Table Mountain—two as calcite, and one as aragonite.

In the form of wine-yellow crystals, it preceded even chabazite, being in all observed cases deposited directly on the basalt, and coated usually by chabazite or thomsonite.

It is rarely found in those cavities to which water has had access through fissures, having been dissolved.

The second deposit of calcite came after apophyllite. These crystals are colorless or slightly straw-yellow, and the form of both varieties is commonly that of a sharp scalenohedron terminated by a low rhombohedron.

The aragonite is present only as a snow-white incrustation, apparently with a special tendency to deposition upon chabazite, though often noticed on apophyllite and thomsonite. It was next to the last mineral deposited, only mesolite having been observed upon it.

6. Mesolite.

Mesolite is the last of the minerals deposited at the locality on North Table Mountain, where all of the species thus far described occur so often together, that their order of succession is plain (this Journal, June). The mineral appears uniformly in masses composed of exceedingly delicate needles, loosely grouped together, very much like the spicules of a fine sponge. Such light aggregates frequently fill the smaller cavities entirely. In the larger ones, the bases of the rounded bunches, 1 to 2 inches in diameter, often touch each other. The very latest deposition, the finishing touch so to speak, is a thin film, coating the whole mass. This is sometimes a continuous membrane, and in other cases more like a thick cobweb. The exquisite delicacy of some of these films is quite wonderful. In rare cases, bunches on the upper and lower walls of a cavity are united by such a membrane. Single needles are clear, but the aggregate appears pure white.

As was mentioned under thomsonite, the loose aggregates of the second generation of that mineral, seem specially suited to attract the deposition of mesolite.

None of the mesolite needles are large enough to allow any determination of their crystal form, even under the microscope at a high power. They seem simply like very fine transparent hairs. The identification as mesolite, rests therefore, on the following chemical analysis:

	a	*b*	*c*
SiO_2	46·138	46·020	46·333
Al_2O_3	26·880	26·870	
CaO	8·770		
Na_2O	6·190		
H_2O	12·168	12·169	12·130
	100·146		

Oxygen ratio:

RO	R_2O_3	SiO_2	H_2O
1	3·06	5·99	2·63

If mesolite be considered as a mixture of the isomorphous silicates contained in scolecite ($CaAl_2Si_3O_{10}+3$ aq) and natrolite ($Na_2Al_2Si_3O_{10}+2$ aq), the present occurrence would answer very nearly to the requirements of the combination of 2 of scolecite + 1 of natrolite, the percentages of which would be SiO_2 46·32, Al_2O_3 26·40, CaO 9·61, Na_2O 5·32, H_2O 12·35 = 100·00.

With mesolite ends the chief series of Table Mountain zeolites. The species described are for the most part clear or colorless, and well defined in crystallization, while they occur so often associated as to make the order in which they have been described a perfectly natural one.

A *second series* of zeolitic minerals will now be taken up, the members of which, in time and manner of deposition, and partially also in composition, are very distinct from those already mentioned.

In the previous article (this Journal, June) chabazite was stated to be "the oldest of the zeolites, with the exception of certain peculiar stratified deposits in some of the cavities." Since then the character of these deposits has been determined, and an interesting association of minerals discovered.

The attention of an observer in the zeolitic zone of Table Mountain is immediately attracted to a reddish-yellow sandstone-like material, which occurs in many of the cavities. In the larger ones it takes the form of a floor, the upper surface being horizontal, and the deposit may be several inches in thickness. Small cavities have been completely filled by it, and it is clear that the deposition has taken place from the bottom of each cavity, upward.

In parts of South Table Mountain especially, the same material has filled fissures. Usually the *lower* portion of such masses is composed of a reddish-yellow mineral, in irregular grains, which form a compact aggregate, in which lie isolated spherules of a similarly colored radiate mineral. These spherules are seldom more than 2^{mm} in diameter, and are very perfect spheres. They increase in number upward and finally compose the greater part of the deposit.

In one cavity, 6 to 8 feet in horizontal diameter and about two feet in height, the deposit is quite different. Here the main mass is loosely granular, and is formed chiefly by a bright greenish-yellow mineral, while a stratified appearance is produced by layers of a white or colorless mineral. Some of the light layers are chiefly made up of easily recognizable stilbite, and the same mineral in distinct tablets forms the upper layer of the whole deposit. There are also irregular seams of white running through the yellow mineral.

The determination of the minerals in these deposits began with the greenish-yellow sand of this last mentioned cavity, and the description will follow the same order.

If the loose sand be placed under the microscope with a power of about fifteen diameters, it is seen to consist of prismatic grains, mostly with broken terminations. Many of the grains are clear and transparent, with the greenish-yellow color mentioned, while others are dull. The clear prisms polarize strongly, and extinction takes place at an angle of 35° to 40° with the vertical axis.

On splitting open some of the white layers, surfaces are obtained, showing minute, stout prismatic crystals, which, seen under the microscope, present the same habitus as the yellow grains. The prism angles are nearly 86° and 94°, and the termination is usually formed by an oblique plane, like a hemidome of the monoclinic system. The optical orientation is the same as in the yellow crystals, and corresponds also to the requirements of the monoclinic system so far as can be determined. The properties given agree with those of laumontite, and in the light of the following analyses, the identification of both yellow and white crystals with that mineral seems entirely justifiable.

	a Yellow grains.	*b* White crystals.
SiO_2	51·738	52·835
Al_2O_3	21·649	21·619
Fe_2O_3	0·947	
CaO	11·949	11·406
Na_2O	0·191	0·484
K_2O	0·352	0·424
H_2O	13·297	13·324
	100·123	100·092

Oxygen ratios:

	RO	R_2O_3	SiO_2	H_2O
a	1	2·95	7·83	3·35
b	1	2·93	8·16	3·43

Aside from the H_2O, these ratios agree closely with the theoretical requirements of laumontite 1 : 3 : 8 : 4, especially as it can scarcely be supposed that the material was absolutely pure. It is quite probable that a small amount of stilbite was included with *b*, which would explain the high percentage of SiO_2.

In regard to the amount of water found it is only necessary to suppose that the dull particles have lost a part of their water, while the transparent grains are entirely fresh, in order to explain the relation of water to the other constituents as shown in the above ratios, a supposition in full accord with the characteristic tendency of laumontite to lose its water on exposure.

The mineral is not quite so easily fusible before the blowpipe as typical laumontite should be, according to the textbooks, but the difference is not sufficiently pronounced to be considered abnormal.

Turning now to the more compact reddish-yellow deposits, which correspond so closely to the one described, the same constituent minerals were sought for. Some small cracks or fissures, usually ending blindly in the yellow mass, were noticed, some of which were only partially filled with minute white crystals. On splitting the mass open, along such a half-filled crack, two surfaces were obtained, coated with minute, but exceedingly perfect clear crystals, easily recognizable under the microscope, as laumontite and stilbite. The little crystals of the former show occasionally the clinopinacoid, and a steep positive orthodome in addition to the prism and basis.

The sand obtained by simple fracture of the yellow, massive portion, on being placed under the microscope, is seen to consist largely of fragments of tabular crystals, the angles of which, so far as they are determinable, correspond to stilbite. The grains which are not evident fragments of tablets, are in part roughly prismatic, though seldom showing definite faces; neither could the optical action be satisfactorily determined.

Chemical analyses were made from two different specimens of the yellow granular mass, care being taken to exclude all reddish spherules. The results are given under *c* and *d* below.

	c	*d*	*e*
SiO_2	55·370	54·802	40·518
Al_2O_3	17·641	17·557	29·216
Fe_2O_3	0·790	0·754	0·788
CaO	8·525	8·412	12·427
K_2O	0·173	0·069	
Na_2O	1·429	1·506	4·306
H_2O	16·278	17·040	12·794
	100·206	100·140	100·049

The oxygen ratios are:

	RO	R_2O_3	SiO_2	H_2O
c	1	2·99	10·42	5·11
d	1	3·00	10·42	5·40

This composition is such as would result from a mixture of stilbite and laumontite, and although the latter mineral could not be positively identified in the sand examined with the microscope, there seems to be no good ground for doubting that it is actually present.

It seems remarkable that the material from two different cavities should contain the two minerals in so nearly the same proportions, as indicated by the analyses.

Concerning the reddish spherules, no data of importance could be obtained except by chemical analysis. Under *e* above is given the composition found for this substance in material which was apparently very pure.

The oxygen ratio for this, is:

RO	R_2O_3	SiO_2	H_2O
1	2·98	4·64	2·44

These figures agree so well with those obtained for the thomsonite of the first series (see Analysis I in June number, this Journal), viz:

1 : 3·09 : 4·76 : 2·51

that in absence of anything to the contrary, the identity of the two substances can scarcely be doubted. It was noticed here as in the other thomsonite, that about 2 per cent of the water could be expelled only at a very high temperature.

Thomsonite in the form of these reddish spherules has been deposited locally in great abundance in irregular cavities on the upper surface of the lower sheet of basalt, and also in the angular spaces, formed where the scoriaceous crust of the flow has been broken or crumpled. It is here deposited alone, free from stilbite and laumontite, but the spherules are exactly similar in size and appearance to those formed in the cavities below.

The ferric oxide in all these minerals seems to replace a portion of the alumina.

The occurrence of cavities containing these stratified deposits side by side with those entirely free from anything of the kind is very interesting. It seems to be explainable with plausibility on the theory that fissures formerly led into those cavities containing the reddish deposits, which were naturally followed by percolating waters.

The formation of zeolites in all cavities alike could only begin after the filling up of these fissures by the deposition of mineral matter. In support of this theory, it was noticed that in no case were the reddish deposits formed upon any clear mineral of the first series described, and that in all cases where minerals of the first series were formed in cavities containing the stratified deposits, they occurred in the same order and manner as in any other cavity, being situated on the roof and sides as well as upon the floor. Fissures filled with these reddish minerals were in fact seen in several cases leading into cavities containing stratified deposits of the same minerals.

In a third article, still other zeolitic species from Table Mountain will be described.

ART. XVII.—*On a Property of the Isentropic Curve for a Perfect Gas as drawn upon the Thermodynamic Surface of Pressure, Volume and Temperature*;* by FRANCIS E. NIPHER.

THE equation of this thermodynamic surface is

$$pv = \text{RT}, \tag{1}$$

where p, v, T represent the pressure, volume and absolute temperature, and where R is directly proportional to the volume of a unit mass (or inversely proportional to the density) of the gas at a standard temperature and pressure.

By differentiation (1) becomes

$$dp = \frac{\text{R}}{v}d\text{T} - \frac{\text{RT}}{v^2}dv \tag{2}$$

For convenience putting

$$\frac{\text{R}}{v} = \text{A}, \quad \frac{\text{RT}}{v^2} = \text{B},$$

and (2) becomes

$$dp = \text{A}d\text{T} - \text{B}dv. \tag{3}$$

1°. To find the direction of maximum slope with respect to the v,T plane at any point on the surface. For this purpose pass a plane through any point in the surface, and at right angles to the v,T plane. Its trace upon the v,T plane is

$$\text{T} = \beta + av, \tag{4}$$

p being indeterminate; where a is the tangent of the angle which the trace makes with the v axis, or

$$a = \frac{d\text{T}}{dv}. \tag{5}$$

From (3) and (5) we have

$$dp = (\text{A}a - \text{B})\ dv. \tag{6}$$

* From Trans. of St. Louis Academy of Science, read April 3, 1882.

Calling S the slope of any element of the intersection of the plane and the surface, dz being the projection of the element on the v,T plane, we have

$$S=\frac{dp}{dz}=\frac{dp}{\sqrt{dv^2+dT^2}}, \qquad (7)$$

which by (5) becomes

$$S=\frac{dp}{dv}\cdot\frac{1}{\sqrt{1+a^2}},$$

and by (6) we have further

$$S=\frac{Aa-B}{\sqrt{1+a^2}}. \qquad (8)$$

In determining the direction of maximum slope at any point, it is evident that A and B will be constant, which gives as the required condition,

$$\frac{dS}{da}=\frac{A+Ba}{(1+a)^{\frac{3}{2}}}=0,$$

or

$$a=-\frac{A}{B}.$$

Substituting the values of A and B, we have

$$a=-\frac{v}{T}=-\frac{R}{p}=\tan i. \qquad (9)$$

For very low pressures, the direction of maximum slope $\frac{dp}{dz}$ becomes more and more nearly at right angles to the plane of p,v; while for high pressures this direction becomes more and more nearly parallel to the plane of p, v. The direction of maximum slope is constant along a line of constant pressure.

2°. To find the direction of the isentropic line at any point on the surface, as related to the direction of maximum slope determined in (9).

Poisson's equation:

$$Tv^{k-1}=\text{const.} \qquad (10)$$

is a projection of the isentropic line upon the plane of v, T, where k is the ratio of the specific heats = 1·41.

Calling a' the tangent of the angle which any element of this projection makes with the v axis, we have

$$a'=\frac{dT}{dv}=\tan i'.$$

This value of a' is obtained by differentiating (10) and is found to be

$$\frac{dT}{dv}=-\frac{T}{v}(k-1)=-\frac{P}{R}(k-1). \qquad (11)$$

Here also the condition of constant pressure gives a constant value for a'. Hence, at any point along any line of constant pressure the projection of an element of the isentropic line, upon the v, T plane, makes a constant angle with the projected line of greatest slope at the same point.

From equations (9) and (11) it follows that

$$\tan i' = \frac{k-1}{\tan i}; \qquad (12)$$

from which it will appear that for either very high or very low pressure the isentropic line runs at right angles to the direction of greatest slope. The condition that it shall coincide with the direction of greatest slope is

$$\tan i' = \sqrt{k-1} = \frac{R}{p'},$$

or

$$p' = \frac{R}{\sqrt{k-1}}. \qquad (13)$$

For air this pressure is about 3·2 millimeters of mercury, and for other gases it is proportional to the volumes of a unit mass, at a standard temperature and pressure.

The thermodynamic surfaces of various gases will lie the one above the other, those having the largest value of R being uppermost. If we now substitute the value of p' of (13) in the original equation of the surface, we have

$$v = \sqrt{k-1}\,T, \qquad (14)$$

which is independent of R. Hence, for all gases which follow the law represented in (1) the lines on their respective surfaces, where the isentropic lines coincide with the direction of maximum slope (13), will all lie in a common plane passing through the axis of P and at right angles to the plane of v, T, its trace upon the latter plane being represented by (14).

If the gases have a common temperature while in this condition, (14) shows that they will also have a common density, which when T is 273° will be 0·000058 grams to the cubic centimeter.

It will be observed that for air, the pressure indicated in (13) is practically the same as that at which Maxwell's law for viscosity begins to fail. This, however, is a mere coincidence. The two phenomena have nothing in common, as is evident both from theoretical considerations and from experimental results.

Washington University, March 30, 1882.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Constitution of Solutions.*—Krüss has applied the spectroscope to the determination of the constitution of solutions. It is well known that the absorption-spectrum of a solution containing two or more colored substances does not correspond in all cases to the sum of the separate spectra. Whether this has a chemical or physical cause has not been settled, though the former is generally assumed. For the comparison of single spectra, Krüss used absorption cells with parallel glass sides, the width of the cell being exactly 5^{mm} and the sides being 2^{mm} thick, and called a. Two of these cells, containing different liquids and placed one behind the other, gave the physically mixed spectra. For the chemically mixed spectra the two solutions were mixed in the proportion of 1:1 and placed in a glass cell whose interior width was $10+a^{mm}$, and whose glass sides were a^{mm} thick. A glass plate of thickness a was placed within the liquid and a second one outside, both being perpendicular to the light-rays. The liquid layer has thus the same thickness as in the previous case, 10^{mm}, the glass absorbing layer has the same thickness, $4a$, and there are as before 4 reflections between liquid and glass and 4 between air and glass. As an illustration, the action of aqueous solutions of pararosaniline (fuchsine), and trinitrophenol (picric acid), is described. The former showed the strong absorption bands from $\lambda=570·4$ to $518·2$ the intensity diminishing—with the exception of a band $\lambda=485$—toward the more refrangible end to $\lambda=429·6$, where it again suddenly increased. The latter showed no distinct color between $\lambda=483·8$ and the violet. When the two cells were interposed, the strong bands at $\lambda=570·4-518·2$ appeared, and also the strong absorption beginning at $\lambda=483·8$. When a mixture of the two solutions was examined, the absorption bands $\lambda=570·4-518·2$ had disappeared and a pretty strong absorption from $\lambda=576·9$ toward the violet had taken its place, while from $\lambda=483·8$ no distinct color could be recognized. These changes have unquestionably a chemical origin. If, however, solutions of neutral potassium chromate and ammonium-cupric sulphate be mixed, no distinction can be observed qualitatively between the spectrum of the mixture and the sum of the two single spectra. When these spectra are examined quantitatively by Vierordt's method, on the other hand, using a solution of the former salt of the concentration $y=0·01805$ grams in 1^{cc}, and one of the latter of $x=0·02$ grams, the superposed spectra show in the region E26F—E45F, a light-intensity of 0·2366 and E63F—E80F of 0·361, corresponding to the extinction-coëfficients $\varepsilon_1=0·52784$ and $\varepsilon_2=0·44250$. These coëfficients, calculated by Vierordt's formula from his data, are identical with the above values within the limits of error. In

the region E26F—E45F, the absorption-constant for ammonium-cupric sulphate is $\alpha=0.02192$ and for potassium chromate $\beta=0.1292$; and in the region E63F—E80F it is $\gamma=0.03472$ for the former, and $\delta=0.05937$ for the latter. From the formula $\varepsilon_1=\frac{x}{2\alpha}+\frac{y}{2\beta}$, the value of $\varepsilon_1=0.52611$ for the former region, and $\varepsilon_2=\frac{x}{2\gamma}+\frac{y}{2\delta}=0.44003$ for the latter. But when the two solutions are mixed, the extinction-coëfficient $\varepsilon_1=0.21468$ and $\varepsilon_2=0.07573$. These values differ so much from the others as to justify the conclusion that a chemical action of some kind has taken place. If solutions of potassium chromate and dichromate, or of permanganate and dichromate are mixed, the spectrum of the mixture is identical with that of the sum of the single spectra. Hence the author concludes that spectrum analysis gives a convenient, rapid and certain method of determining whether in solutions containing two or more coloring matters these substances act chemically on one another or may be mixed together without any chemical change taking place.—*Ber. Berl. Chem. Ges.*, xv, 1243, June, 1882. G. F. B.

2. *On the Vapor-density of Bromine.*—JAHN has determined in Ludwig's laboratory the vapor-density of bromine. The material was carefully purified, and had a constant boiling point of 63·07° C. The vapor-density was determined by Bunsen's method somewhat modified. The first series of determinations was made at 102·6° C., and gave (*a*) 5·7225, (*b*) 5·7388, (*c*) 5·7228; mean, 5·728. The second series, at 131·92° C., gave (*a*) 5·635, (*b*) 5·646, (*c*) 5·638; mean, 5·640. The third gave at 175·58° C., (*a*) 5·603, (*b*) 5·605; mean, 5·604. The fourth, at 210·32° C., gave (*a*) 5·543, (*b*) 5·549; mean, 5·546. The fifth, at 227·92° C., (*a*) 5·5241, (*b*) 5·5245, (*c*) 5·5244; mean, 5·5243. Taking Stas's value for the atomic weight 79·951, the calculated vapor-density is $\frac{159.902}{28.943}=5.5247$; a value practically identical with that last given. If further the expansion be assumed to increase with the temperature and in the linear formula $D=a+bt$, the value of the constants a and b be calculated from the above data by the method of least squares, a is found to be 5·8691 and $b=-0.00153$. Substituting in the formula, the calculated values are obtained for the above temperatures. They agree with the experimental values very well except at 102·6° and 131·92°. Here the expansion curve is a conic section, the temperature being not far above the boiling point. Using, therefore, the quadratic formula $D=5.5189-\frac{8.535}{t}+\frac{3190.04}{t^2}$ the calculated values come out 5·729 at 102·6° and 5·638 at 131·92°. Beyond this point the linear equation holds. Calculating now the vapor-density of bromine at temperatures exceeding its boiling point by intervals of 20°, the author finds that the deviation from the nor-

mal value becomes practically zero at 160° above this boiling point, chlorine reaching its normal density at 240° above its boiling point, and iodine at its boiling point. Jahn attributes this to molecular aggregation, the molecules becoming single and separate only at temperatures at which the vapor-density becomes normal.—*Ber. Berl. Chem. Ges.*, xv, 1238, June, 1882. G. F. B.

3. *New method for preparing Hyponitrous acid.*—For the production of hyponitrous acid, HNO, the agents hitherto used for the reduction of the nitrate or nitrite have been sodium-amalgam or electrolysis, mercury being the negative electrode. ZORN has made a series of experiments on the subject and comes to the conclusion that the best reducing agent for this purpose is ferrous hydrate. When freshly precipitated ferrous hydrate is placed in a solution of sodium nitrate or nitrite, it reduces it energetically, evolving heat and becoming ferric hydrate. There results hyponitrous oxide, hyponitrous acid, ammonia and nitrogen. In practice, pure ferrous sulphate is dissolved in water and mixed with milk of lime, avoiding an excess, and leaving the solution slightly acid. To this thin magma is added, a solution of sodium nitrite (one part of the nitrite being used for every 10 parts of the ferrous sulphate) and the whole is well cooled. The mass foams, and the reduction is effected in a few hours. It is strained and filtered, carefully neutralized with acetic acid, and precipitated with silver nitrate. The precipitate of silver hyponitrite is perfectly pure since by this method of reduction no oydroxylamine is formed, and therefore no metallic silver is mixed with the precipitated hyponitrite. From 100 grams nitrite and one kilometer of ferrous sulphate, 10 grams pure silver hyponitrite was obtained.—*Ber. Berl. Chem. Ges.*, xv, 1258, June, 1882. G. F. B.

4. *On an Apparatus for Liquefying Gases.*—REYNOLDS has described a simple form of apparatus for liquefying ammonia gas, which may be used with other gases as well. It consists of a U-tube, made of gas pipe, the sides of which are 12^{cm} internal diameter, and the bottom pipe 5 or 6^{mm}. One of the sides is 40^{cm} long, the other is 30^{cm}; the bottom piece is 25^{cm} in length, and is screwed firmly at its ends into caps on the lower ends of the side tubes. Upon the upper end of the shorter side a cap is screwed, fitted to support a glass Cailletet tube, the capillary portion of which rises above its top. The upper end of the longer side is also furnished with a cap. The Cailletet tube having been filled with pure dry ammonia gas in the usual way, is immersed in the mercury, with which the apparatus has been filled, and the cap screwed on. Mercury is then removed from the longer leg, leaving a space of 12^{cm} between the metal and the cap. This space is then filled with the strongest solution of ammonia, and the cap is firmly screwed on. If now this tube be heated gradually with a Bunsen burner, the ammonia gas set free by the heat exerts pressure upon the mercury and so compresses the gas in the Cailletet tube until finally liquefaction is produced and a layer of

the liquefied gas appears in the capillary portion of the tube. On cooling, the gas is reabsorbed.—*J. Chem. Soc.*, xli, 259, June, 1882. G. F. B.

5. *Function of two ears in the perception of space.*—Professor SILVANUS P. THOMPSON concludes from a review of rival theories that "Judgments as to the direction of sounds are based, in general, upon the sensations of different intensity in the two ears; but the perceived difference of intensity upon which a judgment is based is not usually the difference in intensity of the lowest or fundamental tone of the compound sound (" or clang") but upon the difference in intensity of the individual tone or tones of the clang for which the intensity-difference has the greatest effective result on the quality of the sound."—*Phil. Mag.*, June, 1882, pp. 406–416. J. T.

6. *Vapor tension of mercury.*—At a meeting of the Physical Society in Berlin, May 26, Dr. HAGEN discussed the results of Regnault on the vapor tension of mercury, and gave the results of his own determinations. Dr. Hagen's apparatus consisted of a V-shaped tube, having at the lower part a long straight tube united to it by fusion, while above either branch terminated in a tube twice bent at a right angle, and closed at the lower end. By means of a Hagen air-pump this tube system was gradually evacuated to a pressure of 1–12,000,000 mm. mercury, and the long straight tube opened under mercury at the lower end. The mercury rose in both branches of the V-tube to barometric height. One of the lateral ends of the apparatus was now kept constant at 0°; while the other was first cooled to −42°, and then heated to various temperatures; each time the position of the mercury in the two branches was observed with a cathetometer, and the difference of their heights gave the vapor tension. The values so obtained were less for all temperatures than those given by Regnault. Dr. Hagen concludes "that the Regnault values for the vapor tension of mercury, which have passed into all text books, are too large."—*Nature*, June 15, 1882. J. T.

7. *Electrostatic dimensions of a magnetic pole.*—CLAUSIUS gives his reasons for believing that Maxwell's expression for the dimensions of the unit of static magnetism, viz: $[m_s]=[M^{\frac{5}{2}}L^{\frac{1}{2}}]$ is wrong and that the true value of this unit should be $[m_s]=[M^{\frac{1}{2}}L^{\frac{5}{2}}T^{-2}]$; Professor J. J. Thomson defends Maxwell and shows that Maxwell's value results from the introduction of μ the magnetic permeability of the medium. Mr. W. D. Niven suggests that the value given by Clausius for the dimensions of a magnetic pole does not make the magnetic force between two such poles of the dimensions of a force, which ought to be the case.—*Phil. Mag.*, June, 1882, pp. 381–398 et 427–429. J. T.

8. *The electricity of flames.*—Several observers have investigated the electricity of flames and have arrived at various conclusions, which may be classed as follows:—

(1.) The electricity of flames depends upon the process of combustion (Pouillet, Hankel).

(2.) The flame behaves like an electrolyte to the metal electrodes which are immersed in it (Matteucci).

(3.) The explanation of the electricity of flames is found in the thermoelectric difference of the electrodes (Buff).

Julius Elster and Hans Geitel believe that previous observers have overlooked the influence which the heated layer of air outside the flame exerts. On account of the great resistance of this air, observers who have used a galvanometer could not detect a difference of potential. They, however, used a Thomson's electrometer and were enabled to study the phenomena, believing that they were the first to use a Thomson's electrometer for this purpose. The same method, however, was used by J. Trowbridge (this Journal, 1873).

Their conclusions are as follows:

(1.) The length polarization of the flame (Hankel) is only an apparent phenomenon and is due to the unequal immersion of the wires which serve as electrodes.

(2.) The flame appears in section to be strongly polarized—and the electrode in the surrounding layer of air appears to be always positive toward the electrode in the flame.

(3.) The electromotive force is independent of the size of the flame.

(4.) The change of polarity of the flame is due to change of position of the electrodes.

(5.) The electromotive force of the flame is dependent upon the nature of the metal from which the exploring electrodes is made, and also upon the nature of the burning gas. Aluminum and magnesium call forth strong electrical effects. If the electrode in the layer of air is covered with a salt the electrical effect is very weak.

(6.) With the use of water electrodes and exclusion of metals, the electrical phenomenon of flames is also seen. The electrode in the outer layer of heated air is always positive to that in the flame itself.

(7.) Flames can be combined in series just as batteries are joined for intensity.—*Ann. der Physik und Chemie*, No. 6, pp. 193–222, 1882. J. T.

9. *Kerr's Phenomenon.*—H. Brongersma has repeated Kerr's experiments on "A new relation between electricity and light," Phil. Mag., No. 4 (50), p. 337, 1875, and has corroborated Kerr's results which certain observers have failed to repeat. Brongersma agrees with Röntgen that Kerr's phenomena has a fundamental importance in connection with the electrodynamic theory of light.—*Ann. der Physik und Chemie*, No. 6, pp. 222–233, 1882. J. T.

II. Geology and Mineralogy.

1. *On the structure and movement of Glaciers.*—M. F.-A. Forel, of Morges, Switzerland, has recently published (Bibl. Univ., III, vii, 329), an important memoir upon glaciers, embodying the results of observations by himself and M. Ed. Hagenbach-Bischoff, with a discussion of these results, and also of those obtained by other observers. His argument rests mainly upon the well attested fact that glacial ice has a distinctly crystalline granular structure, the mass being composed of a confused agglomeration of individual crystals, each optically distinct; and moreover, that the size of these crystalline grains increases from the upper margin of the glacier, at the limit of the névé, where they have the size of a hazel nut, down to the middle part, where the size is that of a walnut, and farther down to the extremity, where they are as large as a hen's egg. For example, at the lower extremity of the Aletsch glacier, or that of the Rhone, the grains have a diameter of 7 or 8 centimeters. In regard to this gradual increase in size of the crystal-individuals, the author remarks that two suppositions are possible: either the growth of some grains must go on at the expense of others less favorably situated, one gaining what the next loses, and absorbing as much heat as is disengaged by the crystallization; or, each grain increases in size by means of the water which reaches it from above from the surface of the glacier. Of these two hypotheses, the first is rejected on the ground that wherever observations have been made, they have shown the grains to be all of sensibly the same size in the same region, and not to be some small, others large, as this explanation would require.

Accepting provisionally the second hypothesis, the author remarks that for the increase in volume of the crystals there are needed: water, cold and favorable conditions. About the last point nothing is definitely known, but the others admit of further discussion. The water is believed to be afforded by the melting of the upper surface of the glacier under the influence of the heat of summer. This water runs over the surface of the ice, descends into the crevasses, and, if it be admitted that the ice contains capillary fissures, a point which is discussed later, much of it would be absorbed by the mass of the glacier and used in increasing the size of the crystalline grains; the rest of the water flows off in the sub-glacial torrent. The low temperature needed for the solidification of the absorbed water is believed to be due to the continued loss of heat during the winter, the glacier as a whole being a mass, the temperature of which can never be above zero, but may fall considerably below. The question as to the mean temperature of the ice at different seasons of the year is discussed at length, and the author concludes, for a variety of reasons which cannot be quoted here, that the middle of the mass of the glacier has probably a temperature at the end of the winter several degrees below 0° C. This excess of cold would be partially expended in causing the solidification of the water which, as already stated, is absorbed into its mass and thus goes to increase its volume. The crystalline grains are then to be conceived as growing by accretion, successive layers being added to them, at the expense of the water derived from surface melting, and in the process of the warming of the glacier which goes on during the summer.

Assuming the correctness of the results of Hugi, as to the increase in size of the crystalline grains, that is, in brief, that they increase from a diameter of 1 to one of 4 centimeters, taking 100 years for the time of their development, the author finds that the annual increase in volume is $4\frac{1}{2}$ p. c. Assuming further that the cold of winter is all employed in bringing about this increase, it is calculated that the hypothesis advanced is satisfied if the temperature of the glacier descends in winter to $-6°\cdot8$ C., or in round numbers $-7°$ C. This temperature, the correctness of which is obviously dependent upon the accuracy of the assumed data as to the rate of increase of volume, is too low to be accepted and leads to the inference that a part of the increase is accomplished by a process different from that which has been described. Thus, at the end of the summer a considerable portion of the glacier must be at the temperature of melting ice, and in the capillary fissures between the crystalline grains there must be water; now as the glacier cools down in the autumn, the first effect of the loss of heat would be the solidification of this water and the consequent increase in size of the crystalline grains. Taking into account this last point, the author regards that the temperature that would have to be assumed for the glacier at the end of the winter would be quite within the range of possibility.

The hypothesis, which has been advanced, depends upon the assumption that the water can find its way into the interior of the glacial mass through the capillary fissures separating the individual grains. This point is one which is yet somewhat doubtful, and the author after considering the various observations of Agassiz and others, which tell for and against the possibility of such a penetration of the water, discusses the question from a more theoretical standpoint, and concludes that the assumption of the impermeability of the glacier is contrary to fact. He promises further to make this a special subject of observation at a later period.

In regard to the cause of the movement of glaciers, M. Forel places himself on the side of Hugi and Grad in supporting the theory of expansion, although modifying somewhat their hypothesis. On the old dilatation theory, it was the expansion of the water contained in the capillary fissures at the moment of their solidification, to which the glacial movement was supposed to be due. According to the view of M. Forel, however, this special expansion plays a subordinate part, and it is rather the gradual increase in volume of the crystalline grain due to the molecular affinity which causes a crystal to grow in the mother-liquor in which it is placed.

In discussing further the application of the hypothesis, a distinction is made as to the course of events during the youth and during the old age of the glacier. The glacier may be divided into three parts. The first is in the elevated region where the glacier has its commencement, that of the névé. Here the heat of summer is not sufficient to melt the whole volume of the snow which falls during the year; only a part of the snow is consequently transformed into water and this penetrates into the layers below and is solidified there; the temperature is much below the freezing point. This is the region of the infancy of the glacier. Following this comes the line of separation where the heat of summer is just sufficient to melt the winter's snow, and there is no excess of heat to attack the ice.

The second stage, that of the youth of the glacier, is found below this line of separation where the summer's heat not only melts the snow, but also partially melts the ice; the water so formed is absorbed and assimilated by the ice, and the temperature below the surface is even at the end of summer below zero. In this region the glacier is increasing in volume and consequently moving downward. Then follows a second line of separation, where the water absorbed is all used in the increase of volume of the glacial grain. At this point the sub-glacial torrent has its origin, and at the summer's end the temperature is at 0°.

The third stage is that of the old age of the glacier, where the supply of water exceeds that needed to bring the temperature of the ice back to 0°, the excess of water flows off in the glacial streams; the temperature of the ice is at 0° during the summer and the excess of the summer's heat goes to cause the melting and destruction of the glacier.

In concluding his interesting memoir, the author promises to test his hypothesis by further observations and experiments, bearing especially upon the questions as to the comparative size of the crystalline grains in the different parts of a glacier, and as to the possibility of the penetration of the surface water into the mass of the ice.

2. *Upper Silurian fossils in the metamorphic rocks of Bergen, Norway.*—The discoveries of fossils in metamorphic rocks are increasing in numbers with the extension of careful observations. Mr. Hans H. Reusch has a memoir on new discoveries of this kind in the peninsula of Bergen, illustrated by a colored geological map and plates, which is published by the University of Christiania, under the direction of Prof. Kjerulf. Bergen is in 60° N., on the west coast of Norway. The predominant rock is granitoid gneiss. With the gneiss, in conformable strata, occur various schists, with nearly vertical dip—dioryte schist with included beds of granulyte and gneiss, labradorite rock, argillitic and ordinary mica schist, chloritic mica schist, hornblende schist more or less chloritic, and in some parts epidotic and calciferous

gneiss; also thin strata of a conglomerate made up of compressed pebbles or stones, a feldspathic quartzyte, and intercalated layers of crystalline limestone containing fossils. In addition the region includes in parallel position with the rest and adjoining the calciferous gneiss, a belt of "saussurite gabbro or greenstone." The strike of the whole is about E.N.E.; and, according to the author, the limestone or marble, the various kinds of schist, including the gneiss and granulyte, together with the quartzyte and conglomerate, appear to make one continued metamorphic series.

He says: The various gneisses which appear to be included within the Silurian terrane, I am inclined to regard as sedimentary, strata originally formed of loose material such as gravel and sand of granite or gneiss origin; and the argillitic and ordinary mica schists, sometimes porphyritic, in which occur Trilobites and other animal remains at Vagtdalen, as once beds of clay or mud; the conglomerates as owing their thin and sometimes lance-shaped pebbles to the pressure attending the metamorphism; and a green gneiss of Trengereid as probably an altered compressed breccia.

The argillitic mica schist [hydromica schist?] occurs in southern Bergen in two zones; in both of them the fine grained argillitic schist graduates into coarse mica schist (muscovitic), and includes layers of gneiss; and *both are fossiliferous.* The fossils found near Osören at Kuven, in lenticular masses of limestone, are *Halysites catenulata*, a species of *Cyathophyllum*, and a tubular fossil probably *Syringophyllum organum;* and at Valle, sections of Gasteropods referred to *Murchisonia* or *Subulites.* In the northern of the two zones the argillitic mica schist is associated with quartzyte or quartzytic sandstone, a conglomerate partly chloritic, "saussurite gabbro," and hornblende schist. The argillitic mica schist contains scattered individuals or crystals of brownish mica transverse to the foliation; it has afforded *Halysites catenulata*, a *Favosites*, a *Cyathophyllum*, trilobites of the genera *Calymene* and *Dalmanites*, and *Brachiopods*, apparently indicating the age to be "the lower part of the Upper Silurian;" and the schist or slate of Ulven water has afforded Graptolites of the genera *Rastrites* and *Monograptus.* Figures are given on plates 1 and 2, showing that the fossils are not doubtful appearances.

In the northeastern part of Bergen, at Trengereid, there are, along with layers of fine-grained gneiss, calciferous mica schist, granulyte, quartzyte, and a conglomerate made of compressed pebbles; there are also five beds of reddish marble in which are found hollow cylinders that appear to be *crinoidal stems*, and a "closely netted *chain-coral*," showing that the beds are of the same horizon as those of Osören.

3. *Geological Examinations in Southern Colorado and Northern New Mexico*, of 1878 and 1879, by J. J. STEVENSON, Prof. Geol. Univ. City of New York, with an Appendix *upon the Carboniferous Invertebrate Fossils of New Mexico*, by C. A. WHITE, M.D. 420 pp. and App. of xxxvi. 8vo, with four plates and many wood cuts. Report of the U. S. Geological Survey West of the 100th

Meridian, in charge of Capt. G. M. Wheeler, Engineer Corps, U. S. Army. Washington, 1881. (Distributed in June, 1882.)—Professor STEVENSON's Report treats of the geology of North Central New Mexico and South Central Colorado, between 37° 20′ N. and 35° 20′ N. and west of 104° 7½′ W., a region along the "Spanish Ranges" and a continuation of the Sangre de Cristo Range—having the Rio Grande on the west and headwaters of the Arkansas on the east. To the north the mountains are high and sharp, one peak over 14000 feet, while the southern part is comparatively gentle in slopes and crossed by roads. He describes the central portion of the mountain region from north to south as consisting mostly of Archæan rocks; on the east side and part of the top, Carboniferous beds, resting on the Archæan; next east, overlying the Carboniferous or else the Archæan, Cretaceous strata of the Dakota, Colorado and Laramie groups, excepting some doubtful sandstones that may be Jura-Trias; and of Tertiary beds in the vicinity of Galisteo Creek, New Mexico. Besides these rocks there are large areas of basaltic lavas with dikes and craters of Miocene age or later; and others of trachytic rocks which are not as old as the Laramie beds, since in some places they overlie these.

Prof. Stevenson devotes many pages to the Laramie or Lignitic group, and follows his descriptions with a discussion of its relations to the Cretaceous and Tertiary. New facts from the author's observations bearing on this disputed point, are brought forward, and the conclusion strongly urged that the formation is the true Upper Cretaceous. The close stratigraphical relations to the Upper Cretaceous and the similarity in the presence of lignitic beds are facts now generally admitted. But Professor Stevenson observes, beyond this, that while the Laramie is largely brackish-water and fresh-water in origin, as usually stated, typical fossils of the Cretaceous of the Fox Hills group (the upper Cretaceous of Hayden), are occasionally obtained, as at Evans and Greeley, as well as along Saint Vrains and Thompson Creeks in Colorado, from the very summit of the Laramie. The query arising here is whether the beds with the Fox Hills fossils are not distinctively of the Fox Hills group. Professor Stevenson's Report after treating with much detail of the topography, displacements and stratigraphy of the region, including a section on the glacial phenomena of the region, closes with a chapter on its Economic geology. An early and important chapter reviews the labors of other investigators over the region of his own work.

Dr. C. A. White's Appendix on the Carboniferous Invertebrate fossils, contains notes on a large number of species collected by the expedition in 1877 and 1878, and by Professor Cope in 1874. They are from New Mexico, and represent, according to Dr. White, rather the Upper part of the Coal Measures than the Middle or Lower. He states that nearly 100 species are identical with species found in the Coal Measures east of the Mississippi. A species of Rotella here described, *R. verruculifera* White, is the first of this genus yet recognized from the Carboniferous. The previously described species of the genus are mostly, if not wholly, Tertiary and recent.

4. *Manual of the Geology of India:* Part III, *Economic Geology*, by V. BALL, M.A., F.R.S., Officiating Deputy Superintendent Geological Survey of India. 664 pp. Royal 8vo, with maps and plates. Calcutta, 1881. (Office of the Geol. Survey of India: London, Trübner & Co.)—The Parts I and II of this very valuable manual, by H. B. MEDLICOTT and W. T. BLANFORD, were noticed in volume xix of this Journal (1880). The last Part, by Professor BALL, is devoted to the economical branch of the subject. This large volume is full of important matter on the metals and metallic ores, precious stones, coals, graphite, petroleum, amber, salt, and other useful materials, afforded by the rock formations of India. The history of the mining operations and discoveries in connection with each product from early time has been worked up, and a large amount of curious and valuable half-lost information brought together, the gathering of which from scattered records cost the author great research. The native processes are described in detail and illustrated by sketches of the workmen at their work, some of which are entertaining as well as instructive. Among the maps one is a large and beautiful topographical map of India; another, similar, illustrates the distribution of the coal mines; and others represent the diamond-bearing districts.

The volume is history, science and popular description combined. As the Superintendent of the Geological Survey of India, Mr. Medlicott, says in his preface, "The student as well as the man of enterprise will long owe the author gratitude for the great store of facts thus brought within easy reference."

5. *Report of Progress of the Geological Survey of Canada* for 1879–80, ALFRED R. C. SELWYN, Director, Montreal, 1881.—The Canada Geological Reports always contain facts of wide geological bearing, and for the special reason that the region under investigation is of great extent and diversity, although the corps of observers is small. This new volume, after a review of the general results by Mr. Selwyn, the Director, has a chapter by the same on boring operations in the Souris River Valley, near the Rivière des Lacs, 229 miles west of Red River. Next follows a Report on the Lignite Tertiary formation from the Souris River to the 108th meridian, by G. M. Dawson, in continuation of that by the same author in his Report on the Geology of the 49th parallel connected with the Reports of the Boundary Commission. Thirteen analyses of the lignites give for the average, 41·10 fixed carbon, 41·41 volatile combustible matter, 5·55 ash, with 12 per cent of water. The clay iron-stones accompanying in thin layers the coal beds, contain the iron mainly as carbonate. The next paper, by Dr. DAWSON, on the plants of the Lignite Tertiary of Roche Percée, Souris River, describes leaves 1½ feet long and broad of *Platanus nobilis* Newberry, a new Sassafras, *S. Selwyni*, *Taxites Occidentalis* Newberry, *T.*

Olriki, of Heer, who has described it from Alaska, Greenland and Spitzbergen. After these there are: a Report by G. M. DAWSON on an Exploration from Port Simpson, on the Pacific coast, to Edmonton, on the Saskatchewan; on Hudson's Bay, and some of the lakes and rivers lying to the west of it, by R. BELL, containing also a paper on the northern limits of trees in Canada, east of the Rocky Mountains, a list of fossils collected by Dr. Bell in Manitoba, by J. F. Whiteaves, and other papers; also Report on New Brunswick, by R. W. ELLS; on Nova Scotia, by H. FLETCHER; on the Magdalen Ids., by J. RICHARDSON, and chemical contribution to the survey, by G. C. Hofmann. The volume is illustrated by many maps, plates and sections.

6. *The Færöe Islands.*—Professor James Geikie has a paper on the geology of the Færöe Islands in the Transactions of the Royal Society of Edinburgh for 1882. The principal rocks are bedded basalts with intercalations of tufas, and in Myggenæs and Suderöe of shale and coal. The basalt, with the shale and coal, are referred to the Miocene. The basalt of Suderöe is mainly a chrysolitic dolerite, mostly fine-grained and rarely porphyritic; a bed sometimes has above a scoriaceous crust, or passes into a jumbled mass of fragments of scoria. The same rock on the northern islands, unless amygdaloidal, is more coarse grained and porphyritic; but amygdaloidal and non-amygdaloidal areas frequently alternate in more or less regular beds parallel to the bedding. The thickness of the basalts is stated to be 9,000 to 10,000 feet above the coal and 4,000 feet below the coal. The islands are glaciated, showing scratches and *roches moutonnées*, and indicating a movement for the most part to the southwest, but partly to the southeast. In the northern islands the thickness of the ice was 2,200 or 2,300 feet, and at least 1,400 on Suderöe; and judging from this thickness, the glacier probably reached out to the 100-fathom line.

7. *Ammonites in the Tejon Group of California.*—In a note on the Tejon Group of California, by A. Heilprin (Proc. Acad. N. Sci. Philad., 1882, 94), the Tertiary features of the fossils of the Tejon Group,—made the upper portion of the Cretaceous by Whitney, and also by Gabb—is remarked upon, and the occurrence in it of an Ammonite (*A. jugalis* Gabb) is mentioned as a case of the genus Ammonites extending into the Tertiary.

This Ammonite was found by Gabb also in the underlying beds of undoubted Cretaceous age, called by Whitney the Martinez group (Rep. Pal. Calif., vol. ii, p. 134). The writer, in his Geology (p. 458), recognizes the Tertiary features of the fossils described by Gabb, and to show it gives a complete list of the species (p. 508); but at the same time suggests that the beds are the equivalent of the Laramie or Lignitic beds, which also are strikingly Tertiary in the mollusks, though most geologists now make them the top of the Cretaceous. The Tejon group is the only lignitic portion of the California Cretaceous. J. D. D.

8. *Paleontology of the Brazilian Geological Survey.*—A letter to the editors from Dr. C. A. White states that he has finished two "Contributions for the Brazilian Survey, on the Cretaceous Conchifers and the Cephalopods, leaving the Gasteropods yet to be studied." He has found a new species of the genus Meekia of Gabb, which he has named *Meekia commemorata*, in commemoration of the able and greatly esteemed American paleontologist, Mr. Meek.

9. *Geological Sketches at Home and Abroad*, by ARCHIBALD GEIKIE, Director General of the Geological Surveys of the United Kingdom. 332 pp., with illustrations. 1882. London and New York. (Macmillan & Co.)—Geological descriptions, illustrating well the keen eye of the author as well as the "restless energy of nature," landscape sketches almost as living as nature herself, fragments of entertaining history, and amusing incidents of travel, are combined in these collected essays of the accomplished author in a manner fitted to attract all readers. The "Old Man of Hoy" is an account of British sea-coast scenery, and the various work of the waves among different kinds of rocks; "The Baron's Stone of Killochan" discourses about bowlders, glaciers, and the delightful scenes of a region within sight of the Firth of Clyde. And similarly, the chapters, "Among the Volcanoes of Central France," "the Old Glaciers of Norway and Scottand," "A Fragment of Primeval Europe," "The Scottish School of Geology," "Geographical Evolution," and others in the work put instruction in an attractive form. Some of the best chapters are those entitled, "In Wyoming," and "the Geysers of the Yellowstone"—regions visited by Professor Geikie in the summer of 1880. Another also, "the Lava-fields of Northwestern Europe," brings in American facts, and in a way to illustrate, most effectively, phenomena of Britain and Europe, as already shown to the readers of this Journal by an extract in volume xxi (1880, p. 145). Science, throughout the work, is made the genial, amusing and knowing companion of the reader.

10. *Columbite, Orthite and Monazite from Amelia Co., Virginia.*—The description by Prof. DUNNINGTON of microlite from Amelia Co., Va., has been noticed in this Journal (xxii, 82, 1881). The same author has recently further investigated the other minerals of the locality. The *columbite* had a red color in thin splinters. H.=5·5. G.=6·48. Analysis gave:

Ta_2O_5	Cb_2O_5	SnO_2	FeO	MnO	CaO	MgO	Y_2O_3(?)
84·81			5·07	8·05	1·27	0·20	0·82=100·22

The author remarks upon the high specific gravity, the unusually large percentage of MnO as probably accounting for the red color, and calculates the ratio of Ta_2O_5: Cb_2O_5 to be nearly 1 : 1; he, however, overlooks the fact that a *translucent* columbite, with G.=6·59, has been described from Branchville, Ct., which contained only MnO (15·58 p. c., 0·43 FeO) and had closely the ratio of 1 : 1 for the metallic acids (G. J. Brush and E. S. Dana, this Journal, xvi, 34, and Comstock, xix, 131).

Orthite occurs in imperfect blade-like crystals several inches in length. An analysis gave: SiO_2 32·35, Al_2O_3 16·42, Fe_2O_3 4·49, Ce_2O_3 11·14, La_2O_3 3·47, Di_2O_3 6·91, FeO 10·48, MnO 1·12, CaO 11·47, K_2O, Na_2O 0·46, H_2O 2·31=100·62. *Monazite* also occurs at the same locality in masses of large size (up to 20 pounds) as previously shown by König (Proc. Ac. Nat. Soc. Phil., Jan. 24, 1882). The analysis by Dunnington shows the presence of 18·6 p. c. ThO_2 and 2·7 SiO_2, and he remarks that these constituents may be present in the form of orangite; excluding them, the mineral is a normal phosphate of didymium, cerium and lanthanum.—*Amer. Chem. Journ.*, iv, 138.

11. *On the propagation of heat as determined by the crystalline structure of minerals and by the schistose structure of rocks.*—M. JANNETTAZ has undertaken a series of experiments in the line so successfully followed by Senarmont, and has obtained some new and interesting results. In regard to the propagation of heat in crystalline minerals, he finds, for example, that this depends upon the cleavage, taking place less readily in the direction of a normal to the plane of cleavage, than in a direction parallel to it. This distinction, however, does not apply to pseudo-cleavages, or in other words, to the lamellar structure resembling cleavage observed in some minerals, for example, sahlite. The author finds also that the relative orientation of the major and minor axes of the isothermal ellipsoid is characteristic for each group of minerals, *e. g.* the amphiboles, and differentiates this group from others. In experimenting with various rocks, M. Jannettaz has shown that true stratification is without influence on the propagation of heat, but that in schistose rocks (when the schistosity is due to lateral pressure), it takes place more readily in a direction parallel than in one perpendicular to the plane of schistosity.

12. *Milwaukee Clays and Bricks.*—The following are analyses by Mr. E. T. SWEET of (1) the Milwaukee clay that produces the buff-colored brick; (2) of a clay from Madison, Wisconsin, which burns red; and (3), of the Milwaukee brick.

	1.	2.	3.
Silica	38·22	75·80	53·78
Alumina	9·75	11·07	13·21
Peroxide of iron	2·84	3·53	4·92
Protoxide of iron	1·16	·31	·26
Carbonate of lime	23·20	2·45	
Carbonate of magnesia	15·83	·17	MgO 7·41
Lime (CaO)	3·24	·39	17·71
Potash	2·16	1·74	1·54
Soda	·65	1·40	·92
Water in composition	1·85	2·16	
Moisture	·95	1·54	·19
	99·85	99·56	99·94

Mr. Sweet suggests that the ingredients of the clay enter into a combination somewhat analogous to some members of the amphibole group.

12. *Sammlung von Mikrophotographien zur Veranschaulichung der mikroskopischen Structur von Mineralien und Gesteine* ausgewählt von E. COHEN, aufgenommen von J. Grimm in Offenburg. Stuttgart, 1881–82 (E. Schweizerbart'sche Verlagshandlung).—This work consists of a series of quarto plates illustrating the various points of interest in connection with the microscopic structure of minerals and rocks. Five parts have thus far been published, including forty plates, each giving four distinct photographs. The plates already issued cover a wide range of subjects, including the inclosures in minerals, as crystallites, microlites, glass inclosures, inclosures of fluids and gases; showing also their arrangement in crystals; cleavage; all the varieties of structure, fibrous, zonal, contretionary, etc.; the figures produced by etchings, by a blow or by pressure; also various optical phenomena, anomalous double-refraction and so on. The execution of the plates is worthy of the highest praise. Dr. Cohen deserves the thanks of all interested in studying or teaching this branch of mineralogy and lithology, for editing this invaluable work.

13. *Occurrence of Vivianite in Los Angeles County, California.*—Mr. Henry G. Hanks states that vivianite occurs with asphaltum at the Brea Ranch, Los Angeles County, California. The mass examined was a dark-colored earthy mineral, with streaks and veins of asphaltic substance, the whole being evidently the sandy desert soil blown over and cemented by the formerly liquid asphaltum. The vivianite is in small inclosed nodules, never larger than a pea and generally smaller. The mineral is that variety known as blue iron earth or native Prussian blue. It is soft, pulverulent; under the microscope it is crypto-crystalline.

14. *Helvite from Virginia.*—The rare mineral helvite has been identified by Professor H. C. LEWIS among some minerals brought from the mica mine near Amelia Court House, Amelia County, Virginia. This is the locality which has furnished the large specimens of microlite (xxii, 82), and also monazite, orthite, etc. (see 10 above). The helvite occurs in crystals and friable crystalline masses imbedded in orthoclase, and generally associated with pale red topazolite. Its characters are: hardness about 6, specific gravity 4·306, color sulphur yellow, luster somewhat resinous, translucent. An analysis by R. Haines afforded (1); after the deduction of the gangue and the calculation of a portion of the MnO as Mn combined as MnS, the results in (2) are obtained:

	SiO_2	BeO	MnO	Al_2O_3	Fe_2O_3	CaO	K_2O	Na_2O	S	gangue
(1)	23·10	11·47	45·38	2·68	2·05	0·64	0·39	0·92	4·50	9·22=100·35
(2)	25·48	12·63	39·07	2·95	2·26	0·71	0·43	1·01	4·96	Mn8·66= 98·16

The author remarks that the last analysis does not correspond with the original helvite, which has 33 per cent SiO_2, so that a further investigation is to be desired.—*Proc. Ac. Nat. Sci. Philad.*, 1882, 100.

15. *Nickel ore in Oregon.*—It is announced that a deposit of a hydrated silicate of nickel and magnesia has been discovered on

Piney Mountain, Cow Creek, Douglas County, in southern Oregon. The mineral is amorphous, has an apple-green color; two varieties analyzed afforded 24 and 30 per cent of nickel oxide respectively, and 48 and 40 per cent of silica. In mineralogical character and in mode of occurrence the nickel silicate is closely related to the garnierite (and noumeite) of New Caledonia.

16. *Corundum from Lehigh County, Penn.*—The occurrence of large crystals of corundum near Shimersville, Lehigh County, Penn., is described by Edgar F. Smith and N. Wiley Thomas. The crystals have been found loose in the soil, thrown out in plowing. The largest crystal had a length of eight inches and a diameter of four and a half inches; another crystal, in the form of a double pyramid, had a length of five and a half inches and weighed over five pounds. A considerable number of smaller well-defined crystals have also been obtained.—*Am. Phil. Soc. Philad.*, March 17, 1882.

III. Botany and Zoology.

1. *Our Native Ferns and their Allies;* by Lucien M. Underwood, Ph.D., Professor of Geology and Botany in the Illinois Wesleyan University. Bloomington, Ill., 1882. 12mo. 134 pp. —This is a second and enlarged edition of a former work by the same author. "Our Native Ferns and how to Study them" included ferns only: the present volume has the remaining orders of fern-like plants. The work has nine chapters devoted to the habits, structure, physiology, description, literature and study of the plants, taking up nearly half the volume; and then follows the systematic and descriptive part, concluding with a well-ordered index and glossary. The work contains about thirty-seven illustrative figures, many of them from the author's own pencil. The subject is well-arranged, and concisely but sufficiently developed and explained, in the nine chapters, which taken together form a very useful introduction to the study of this class of plants. The genera and species are mostly arranged in accordance with the authorities which the author refers to; as well as most of the carefully worded descriptions and the statements of the geographical ranges. The species of ferns, including Ophioglosseaæ, are 156, of the other orders, 55, making 211 recognized species of Pteridophyta, or Vascular Acrogens.

The price of the work is so low that no one need longer refrain from the study of these interesting plants on account of the cost of the needed literature. D. C. EATON.

New Haven, July 10, 1882.

2. *Europas och Nord Amerikas Hvitmossor*; i. e. European and North American Peat-mosses (*Sphagna*); by S. O. Lindberg. Helsingfors. 1882. Pp. 88 and xxxviii, quarto.—Following upon Dr. Braithwaite's monograph of *Sphagnum*, comes this now from Professor Lindberg, with a copious morphological introduction. The twenty-one species are arranged under the three sections, *Eusphagnum* (which includes the groups, *Palustria*,

Subsecunda, *Compacta* and *Cuspidata*), *Isocladus* (for *S. macrophyllum*), and *Hemitheca* for *S. Pylaiei* and *S. cyclophyllum*); the ample characters are in Latin, and the synonymy is very full, —that of *S. cuspidatum*, for example, fills four pages. There is a complete index to the synonymous names. Although arranged primarily for Scandinavian use, the treatise will be welcomed by all bryologists. A. G.

3. *Nomenclator Zoologicus*, by SAMUEL H. SCUDDER. Part I. Supplemental list. 376 pp. 8vo. 1882. Bulletin of the U. S. Nat. Mus. Dept. of the Interior. Published under the direction of the Smithsonian Institution.—Mr. Scudder, in Part I of his Nomenclator, has given to zoologists, as the result of an immense amount of personal labor and assistance from many zoologists, a supplement to Agassiz's Nomenclator, making it to include all generic names employed in Zoology and Paleontology to the close of the year 1879, which are not contained or not correctly given in the works of Agassiz and Marschall, or in the Zoological Record Indexes. It contains 15,939 entries of genera, and besides these the genera of the Zoological Record for 1878 and 1879, and those of the Zoologischer Jahresbericht for 1879. References to places of first publication and derivations are also given.

The preface states that Part II, or the "Universal Index," contains about 80,000 references and includes the generic names in all previous lists. It gives the name of the genus (including also, in italics, such family or higher names as appear in Agassiz's Nomenclator or the author's Supplemental List); 2d. The authority; 3d. The group; 4th. The date; and 5th, the reference to the Nomenclators. It is also announced that *Decennial Supplements* will hereafter be issued by the Smithsonian Institution, the first to include the additions for the years 1880–1889. The Smithsonian Institution by these publications is doing great service to natural science throughout the world.

4. *Synopsis of the Fresh-water Rhizopods.*—A condensed account of the genera and species, founded upon Professor Joseph Leidy's "Fresh-water Rhizopods of North America." Compiled by ROMYN HITCHCOCK, Pres. N. Y. Microscopical Society. 58 pp. 8vo, with four plates. 1881. New York (Romyn Hitchcock). This is a convenient hand-book for all who would take up the examination or study of fresh-water Rhizopods, especially if they have not already the large and copiously illustrated work on the subject by Professor Leidy. This bottom branch of zoology is a fertile field for the capable embryological investigator.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *American Association.*—The circular of the Local Committee of the meeting at Montreal of August 23, states the following with regard to reduced rates of fare on railroads and steamboats.

The Grand Trunk, the Great Western, the Intercolonial, the

Quebec, Montreal, Ottawa and Occidental, the South Eastern and the Canada Pacific Railroads, the Richelieu and Ontario, the Ottawa and the St. Lawrence (Steamboat) Navigation Companies, will give tickets at half-rate for a single journey or at a single fare for going and returning over their lines. The steamboats of the latter company make daily trips down the St. Lawrence to Montreal, shooting the rapids, and connect at Clayton, above the Thousand Islands, with night-trains by the New York Central R. R. from Niagara Falls.

The Delaware and Hudson and the Central Vermont Railroads give tickets over their lines to go and return, at a single fare, the tickets on the two lines being interchangeable between Montreal and New York city. Negotiations are pending which, it is hoped, will secure similar arrangements with other railroad lines to the south and west. Those members whom this matter may concern will please address inquiries to one of the Honorary Secretaries at Montreal. Tickets at the above-mentioned rates, good for going and returning from August 10th to September 10th, will be furnished to persons presenting a certificate of membership of the Association for 1882. The following list of some principal points on the above-mentioned railroad lines in the United States may serve as a guide to members: Albany, Binghamton, Boston, Chicago, Detroit, New York, Portland, Providence, Saratoga, Springfield, Troy, Worcester.

There will be excursions to Ottawa and Quebec by the Quebec, Montreal, Ottawa and Occidental R. R.; to Lake Memphremagog by the South Eastern R.R.; and also one to Lachine by the Grand Trunk R. R.; which will be given by these lines free of charge.

Through the liberality of the Western Union and the Great North Western Telegraph Companies, telegraphic messages relating to family, social or scientific matters, will be sent from Montreal during the meeting, for members of the Association, free of charge, to all parts of the United States and Canada.

The Canadian, the National, and the United States and Canada Express Companies will undertake to forward and deliver promptly, free of charge, all parcels of books, drawings, instruments, or specimens of natural history for the use of members of the Association at the Montreal meeting, and will return the same at the lowest rates. The parcels should be addressed to the "*Care of Professor Bovey, A. A. A. S., McGill College, Montreal,*" and should have their contents marked on the outside. By the courtesy of the Collector of Customs such objects will be admitted from the United States free of duty.

Letters to members after August 15th should be addressed A. A. A. S., Montreal, Canada. All enquiries respecting lodgings should be addressed to Mr. J. Bemrose, Secretary Nat. Hist. Soc., Montreal. Rates per day at Hotels: Richelieu, American and Albion, $1.50; St. James and Canada, $1.50 to $2.00; St. Lawrence Hall, $2.50 to $3.50; Windsor, $3.50 to $5.00.

The sessions, beginning August 23, at 10 A. M., will be held in the buildings of McGill University.

2. *Darwin Memorial Fund.*—The following persons have consented to act with the English Executive Committee in contributing and collecting funds for the Darwin Memorial: Asa Gray, Chairman; Spencer F. Baird, James D. Dana, Charles W. Eliot, D. C. Gilman, James Hall, Joseph LeConte, Joseph Leidy, O. C. Marsh, S. Weir Mitchell, Simon Newcomb, Charles Eliot Norton, Francis A. Walker, Theodore D. Woolsey, and Alexander Agassiz, Treasurer.

Subscriptions should be sent to Alexander Agassiz, Cambridge, Mass.

The Athenæum of July 8th states that the Darwin Memorial fund, which had already amounted in England to very nearly £2500, will take the form of a marble statue, and that the Trustees of the British Museum will be asked to place the statue in the large hall of the Museum (Natural History), at South Kensington.

3. *Transactions of the Connecticut Academy of Arts and Sciences.*—Volume iv, pt. 2, contains: Some interesting new Diptera by S. W. Williston; on the species of Pinnixa inhabiting the New England coast with remarks on their early stages, by S. I. Smith; occasional occurrence of tropical and sub-tropical Decapod Crustaceans on the coast of New England, by S. I. Smith; on the Amphipodus genera, Cerapus, Unciola and Lepidactylis described by Thomas Say, by S. I. Smith, with plate 2*a*; New England Annelida, pt. 1, historical sketch with annotated lists of the species hitherto recorded, by A. E. Verrill, with plates 3–12; the North American species of Conops, by S. W. Williston. Vol. v, pt. 2, consists of a paper by A. E. Verrill, on the Cephalopods of the north-eastern coast of America, with plates 26–41, 45–56; and Catalogue of the Marine Mollusca added to the Fauna of the New England region during the past ten years, by the same, with plates 42–44, 57, 58.

OBITUARY.

Dr. George W. Hawes, Curator of the Geological Department of the National Museum at Washington, died on the twenty-second of June last, at Manitou Springs, Colorada. Dr. Hawes was born December 31, 1848, at Marion, Ind. His parents died when he was very young and his early life was spent at Worcester, Mass. In 1865 he entered the Sheffield Scientific School in New Haven, and remained there until the end of his Junior year (1867) when he left to go into business in Boston. His natural taste for scientific pursuits, however, was too strong to allow of his being satisfied with such a life, and after trying this for four years, he returned to New Haven and was graduated at the Scientific School with the class of 1872. During the college year of 1872–73 he was private assistant to Professor Johnson in his chemical laboratory, and from 1873 to 1878 he filled with marked success the position of assistant and instructor in mineralogy and blowpipe analysis, in the Scientific School. In March 1878 he went abroad and studied through the summer semester at Breslau with Professor A. von Lasaulx, devoting himself especially to microscopic lithology. On returning to New Haven he resumed his former position as instructor, and retained it until the following spring, when he again went abroad for further study. From March 1879 to June 1880, he was a student of mineralogy and crystallography at Bonn with Professor vom Rath, and of lithology at Heidelberg with Professor Rosenbusch. At the completion of his studies in Heidelberg he took there the degree of Doctor of Philosophy. He returned once more to his old place and duties in New Haven. But at the end of the year (1880) he accepted the position of Director of the Geological Department of the National Museum at Washington, which he held up to the time of his death. During the first half of the year of 1881, Mr. Hawes, besides carrying on his labors in connection with the Museum, was engaged on a special study of the building stones of the country, undertaken under the auspices of the U. S. Census. His interest in this work led him to overtax his strength, and before the close of the year it became evident to his friends that consumption had taken a strong hold of him; and in some nine months after the disease was first distinctly recognized, it had done its work.

The death of Dr. Hawes takes from the ranks of the younger scientific workers in the country one of the most gifted and promising. By years of patient study, urged forward by his own love of science, not by influences from outside, he had fitted himself to do the very best work in the subjects to which he had devoted himself. It is occasion for the deepest regret that so useful a life should be cut off thus prematurely. During the years of his residence in New Haven, Dr. Hawes published some twenty memoirs on various subjects connected with mineralogy and lithology. In 1878 he wrote a report on the mineralogy and lithology of New Hampshire, published as Part iv of the Geology of New Hampshire. This report covered 251 pages (4to) with twelve plates, and forms his most important contribution to science; it contains the results of extensive field work, as well as the microscopic examination of several hundred thin sections of rocks. It is throughout an excellent work and shows the careful painstaking way in which he carried out all that he undertook. Dr. Hawes's investigation of the building stones of the country, already alluded to, was a work in which he felt great interest, and which promised to yield most valuable results; unfortunately he was not allowed to carry it to completion.

Of the private character of Dr. Hawes this is hardly the place to speak. Though possessed of but few near family relatives, he had a singular power of winning personal friends, so that he leaves a wide circle to mourn his death. His purity and modesty of character, earnestness and uprightness of purpose, and unselfish interest in others will be long remembered by those who knew him well.

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XVIII.—*The affinities of Palæocampa* Meek and Worthen, *as evidence of the wide diversity of type in the earliest known Myriapods;* by SAMUEL H. SCUDDER.

[Read before the National Academy of Sciences, in April, 1882.]

IN an article on the structure of Euphoberia of the Mazon Creek nodules, published in this Journal a year ago, the wide departure of modern myriapods from their ancient allies, in structure, general appearance and habits, was clearly pointed out by detailed comparisons between the relics preserved in the Carboniferous rocks and the corresponding parts in modern types. A considerable number of specimens of Archipolypoda, as the ancient forms were termed, bearing out in every particular the points then brought forward, have since been examined, and have been fully represented in an illustrated memoir just published by the Boston Society of Natural History. Thanks to the local naturalists who have so well explored the beds of Mazon Creek, and who have furnished nearly all the material for the papers mentioned, I shall now attempt to show that Palæocampa is neither the caterpillar of a lepidopterous insect, nor a worm,* but a myriapod of another new and strange type. Messrs. Carr and Bliss, of Morris, Ill., have sent me three specimens of Palæocampa in fine condition, better preserved and a little larger than the original, which has

* Cf. Meek and Worthen, Proc. Acad. Nat. Sc. Philad., 1865, p. 52;—Ib., Geol. Surv. Ill., vol. ii, p. 410, pl. 32, fig. 3; vol. iii, p. 565;—Scudder, Geol. Mag., vol. v, p. 218.

been lost by fire. Messrs. Meek and Worthen have also examined a second specimen, so that five in all have now been studied. Only one of these, that procured by Mr. Bliss, is preserved in such a way as to show the legs, and, until its discovery, the affinities of this animal would necessarily have remained very obscure.

But for my previous study of the Archipolypoda of Mazon Creek, and the revelation which these ancient types give of the divergence of structure between extinct and modern forms of Myriapoda, it would have been difficult to reach the full conviction that Palæocampa was a myriapod. It is a caterpillar-like, segmented creature, three or four centimeters long, composed of ten similar and equal segments besides a small head; each of the segments excepting the head bears a single pair of stout, clumsy, subfusiform, bluntly pointed legs, as long as the width of the body, and apparently composed of several equal joints. Each segment also bears four cylindrical but spreading bunches of very densely packed, stiff, slender, bluntly tipped, rod-like spines, a little longer than the legs. The bunches are seated on mammillæ and arranged in dorsopleural and lateral rows.

The individual rods have an intricate structure; instead of being striate, as supposed by Meek and Worthen in their last examination, they are furnished externally with about eighteen longitudinal, equidistant ridges, about half as high as their distance apart; the edges of these ridges are broken into slight serrations at regular intervals about equal to the distance between neighboring ridges, the highest point of each serration being toward the apex of the spine; the body of the ridge itself appears as if broken at each serration. The intervening space between neighboring ridges is equally divided by two or three exactly similar, but miniature ridges, serrated at more frequent intervals. This serration of both larger and smaller ridges, with the apparent jointing or incision of the ridges to the base at the lowest point of each serration, gives the whole spine a jointed appearance; but a close inspection of the floor of the spine itself between the ridges shows no sign whatever of any break in its perfectly smooth surface. The diameter of the spines is only about one-tenth of a millimeter, and yet it gives room for an exquisitely regular division of its periphery by seventy or more delicate ridges, every fourth one higher than the intervening, and all broken at minute intervals by uniform serrations. The preservation of these structures from Carboniferous times is only less remarkable than the occurrence, apparently so near the origin of the type to which it belongs, of ornamentation of such excessive delicacy, finish, complication and regularity. I cannot discover that dermal appendages of such delicate and specialized organization occur anywhere to-day among arthropods, unless it be when developed as scales, as in Lepidoptera, and occasionally in other groups of hexapods; some chætopod worms have indeed hairs of curious asymmetrical structure, often very delicate and somewhat specialized, but never, so far as I can learn, to nearly so high a degree as here. The collection of these rods into fascicles is also not a little curious, and is again a feature known now in arthropods only in a few instances, such as some tufts of hairs in lepidopterous caterpillars like Orgyia; or the pencils of hair-like scales in the males of some perfect Lepidoptera, e. g. at the tip of the abdomen in Heliconia, Danais, Agrotis, Leucarctia, etc.; or in the terminal fascicles of barbed hairs in the myriapodan genus Polyxenus.

There is no group of animals into which such a jointed creature as this could fall excepting worms, myriapods, or the larvæ of hexapod insects. The certainty that this animal possessed a single pair of well developed legs of identical character on every segment of the body behind the first segment or head is of itself sufficient evidence to exclude it both from the worms and from the larvæ of hexapod insects. No such legs or leg-like structures occur to-day in worms, and it would be idle to look for them in their ancestors of Carboniferous times. The only approach to such an appearance in hexapod larvæ is in the young of tenthredinous Hymenoptera, where, however, a difference of great morphological significance is found between the true or thoracic legs and the prolegs or those attached to the abdomen; a difference based on one of the most essential underlying features of their structure as hexapods. No such difference occurs in Palæocampa, and it is therefore impossible to conceive of it as the larva of a hexapod insect of any sort.

In myriapods only do we find a repetition of legs of exactly similar structure on every or nearly every segment of the body;* by this test Palæocampa is a myriapod; and now that we have found ancient types of this group, like the Archipolypoda, bearing huge and bristling spines arranged in series along the sides of the body, we need not be at all disconcerted at discovering this new type, with longitudinal series of fascicles of stiff rods, although we cannot restrain our surprise and admiration at their exquisite intricate structure.

Accepting Palæocampa then as a myriapod, we may next ask what relation it bore to the myriapods of the same period and found in the same waters, and also to myriapods of to-day.

* Some smaller groups, formerly, and by some authors still, considered as belonging to the myriapods, must be excepted from this statement; their relation to Palæocampa will be discussed further on.

The differences between the stout, forked and bristling spines of the Archipolypoda and the close set but spreading bunches of highly organized stiff rods of Palæocampa appear upon the barest statement. Were it not however for the complicated ornamentation of the rods themselves, the distinction between the fascicles of Palæocampa and the spines of Euphoberia would be hardly greater than that between the latter and the long hairs of an undescribed genus of Archipolypoda which has recently fallen under notice ; so that to this feature alone we cannot grant so high an importance as to another which has already been named : the presence in Palæocampa of a single pair of legs (and consequently, to judge by analogy, of a single ventral plate) to each segment; while there are two ventral plates and pairs of legs to each segment in Archipolypoda. This is a difference of profound significance, which has separated the prevailing types of myriapods down to the present day, lying as it does at the base of the distinctions between the living chilopods and diplopods. The discovery of this type is of the greater importance because we have hitherto known nothing of any chilopodiform myriapods previous to Tertiary times, unless Münster's dubious *Geophilus proavus* from the Jura possibly be an exception.

In studying the Archipolypoda we necessarily confined our comparisons with modern types to the Diplopoda, because of their common possession of the fundamental feature just named; in the same way the comparisons between Palæocampa and recent forms must be reduced to the common features or the radical distinctions which appear in studying the Chilopoda. Now although the structure of Palæocampa can be far less perfectly known than that of the equally ancient Euphoberia and its allies, enough can be seen to point conclusively to wide and important differences between it and modern Chilopoda.

In Chilopoda, of which the modern scolopendra or centipede is the type, the body is always depressed, formed of many segments, rarely as few as sixteen behind the head, each of which is compound, being formed of two subsegments, one of them atrophied and carrying no appendages; both dorsal and ventral plates are coriaceous, of nearly equal width, and possess no armature whatever excepting the simplest hairs, which are occasionally scattered over the surface. The larger subsegment bears a single pair of legs, which are composed of five slender, cylindrical, subequal joints beyond the coxa, and armed with a single apical claw ; they are attached to the interscutal membrane uniting the distinct dorsal and ventral plates of each segment and are therefore separated by the entire width of the broad ventral plates. The hindmost legs are transformed to anal stylets, while the first two pair are more profoundly transformed to subsidiary mouth-parts, the first becoming palpi and the second stout nippers. The head, really composed of eight primitive segments, is apparently made up of two, each of which is generally of about the same size as the body segments and as distinctly separated: the stout biting jaws, composed of the second pair of legs, spring from this second segment of the head, and the palpi or first pair of legs from the hinder part of the first cephalic segment; the anterior part of the same bears the many-jointed simple antennæ.

Passing now to the comparative study of Palæocampa, we find that its body was in all probability cylindrical, composed of a limited number of segments behind the head, and the head itself, considerably smaller than the body segments, is composed of only a single apparent segment. The legs of the segment immediately succeeding it are in every respect like those of the rest of the body, and have nothing whatever to do as auxiliary to the mouth. In this point alone we have a distinction as wide and incisive as any which separate the modern Diplopoda and Chilopoda. In the body segments we discover no trace of anything more than a simple ring without subdivision, but as the specimens indicate a coriaceous structure like that of modern Chilopoda, and no trace of the division between the dorsal and ventral plates can be seen in any of them, the separation of the segments into two sub-segments, as in Chilopoda, one of them greatly atrophied, could hardly be apparent did it exist. But on the other hand, as we regard the second subsegment of Chilopoda as atrophied, we should expect to find it fully or partially developed in these creatures, which of all known ancient types are certainly the most closely related to them. Yet we find here no sign of anything more than the simplest possible, uniform, leg-bearing segments, and of a very limited number. In one feature however, they are not so simple as in Chilopoda; for, as stated, each is provided on each side with two pairs of mammillæ, supporting very large bunches of spreading rods, and the rods themselves sculptured in a very remarkable way. This distinction between the two types, though more striking and noticeable than any other, is in itself by no means so important as the others, but may be added to the catalogue; and it must have some weight, from the total absence of appendages of any sort (beyond scattered hairs) from the dorsal plates of Chilopoda. The position of these rows of fascicles and of the legs indicates that the ventral plates were only a little narrower than the dorsal, and probably of about the same extent as in the Archipolypoda; in this respect they would not differ to any important degree from modern Chilopoda. The legs were different in form, but their poor preservation in the only specimen in which they have been seen prevents any thing more than the mere statement of the following difference: while the legs of Chilopoda are invariably horny, slender, adapted to wide extension and rapid movement; those of Palæocampa are fleshy, or at best subcoriaceous, very stout and conical, certainly incapable of rapid movement, and serving rather as props.

These differences, which underlie every part of the body that is preserved in Palæocampa, show that while the general accordance of grand features compels us to look upon Palæocampa as a precursor of the Chilopoda, we must separate it from them in the same way as we separate the Archipolypoda from the Diplopoda. For such a group the name of Protosyngnatha is proposed, indicating its ancestral relations to the chilopods, or Syngnatha, as they were called by Latreille.

There are, however, two aberrant groups of living animals more or less closely related to myriapods, and placed with them by some authors, with which also we should compare Palæocampa. The first of these is Peripatus, our knowledge of which has been so much increased of late years, and especially by the researches of Moseley.

In external appearance Peripatus resembles an annelid, but is furnished with a pair of long, jointed antennæ, and with numerous fleshy, tapering legs, each armed at tip by a pair of claws; the legs, set wide apart, are obscurely jointed, the joints being perceptible only at the extreme tip and on the apical half of the inner side, above which are the large elongated openings into the nephridia. The entire body is of a leathery texture with no external sign of segments, or of the separation of the head from the rest of the body, except the appendages: namely, the legs, the nephridia opening on the legs, and the ordinary appendages of the head. The same is true when the internal structure of the body is examined, for neither in the disposition of the muscles nor of the tracheal apparatus does it appear that one could judge whether a pair of legs represented one or more segments of the body; even in the nervous system it is only indicated by a small ganglionic swelling next each pair of legs. The tracheæ are like extended cutaneous glands, independent of one another, and scattered over the body, and the longitudinal muscles show no regular segmental breaks. This weakness of segmental divisions is nowhere paralleled among hexapods, arachnids or myriapods, and is an indication of very low organization among arthropods generally. The number of legs indicates from 15 to 35 segments in the body, according to the species. The first pair, as they are developed in the adult, are functionless as legs, and are situated (in the specimens I have examined—a South American species, probably *P. Edwardsii*), midway between the antennæ and second pair of legs, and not only outside of but at some distance from the mouth parts, so that the latter are not furnished with auxiliary appendages borrowed from a segment behind the first, as in chilopods; this is further proven by the development of these parts in the two groups. The body is profusely covered above with corrugated papillæ, without regular distribution.

From this it will appear that Palæocampa differs in many essential features from Peripatus, and in most at least of these shows a higher organization. The segments are well separated from one another, and the head is distinctly marked. The number of segments is much less, and each bears clusters of appendages of a highly specialized character. Although no spiracles are present in the remains we have of Palæocampa, it is clear that respiration must have been effected through linearly disposed openings; since the muscular or mechanical requirements for the movement of a completely segmented body (especially if, as in Palæocampa, the segments bear a heavy armature), forbid the miscellaneous distribution of tracheæ, and demand a well-developed system with the same linear arrangement which we find in the armature. The best that can be said of the respiratory apparatus in Peripatus is that the tracheal bundles show a tendency toward "a concentration along two sides of the body, ventral and lateral." The possession, however, in each type, of a single pair of legs to every segment behind the head indicates an affinity which cannot be overlooked, and which is the more interesting since one of the types is very ancient and the other is universally looked upon as an existing survivor of an ancient type. The form of the body and of the fleshy legs is also similar, but these are minor points: and however close the agreement between these forms we cannot look upon Palæocampa, with its undoubtedly well-developed tracheal development, as in any sense the genetic predecessor of Peripatus, for the generally distributed tracheal apertures of the latter could not have developed from a serial disposition, without a degradation of type which, as Moseley points out, many other features combine with this to disprove. It may also be added that while the legs of Palæocampa are poorly preserved in the only specimen which gives a side view, the presence of nephridial openings, of such an extent and in such a place as in Peripatus, could hardly fail of detection, and they are entirely absent. The presence of these in Peripatus is one of the marks of their inferior organization, or rather of their alliance to an inferior type, the annelids.

The other aberrant group which we must specially notice is Scolopendrella, placed at first among Chilopoda, but recently shown by Ryder and Packard to differ from them in very important features, in some at least of which it agrees with Palæocampa. The researches of these naturalists, as well as the earlier observations of Menge, clearly prove that it must be separated from the myriapods altogether, and that it is certainly provided with many points of affinity to the Thysanura. Ryder suggests for it an independent place between the Myriapoda and Thysanura under the name Symphyla. Packard, with better reason, would place it within the Thysanura, under which head he would also include the Collembola and Thysanura proper, or Cinura, as he terms them.

Scolopendrella, as these authors point out, differs from the Chilopoda in that the appendages of the segment behind that furnishing the mouth-parts proper do not serve as auxiliary organs for manducation, but are developed, like those of the succeeding segments, as legs, while the mouth parts resemble those of Thysanura, and differ from those of Chilopoda; indeed the whole head is decidedly thysanuriform; the legs are provided with a pair of claws, and the terminal segment bears a pair of caudal stylets with a special function. Besides these points the possession of a collophore is distinctively thysanuran, and the position of the stigmata, between the legs, is different from the position they uniformly maintain in Chilopoda, while it only adds to the great irregularity of place seen in Thysanura. On the other hand, the identity of form in the thoracic and abdominal segments, the full development, upon the abdominal segments, of jointed legs like those of the thoracic segments, and the occasional alternation of leg-bearing and apodal segments in the abdomen, are striking marks of its real affinity to the chilopods. Abdominal appendages, homologous with legs, but unjointed, do, however, occur in Thysanura to a greater degree than in other hexapods, so that we can hardly refuse to admit these polypodous creatures as lowest members of the sub-class of insects proper, although they are the only non-hexapodal type.

Now the separation of the head and its appendages from those of the next succeeding segment distinguishes Palæocampa from the chilopods in the same way as it does Scolopendrella; so, too, the segments behind the head in Palæocampa and Scolopendrella, alone of all arthropods in which the head is thus clearly separated, agree in showing no distinction whatever between what may be looked upon as thoracic and what as abdominal, whether in the form of the segment itself, or in the appendages of the segments. These are certainly fundamental points, but when we have mentioned them we have reached the end of all possible affinities, or points of resemblance, unless we may consider the minute structure of the rods in the fascicles of Palæocampa paralleled by the well-known delicacy of organization of the scales in other Thysanura, though they do not exist in Scolopendrella. The limited number of abdominal segments might be looked upon as a further point were it not that the number is even less than in Scolopendrella or in the Cinura; and that the Pauropida among diplopod myriapods have in some instances even a still smaller number. On the other hand, the character of the legs, the apparent absence of a double claw at their tip, the peculiar armature of the fascicled rods, which forms so striking a feature in Palæocampa, the want of any caudal stylets, and the complete uniformity of the segments of the body unprovided with distinct dorsal scutes, distinguish Palæocampa not only from Scolopendrella but from all Thysanura whatever; the general form of the body, too, is altogether different from anything occurring there, even its cylindricity being foreign to the Thysanura, excepting in their highest types among the Collembola. It seems therefore clear that the points of affinity between Palæocampa and Scolopendrella, with the single exception of the separation of the head and its appendages from the body, are precisely those in which Scolopendrella is chilopodan, and that the assemblage of features which our fossil presents are therefore chilopodan rather than thysanuran.

Regarding Palæocampa then as a myriapod, though of a type very distinct from any known, whether living or fossil, we are brought face to face with two remarkable and somewhat parallel facts: First, that *in this ancient myriapod*, as old as any with which we are acquainted, carrying us back indeed as far as any traces of wingless tracheate arthropods have been found, and therefore presumably not far from the origin of this form of life upon the earth, *we find dermal appendages of an extraordinarily high organization*, more complicated, as we have pointed out, than anything of the sort found in living arthropods, excepting the more varied but not more exquisite scales of several orders of hexapods; a form of appendage which it would seem, on any genetic theory of development, must have required a vast time to produce, but which we now seem to find at the very threshold of the apparition of this type of arthropod life.

Second, that *at this early period*, in marked contrast to what we find in other groups of articulated animals, *the divergencies of structure among myriapods was as great as it is to-day.* This is the more surprising because we possess only imperfect remains of a few types, and yet from what we already know of the Archipolypoda on the one hand, and of the Protosyngnatha on the other, they are found to differ quite as much as the Diplopoda and Chilopoda, and in points fully as important as those which separate so sharply these great modern groups. Whether they are to be looked upon, one as the ancestor of one, the other of the other, of these modern groups, is another question. It would certainly be reasonable to consider the Archipolypoda as the common ancestors of both the Chilopoda and Diplopoda; and possibly on the Protosyngnatha as the descendants on one line of a primitive type which, on another line, has retained its integrity up to the present day in Peripatus (and on possibly a third line has reached Scolopendrella); while on that which produced Palæocampa it has not, so far as we know, survived the Carboniferous epoch. With the facts of structure of ancient and modern types now before us, we are compelled, on any genetic theory, either to presume a great acceleration of development in earlier times or to look for the first appearance of myriapods at a vastly remoter epoch than we have any reason to do from the slighter hints in the rocks themselves—a period so remote as to antedate that of winged insects, which are now known from rocks older than any which have yielded remains of myriapods. In a memoir on Devonian insects, the concluding portion of which was republished in this Journal,* I showed the probability, on developmental grounds, that some of the Carboniferous insects, "together with most of those of the Devonian, descended from a common stock in the Lower Devonian or Silurian period; and that the union of these with the Palæodictyoptera (of the Carboniferous), was even further removed from us in time." The structural relations of myriapods and hexapods render it probable that the former preceded the latter: and in complete accordance with this expectation, the structural relations of the oldest fossil myriapods indicate their apparition at a period earlier than that to which the winged insects are hypothetically assigned. This would compel us to consider the earlier type as aquatic, for which we have presumptive evidence in the structure of the Euphoberidæ, and renders it all the more surprising that the penetrating researches of the last thirty-seven years, since the first Carboniferous myriapod was discovered, have not yielded the slightest trace of fossil myriapods below the Coal measures. This discrepancy between fact and hypothesis should never be lost sight of, and should stimulate to more searching investigations, particularly of those articulates of the older rocks whose affinities have not been satisfactorily settled.

* Vol. xxi, p. 117.

ART. XIX.—*A Source of the bituminous matter in the Devonian and Sub-Carboniferous Black Shales of Ohio;* by EDWARD ORTON, Columbus, Ohio.

THERE are three strata of black shale in the Devonian and sub-Carboniferous series of Ohio, viz: the Huron and the Cleveland shales of Newberry and the Waverly Black shale of Andrews. The latter name, I have followed Meek in replacing by the designation Berea shale. It constitutes the base of the Cuyahoga shale of Newberry. The first of these strata is unquestionably Devonian in age, and the last is referred without dispute to the sub-Carboniferous series. To the same division is referred the Cleveland shale by Newberry, on account of the presence in it of fishes of sub-Carboniferous type. In northeastern Ohio the Cleveland shale is separated from the underlying Huron shale by the Erie shale of Newberry, a mass of green and blue shale which ranges from nothing to 1,000 feet in thickness. Dr. Newberry showed, a number of years since, that the Erie shale thinned out as it was followed westward from the northeastern counties, and disappeared altogether in Huron county, letting the black Cleveland shale down, by overlap, upon the underlying Huron shale, which is also black. I have since shown that it is this compound stratum, the Cleveland (Erie), Huron shale, that constitutes the great black shale of Ohio, that extends from Lake Erie southward to the Ohio River and beyond. In central and southern Ohio, at least, it seems impracticable to divide it, and to refer one portion to the Devonian and another to the sub-Carboniferous, from the lack of characteristic fossils or stratigraphical marks in the formation. The average thickness of the compound formation through the State is probably not less than 300 feet.

The Berea shale, which directly overlies the Berea Grit, ranges from 15 to 50 feet in thickness, and is separated from the great black shale by an interval of 100 to 150 feet, the interval being occupied by the Bedford shale and the Berea Grit of Newberry. In northern Ohio the upper boundary of the Berea shale is not well defined. In central and southern Ohio, it is sharp and distinct.

These several beds of shale contain, as their color indicates, a notable quantity of organic matter. The proportion ranges, according to published analyses, from 8 to 21 per cent, the higher proportion having been found in some phases of the Berea shale.

The sources of this bituminous matter have not as yet been made apparent. The presence of conodonts and fish remains in the upper or Cleveland division of the great black shale, and also in the Berea shale, has been noted as one source of this organic matter, and occasional strap-shaped leaves of fucoidal origin occur in both formations, but neither of these sources seems at all adequate to the supply. Dr. Newberry has referred to a "sargasso sea" as affording the most probable explanation of the facts involved, and offers "the suggestion that the carbon of the shale was derived from vegetation which lined the shores and covered the surface of a quiet and almost land-surrounded sea." This vegetation he is disposed to regard as exclusively marine. (Geology of Ohio, vol. i, pages 155–6.)

Professor E. B. Andrews, in the Ohio Geological Report of 1869, also discussed the problem briefly. He believed that the water in which the shale was deposited must have abounded in minute forms of vegetable or animal life, but he added that a search for these forms had been unrewarded.

Within the last few months I have discovered a new source, and, as I believe, a chief source of the bituminous matter of these shales, in certain minute forms of vegetable origin which they contain in vast numbers. I herewith present a brief account of the discovery and of the facts involved.

In 1881, Mr. J. A. Flickinger, County surveyor of Ashtabula county, Ohio, sent me specimens of the drillings from a deep well which was being sunk at Kingsville, Ashtabula county, in the search for petroleum or gas. For 800 to 900 feet the drill passed through blue shale, quite uniform in appearance, and destitute of fossils. This is evidently the Erie shale of the Ohio scale.

At about 900 feet layers of black shale began to be met, and they continued to occur for 300 feet, when the boring was stopped.

In examining with a microscope the fragments of this black shale I found many of them covered and filled with yellow, translucent discs, ranging from one one-hundredth to one two-hundedth of an inch in their longest diameters. The discs present the appearance of empty and flattened spherical sacs. When the shale is cut transversely, the discs appear as elongated and translucent yellow bars, roughly parallel to the bedding, and sometimes they present the appearance of flattened hoops.

The discs have a decidedly resinous appearance, but they yield but slowly, if at all, to ordinary solvents. When the shale is raised to a red heat, they disappear entirely, leaving empty pits in the shale.

At some points, and especially at a depth of 1,000 feet, the shale is so charged that every fragment contains them, while some pieces acquire a rusty or yellowish color, even to the naked eye, from their aggregation.

At a later date I found the upper member of the great black shale in the vicinity of Columbus (the Cleveland shale), charged with identical forms. In addition to the discs already described there are occasionally found in this stratum flattened spheroids, considerably larger in size and somewhat darker in color, but obviously referable to the same group of forms. These larger bodies range from one fifty-fourth to one sixty-fourth of an inch in their long diameters, and consequently are discernible by the naked eye when they are well located. They burn with a flame and leave no residue.

I have lately examined specimens of the black slates of the three horizons named, viz: the Huron, the Cleveland and the Berea shale, from every part of the State in which they occur, and I find forms agreeing in general characters with those first described, everywhere present and often in great numbers. I am not now prepared to make computations of the number present in any measured volume of the shale, but the proportion is a notable one in many instances.

As to the nature of these bodies there seems no reasonable room for doubt. They agree in general characters with the spore-cases of several of the lower orders of plants. The descriptions given by Williamson of the lycopodiaceous spores in English coals will apply without change to the general appearance of these forms, in sections parallel and transverse to the bedding, but they lack the peculiar markings and shapes that characterize lycopod spores in particular, and will probably find their place in some lower group.

Different sizes have been recorded for these forms, but there is no doubt that all of them are macrospores. The finely-divided carbonaceous matter that is associated with them in the shale may represent the microspores.

There is nothing new in the detection of spores in formations that agree in general character with these black shales. Williamson records the presence of lycopod spores in great numbers in British fire-clays and iron ores. Binney has urged the view that the Boghead Cannel and other similar deposits must be referred to microspores for their origin.

The two inflammable Australian minerals, white coal and tasmanite, have been shown by microscopic sections to owe their inflammability to the resinous spores of lycopodiaceous plants. These minerals belong to a much later geological period than the Carboniferous. The tasmanite above referred to is a shale containing 26 to 30 per cent of combustible matter. It is therefore but little richer than the best portions of our Berea shale, which contain 21·4 per cent of bituminous matter.

I do not know, however, that spores have heretofore been shown to supply bituminous matter in large amount to any formation older than the Carboniferous.

If the construction placed upon the facts recorded in this paper shall be accepted, and vegetable spores shall be recognized as a chief source of the bituminous matter of these black shales, the perplexing question as to their origin will have been carried one step further back.

These black bands of the Huron shale lie geologically not far below the Venango oil-sands of western Pennsylvania. The resinous substances now described seem to offer an adequate and natural source of the petroleum and gas with which these rocks are charged. Dr. Newberry has long insisted on the adequacy of these beds and of these only for this supply, and he has sagaciously noted the fact that the carbonaceous matter of these shales consists mainly of hydro-carbons. The discovery of an ample supply of resinous spores within the substance of the shales certainly strengthens the claim that has been made for them as the main source of the valuable accumulations of oil and gas of the sandstones and conglomerates that overlie them.

P. S. Since writing the above I have learned, through correspondence with Principal J. W. Dawson of Montreal, that he has already recognized and described the most characteristic of the forms above referred to under the name of *Sporangites Huronensis*. (See this Journal, April, 1871, page 257.) The specimens on which his description was founded came from the bituminous shale of Kettle Point, Lake Huron. A bed of brown shale, burning with much flame, of Upper Devonian age, from twelve to fourteen feet in thickness, occurs here. The spore-cases are described as flattened, disc-like bodies, scarcely more than one-hundredth of an inch in diameter, slightly papillate externally, with a point of attachment on one side and a slit more or less elongated and gaping on the other. In sliced sections of the rock, they appear yellow like amber and show little structure, except that the walls can sometimes be distinguished from the internal cavity and are seen to enclose patches of granular matter which may be the microspores.

Dr. Dawson has kindly furnished me with a piece of the Kettle Point shale. The spore-cases appear to be identical with those first recognized by me, coming from Kingsville, Ohio. In the large range of rock which I have now reported, there are apparently several species of these bodies.

Dr. Dawson refers the spore-cases to Lycopodiaceous plants, and suggests two species of Lepidodendron, the remains of which are found at the same horizon, as likely to furnish them, viz: *L. Veltheimianum* and *L. Gaspianum*.

Columbus, Ohio, June 1, 1882.

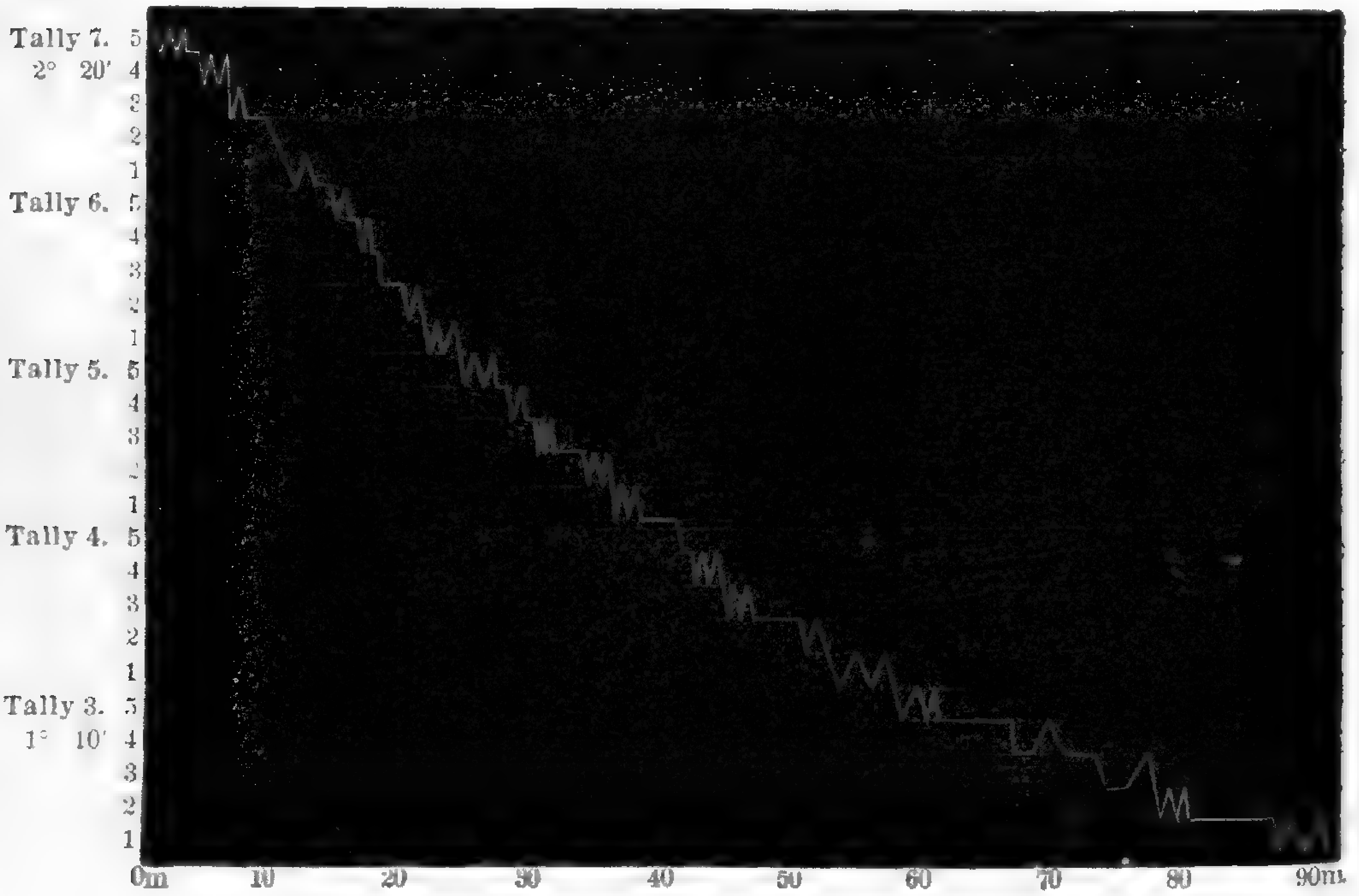
Art. XX.—*A Pendulum Study;* by O. T. Sherman.

"Le mode d'installation du pendule, la nature du support sur lequel il est placé, en raison de l'elasticité de la matière dont il est composé ou de sa masse relativement peu considérable, peut exercer une influence sur le mouvement du plan de suspension. Cette influence est tres-sensible pour un support en bois; . . . . elle est encore appréciable entre un pilier en pierre . . . . et le pilier très-massif sur lequel les observations ont été faite . . . . a Genève."—E. Plantamour.

The above describes pretty completely the only result which it is my fortune to draw from a series of pendulum observations taken during a northern journey. But, what is the mode of action of the disturbance? It affects the mean of the observations; can its correction be drawn from the observations themselves?

The stand with which the expedition was furnished was formed by three beams of about five inches square, and fastened by bolt and screw mutually at right angles. These are braced in each of the three coördinate planes. The pendulum case, of light wood, rested on a bracket and was secured to the upright by bolt and screw. The agate planes were fastened to a weighty, solid gun-metal casting, and it in turn by screws to the back of the case; the whole forming a support as stable as the material would allow. While studying the subject since returning, the case has been fastened to the brick wall of the clock room of the Observatory of Yale College. The connection is made through wood. The results show, if any, very little improvement over the portable stand. The pendulum itself is a Baily's bar made to beat in three-quarters of a second at Washington, D. C. It was customary in the field to measure the amplitude of the arc by making the cross wire of the observing theodolite coincide with the extremities of the arc, and noting the angle subtended. The observations were not frequent and no discrepancy was noticed. When the instrument again reached my hands it was provided with an arc divided into degree and ten-minute spaces. The scale was subjected to a critical study and the errors of the graduations tabulated. We then endeavored to trace the decrement of the arc by observations every five minutes. After making every correction it was found impossible to represent the observations by any smooth curve. The observations for the larger arcs might be fairly represented by a somewhat sinuous, the smaller arcs by a very jagged, line. Thoroughly dissatisfied with the action of this scale it was replaced by a net formed by a number of silk threads passed over two similar screws.

For better distinction the threads were divided into tallies—five black and five white. The interval between the threads was about seven-tenths of a millimeter. The observer then sitting behind the telescope made at each apparent contact of the knife edge with a thread, a signal on the chronograph at once representing the tally and thread which the knife edge seemed to touch. The result was so unforseen as for some time to cause a doubt in the mind of the observer as to its correctness. He assured himself of its reality by obtaining fairly identical results again and again. Over some threads the knife edge passed with rapidity. On others it rested for an interval increasing with the decreasing rapidity of the movement. Many it touched, passed, retouched, repassed. A representation is annexed. The abscissæ being the interval in minutes since the commencement of observation. The ordinates, the number of threads from the center.



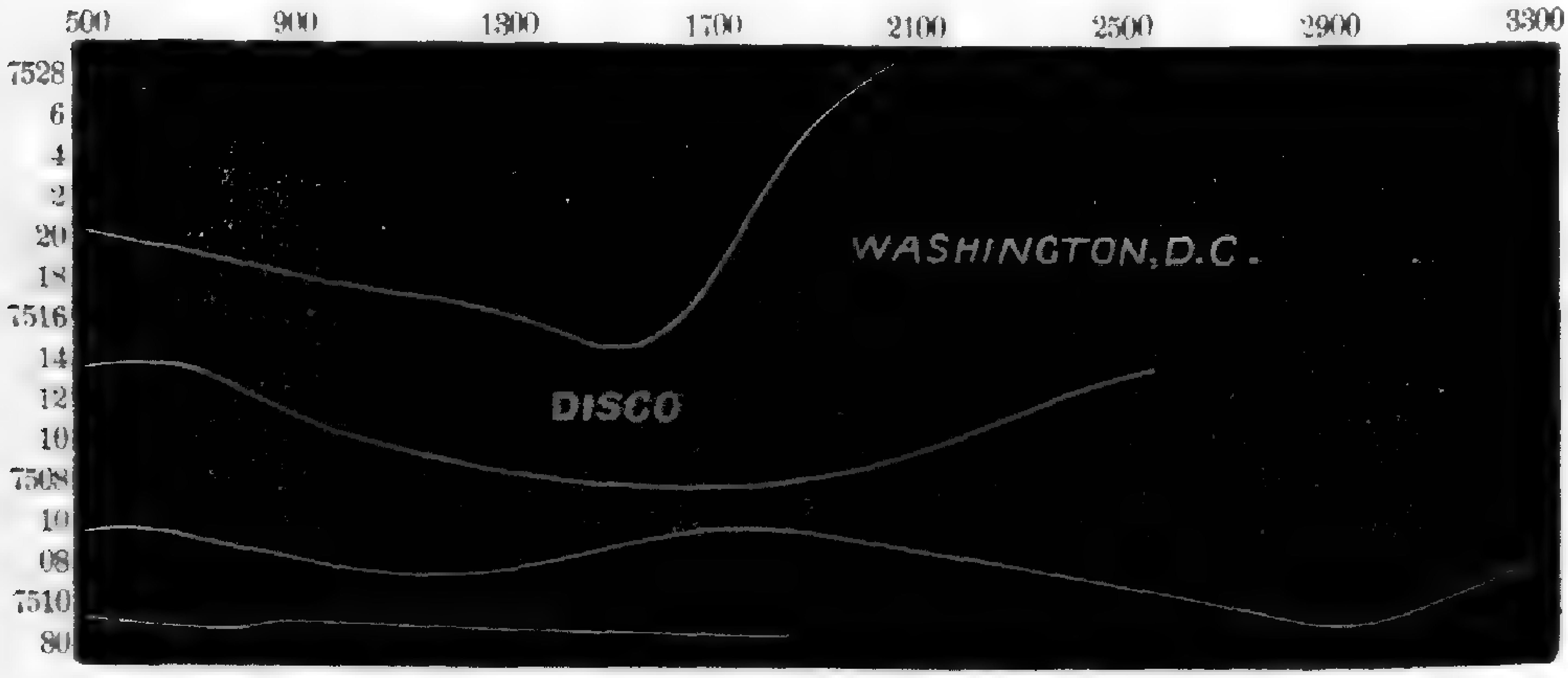
It is interesting to compare with the above paragraph a remark of the Coast Survey Observer, who notices that the discrepancies of the separate observations of the intervals at which his pendulum reached a given arc are several times larger than can well be attributed to errors of observation. Is it not quite probable that there was in his case an indeterminateness similar to that shown in the diagram?

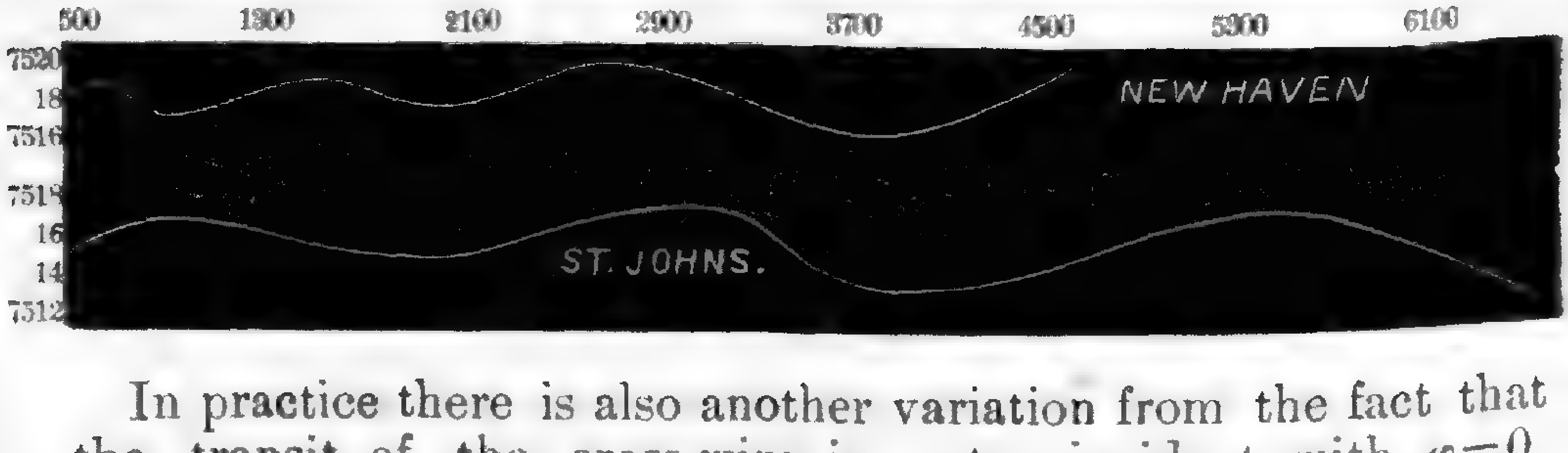
It seemed likely that this was due to a walking of the pendulum, such as might effect a change in the absolute position of the bar during the time of swing. I therefore fixed on the bar a small bit of looking-glass in which was reflected a scale. At the beginning of the swing a thread was set so that when covered by the cross-wire of the telescope it bisected the knife edge. The telescope was then directed to the mirror and focused so that a division of the reflected scale was visible on the cross-wire. The pendulum was then carefully set in motion and allowed to come to rest. The position of the reflected scale was first re-examined then the telescope re-directed toward the thread. Although a hundred and twenty observations were taken no change was detected.

The only other explanation which has suggested itself is that of small movements of the stand which are not synchronous with the swing of the pendulum. In one set of observations this resulted from the nature of the ground on which the stand rested; in another it varied with the varying tightness of the joints from the dryness of the wood; in a third which has lately been called to our attention it is apparently caused by the vibration of the clock on the same wall. It has been shown that the effect of the motion of the plane of suspension due to the elasticity of the support increased the time of vibration by a constant. If, however, there are other causes for the motion of this plane than the elasticity of the support, the variation of the time is represented by

$$\varDelta T = \frac{1}{2g}\int_{\varphi=}^{\varphi=} \frac{\delta^2 s}{\delta t^2} \cdot \frac{\cot\varphi}{V} \cdot \delta\varphi$$

where $\frac{\delta^2 s}{\delta t^2}$ represents the variation of the velocity of the motion of the plane of suspension; V, the velocity of the pendulum due to its instantaneous position. Of this differential $\frac{\cot\varphi}{V}$ passes through its series of values with each swing. If $\frac{\delta^2 s}{\delta t^2}$ has the same period the integral is evidently a non-periodic function of the arc or a constant. If, however, $\frac{\delta^2 s}{\delta t^2}$ has a period, or series of periods, which are different from that of $\frac{\cot\varphi}{V}$, the value of the integral will depend on the phase with which $\frac{\delta^2 s}{\delta t^2}$ enters; and since in the course of the observation this phase will again occur with the commencement of the period of $\frac{\cot\varphi}{V}$, the function representing the disturbance of time of oscillation should be one possessing maxima and minima disposed according to some law. Since the phase of $\frac{\delta^2 s}{\delta t^2}$ at entrance reacts on the time of swing, the limits of the integral will be irregular with respect to the portion of $\frac{\partial^2 s}{\partial t^2}$ included, and we should have a series of minor irregularities, themselves following some law, superposed on the curve produced by the varying phase at entrance. Again, since the value and relative period of $\frac{\partial^2 s}{\partial t^2}$ and V do not necessarily decrease in the same ratio with the continuance of the observation, the amplitude and period of the disturbance should continually increase or decrease. All of these are distinct from the traces of other errors of the pendulum. This curve is a record of the variation of the time of vibration produced by the motion of the plane of suspension, and therefore a definition of the steadiness of the stand. We deal, however, with means rather than the time of single vibration, and obtain a different defining curve for different limits of the second integral. But from whatever number of vibrations our means are derived we obtain the above peculiarities.





In practice there is also another variation from the fact that the transit of the cross-wire is not coincident with $\varphi=0$. Experimentally we can obtain but an approximation to the actual curve representing ΔT, but yet certainly a sufficient approximation. To this end the observer seated with his eye at the telescope has recorded on the chronograph the time of each transit in the same direction. Frequent short breaks are indulged in. They break the rhythm and better rather than injure the observation. Then reading the sheet we have taken

(e. g.) the mean of the interval bounded by the first and thousandth transit, the second, and thousandth and second, etc. Thus including in the second interval by far the greater part of the first interval, but depending on two different observations. This served to insure against accidental errors. These values are then carefully plotted, the number of transits from the beginning being used as the abscissæ. The curves thus derived fulfill our expectations as far as we can sharply criticise a statement so general.

Furthermore, curves from the same mounting preserve their general peculiarities for different observations. For different mountings the amplitude is greater with the less stability. In the preceding diagram we represent certain of these curves for the different places of observation. The sharp and quick irregularities are omitted on account of the smallness of the scale. In fact we have not now to deal with them. Since at the time of observation we supposed ourselves dealing with synchronous motion, the curves are not complete. They serve their purpose. The curve for Washington represents the least stability; that for Disco the greatest. At Disco we give three curves. The first represents the action of the stand when first set up, the parts being dry. The stand was exposed to the weather. Between the first and second series a heavy fog had swollen the parts. Between the second and third a heavy snow storm had still further swollen the various parts. For the first installation the amplitude of the curve is at least 0·0008 of a second; for the second at least 0·0003. For the third it is indeterminate. All refer to about the same amplitude of vibration. The curve for St. Johns represents fairly the increased effect of the disturbance with decreasing arc. The same is also shown in the curves for New Haven, and the second curve for Disco. It has not seemed necessary to correct the values here represented for arc.

We venture to think, then, that while an observer who finds himself compelled to work with a mounting other than he would wish can not consider that his time is increased by a constant, yet he is in a position to detect and define the effect of the stand movements at the moment of observation. This would seem the first step toward eliminating the effect. That such an elimination can be made—at least a practical elimination—we hope to show later. We can offer as yet no experimental data of its completeness.

It is to be observed that the curves derived from this cause are distinct from those produced by the form of the knife edge. It is easily shown that for any smooth, rounding, and practically, for any slightly waving form of the edge, the time of vibration is represented by

$$t=\sqrt{\frac{l}{g}}\sqrt{\frac{1}{1+\mathrm{P}\alpha^2}}\cos^{-1}\pm\frac{0\alpha^2+2(1+\mathrm{P}\alpha^2)\varphi}{\sqrt{0^2\alpha^4+4(1+\mathrm{P}\alpha^2)\alpha^2}}$$

where P and 0 are constants depending on the form of the knife edge and varying inclination of the instantaneous axis to the face of the pendulum. Such a variation, as has already been recognized (India Survey, Pendulum Operations: Coast Survey Report, 1876), is detected by a non-periodic acceleration or retardation of rate.

ART. XXI.—*On the Effect of Mechanical Hardening on the Magnetic Properties of Steel and Iron*; by LOUIS M. CHEESMAN.*

1. *Introduction.*—The relation between the magnetism and hardness of steel and iron has for many years been a subject of scientific investigation, and especially in the last few years many valuable results have been obtained in this connection.

These investigations, however, have been almost exclusively confined to the effect of the hardness brought about in steel and iron by the action of heat, while that which is caused by mechanical means has been left for the most part unconsidered. This is the more remarkable as the fact, that the mechanical hardening exerts an influence on the capacity to retain magnetism, has certainly been known for nearly a century. Coulomb,† who I believe was the first to publish this fact, says, in speaking of increasing the magnetic capacity by means of hardening, that "the hardness does not need to be accomplished by heating to redness and then suddenly cooling, but that a mechanical hardening as well causes an increase in the permanent magnetic moment."

In this connection should also be mentioned an investigation by Airy,‡ who informs us that the magnetism assumed by cold- and hot-rolled iron, under similar circumstances, are to each other as 6 is to 5. Lastly I would refer to a passage in one of Lamont's§ works, where we find it stated that the capacity of soft iron for induction is materially altered by a mechanical hardening. Thus, although the subject under consideration is by no means a new one, still little, if anything, beyond what has already been stated, seems to be known in regard to it; and I have therefore endeavored, at the instigation of Prof. F.

* Translation from Wiedemann's Annalen, vol. xv. 1882.

† Coulomb, mém. del'Acad. roy. des Sciences, p. 266. 1784. Wied. Galv., II. a, p. 341.

‡ Airy, Experiments on Iron Built Ships. Philos. Trans. 1839. Fortschr. der Physik., xix, p. 454. 1863.

§ Lamont's Handbuch des Magnetismus, p. 255.

Kohlrausch, to study the matter somewhat more systematically than hitherto has been done, with especial reference to the question, whether there are any qualitative differences between the effects of the two kinds of hardening on the magnetic properties of steel and iron.

2. *Division of the work.*—The work divides itself naturally into a consideration of the effect of the mechanical hardening: 1st, on the permanent magnetism of saturated magnets; 2d, on the temporary, as well as the permanent magnetism, by various intensities of the magnetizing force.

3. *Material.*—In regard to the material used it should be stated, that experiments were made with steel and iron from many sources. The kind of steel chiefly employed however, was that known as "English Silver Steel," which was obtained from Crooks Bros. in Sheffield and Manchester, in the form of wires, 330^{mm} long, with the diameters $1{\cdot}0^{mm}$, $1{\cdot}2^{mm}$ and $1{\cdot}6^{mm}$. The iron magnets were cut chiefly from a long piece of soft "Commercial Iron Wire," having a diameter of $1{\cdot}6^{mm}$.

All the material, when the contrary is not stated, was softened, before being used for the experiments, by heating it in an iron box filled in with forge scales. After the box with its contents had been at a red heat for some time the fire was allowed to die out, the material remaining in the forge until it had cooled down to the ordinary temperature. After the wires had been softened every precaution was taken to prevent any unintentioned hardening.

4. *Hardening.*—The wires were hardened either by "bending," "stretching," "hammering," or "pulling" them through holes in the well-known apparatus for reducing the diameter of wires.

The last mentioned method has the great advantage of enabling us to obtain wires of different degrees of hardness with very nearly equal diameters. Thus if three wires differing in hardness are to be obtained they may be pulled, for example, wire (a) through holes [1], [2] and [3], wire (b) through [1] and [2], and wire (c) through hole [1]; they are then softened and wire (c) pulled through [2] and [3], wire (b) through [3] and wire (a) left soft, all thus having the diameter of hole [3]. This advantage, however, is more than counterbalanced by the fact, which was evident in many ways, that the hardening is very irregular.

By far the most satisfactory experiments were made with wires hardened by "stretching" them in an apparatus [Perreaux] for determining the "breaking weight," the weight being read off by an index in kilograms.

I.—Permanent Moment of Saturated Magnets.

The general course of the experiments here was to magnetize to saturation wires having, as far as possible in the same set of experiments, the same constitution and dimensions, but differing in their hardness; then to determine their magnetic moments.

5. *Magnetization.*—The wires were magnetized by means of a large horse-shoe magnet,* and in all cases the magnetization was repeated until the deflection on the magnetometer remained constant within at least $\frac{1}{2}$ %. As great care was used to treat all wires similarly, two magnetizations were generally sufficient.

It should be stated that a series of experiments made later, the wires being magnetized by means of a coil and the current from a dynamo-electric machine, afforded results differing in no essential degree from those given here.

6. *Determination of the magnetic moment.*—The magnetic moment was determined with a small magnetometer by the Gauss deflection method, the magnets lying in such a position, west of the magnetometer, that the prolongations of their axes were perpendicular to the undeflected magnetometer needle at its middle point; the readings were taken by means of a scale and telescope.

A steel mirror, [Sauerwald, diameter 22^{mm}] hung on a silk fiber, served as magnetometer needle.

To eliminate any unsymmetrical distribution of magnetism, as well as the zero point of the scale, the magnets were placed alternately with their north and south ends toward the magnetometer, in both positions the scale reading being taken.

The distance between the mirror and magnet was determined within $0{\cdot}15^{mm}$, and though not always the same was about 450^{mm}; the distance between the mirror and scale was about 2000^{mm}.

7. *Calculation of the Experiments.* — The *specific magnetism* was calculated by the following formula:

$$s=\frac{M}{m}=\frac{1}{2}\frac{r^3 T \operatorname{tg}\varphi}{1+\frac{1}{2}\frac{l^2}{r^2}}\cdot\frac{1}{m}\,\mathrm{mm}^{\frac{1}{2}}.\,\mathrm{mg}^{-\frac{1}{2}}.\,\mathrm{sec}^{-1}$$

s denoting the specific magnetism,
M denoting the magnetic moment,
m denoting the mass of the magnets in mgs.,
φ denoting half the angle of deflection of the magnet,
T denoting the horizontal intensity of the earth's magnetism,
r denoting the distance between the center of the magnets and the mirror in mm.,

*Horse-shoe magnet made by Funckler; portative force, 50 kg.

l denoting the distance between the poles of the magnets in millimeters.

In all cases the *specific magnetism*, i. e., the magnetic moment divided by the mass of the magnet, is given, instead of the magnetic moment, so as to allow a comparison of the results obtained with magnets of different dimensions.

The value of the horizontal intensity for one point in the laboratory being known from a recent absolute determination by Professor Kohlrausch, its value for the position of the magnetometer was obtained by relative determinations.

As the results to be obtained did not possess sufficient quantitative importance to warrant an experimental determination of the distance between the poles in the case of each magnet, 0·85 of the length of the magnets was used as approximation for the quantity (l).

The torsion-ratio of the fiber holding the mirror was determined as 0·00027 and not taken into consideration in the calculation of the results.

Experiments.

8. *Experiments with Iron.*

Set I.* Iron. Length=90 mm.

No.	Condition.	Diameter.	Deflection in scale divisions.	Specific Magnetism.
1	Natural	1·70mm	22·0mm	161
2	Hammered	1·71	27·9	208
3	Stretched	1·60	31·7	276
4	Stretched	1·61	30·8	253

* Not specially softened.

Magnets 3 and 4 were hardened by stretching, one end being held in a vice.

Set II. Iron. Length=100mm. Diameter=0·94mm.

No.	Number of holes.	Deflection in scale divisions.	Specific magnetism.
1	0	16·8mm	341
2	1	25·2	490
3	2	26·6	489
4	3	26·3	492
5	4	28·1	525
6	5	25·6	491
7	6	27·6	526
8	6	29·8	557

These wires were hardened by "pulling" them through the number of holes designated in the second column, by the method more fully described under "Hardening." (See 4, above.)

SET III. IRON. LENGTH 100mm.* DIAMETER 1·67mm.

No.	Stretching weight.	Deflection in scale divisions.	Specific magnetism.
1	0 kg	25·2	164
2	0	24·6	160
3	10	26·4	173
4	25	25·0	165
5	35	30·8	204
6	45	30·3	201
7	55	31·9	217
8	60	32·5	230
9	65	33·3	241
10	65	35·4	275

* The decrease of the diameter from No. 1 to No. 10 was about two per cent of the diameter of No. 1.

These wires were hardened by subjecting them to the action of a stretching force in the apparatus made by Perreaux for determining the "breaking weight" of wires.

Wire No. 1, of Set III, being subsequently hardened by "hammering," the increase in length due to the same being cut off, had after magnetization a specific magnetism of 195.

Wire No. 2, of Set III, having been bent several times and remagnetized, had a specific magnetism of 189.

Comparing I, II and III, we find in each set the smallest value of the specific magnetism in the case of the softest wire and a gradual increase of the same with the hardening, in set III the increase amounting to 70 per cent. The increase of the specific magnetism seems at times somewhat irregular; this however is easily explainable by the remarks made under the head of "Hardening."

Experiments made with a magnet of cast iron (length 102mm. diameter 7mm.) also gave an increase of the specific magnetism with the hardness, the hardening being brought about by gentle hammering.

9. *Experiments with Steel.*—In the experiments with steel a difficulty presented itself, which though also present with iron was far less annoying there, namely the fact that the different wires were not homogeneous. This was noticeable not only from the fact that wires, in as far as possible the same physical condition, could be magnetized to very different extents, but also in that their "breaking weights" differed widely. On the other hand, however, pieces cut from the same wire gave results comparable with each other.

In the following experiments a piece of each wire used was left soft for the sake of comparison.

Set IV. "English Silver Steel." Length 100mm. Three wires.

			Diameter.	Deflection.	Specific mag.
No. 1	*a.*	Broken by a weight of 125 kgs.	1·48mm	51·9	452
	b.	Soft	1·56	85·6	685
No. 2	*a.*	Subjected to a stretching weight of 60 kgs.	1·51	59·2	499
	b.	Soft	1·54	72·2	580
No. 3	*a.*	Subjected to a stretching weight of 30 kgs.	1·51	76·5	621
	b.	Broken by a weight of 77 kgs.	1·52	46·0	379
No. 1	*b.*	Hammered } remagnetized		65·5	524
No. 2	*b.*	Hammered } remagnetized		61·1	480

Set V.* Steel. Length 90mm.

Wire.	Stretching weight in kg.	Diameter.	Deflection.	Specific magnetism.
II a	0	1·28	61·4	781
I a	0	1·28	60·0	756
III a	0	1·28	60·1	769
I b	20	1·27	61·0	776
II b	30	1·29	61·1	773
I c	50	1·28	61·1	775
III b	55	1·27	60·2	774
III c	60	1·28	55·2	708
III d	65	1·26	48·4	623
II c	70	1·29	50·1	637
I d	75 (brach)	1·29	43·7	556

* Not specially softened.

These wires were hardened as in "Set III, iron."

Comparing the results obtained with steel (sets IV and V) we find the reverse of what we saw in the case of iron, namely, that the greatest specific magnetism occurs with the softest wires.

Many experiments with both steel and iron similar to those already given were made, but as nothing was obtained from them not contained in the above they are here omitted.

10. *Influence of the ratio of the length to the thickness on the specific magnetism.*—Later results obtained with steel, though in fact corroborating the earlier experiments, seemed at first to contradict them. Hitherto I had observed in all cases with steel a decrease of the capacity to retain magnetism with the hardening; a steel bar however, having a length of 100mm. and a diameter of 7mm., gave the reverse result, its specific magnetism when soft being 100, after hardening and remagnetization 133. The possibility that the bar was iron was refuted by the hardness it assumed on being heated and suddenly cooled. Experiments were then made with bars of "English Silver Steel," from Crooks Bros., the dimensions being the same as those of the above-mentioned magnet; also in this case an increase of the specific magnetism with the hardening was observed.

Thus was proven that the increase of the magnetism in the one case and the decrease in the other did not lie in the different quality of the steel employed.

It will be observed, however, that the dimensions of the magnets used in these later experiments were very different from those of the magnets used earlier, when the magnetism was found to decrease with the hardening; in the former case the ratio of the length to the thickness being 14·3, in the latter case in the neighorhood of 65.

To ascertain whether this caused the apparently contradictory results obtained, a magnet was made of "English Silver Steel," the length being so chosen as to obtain a magnet with about the same value of $\frac{L}{D}$ as in the case of those magnets, which had shown an increase of the specific magnetism with the hardening.

The constants of the magnet were: length = 21·0mm., diameter = 1·54mm., $\frac{L}{D} = 13{\cdot}6$. The magnet showed a 30 per cent larger specific magnetism in the hard than in the soft condition.

Thus the apparently contradictory results with steel seemed to be due to the different values of the ratio $\frac{L}{D}$.

The following sets of experiments, VI, VII and VIII, were made to test this conclusion more fully.

SET VI. "ENGLISH SILVER STEEL."

The wires designated by (b) were hardened by a stretching weight of 70kgs.

Wire.	Length.	$\frac{L}{D}$	Deflection.	Specific magnetism.
1 b	21·0mm	13·7	10·9	80
1 a	21·0	14·3	13·3	102
2 b	40·0	26·0	50·0	190
2 a	40·0	26·7	62·2	247
3 b	60·0	39·0	124·0	309
3 a	60·0	40·8	124·1	338
4 b	120·0	80·0	600·1	742
4 a	120·0	78·4	428·7	522

SET VII. FROM ONE WIRE OF "ENGLISH SILVER STEEL."

1b, 2b, 3b were hammered to obtain 1a, 2a, 3a.

Wire.	Length.	$\frac{L}{D}$	Deflection.	Specific magnetism.
1 b	31·1mm	20·1	31·8	162
1 a	31·3	20·1	38·5	186
2 b	60·0	38·9	175·2	454
2 a	61·0	39·1	176·4	456
3 b	100·0	64·9	463·7	706
3 a	101·0	65·4	371·9	566

SET VIII. FROM ONE WIRE OF "ENGLISH SILVER STEEL."

The wires were hardened as in set VII.

Wire.	Length.*	$\frac{L}{D}$	Deflection.	Specific magnetism.
1 b	27·0mm	22·5	18·0	164
1 a			19·8	180
2 b	48·5	40·4	92·3	480
2 a			93·0	484
3 b	70·3	58·6	217·0	756
3 a			173·8	604

* By mistake the increase in length due to the hammering was not measured.

The results of VI, VII and VIII, are represented graphically in fig. 1, p. 193.

From these results we see that a cylindrical magnet, magnetized to saturation, is able to retain more or less magnetism when soft than when hard, according to whether the quotient of its length by its diameter is greater or less than some value (α_0).

Furthermore it is evident that the specific magnetism is a continuous function of the quotient $\frac{L}{D}$.

Both of the foregoing laws have already been proven for heat-hardened magnets.*

No further experiments were made to ascertain from what the value of $\frac{L}{D}$ where the curves cross (α_0) might depend; Ruths found (α_0) to vary between 30 and 40, while in the three cases given here it varies but little from 41.

With iron no crossing of the curves of the hard and soft magnets was observed; it is probable, however, that at greater values of $\left(\frac{L}{D}\right)$ the curves do cross, and I hope at an early opportunity to study this portion of the subject more fully.

11. *Effect of heating the hardened wires.* — The question might well be asked if, when mechanically hardened wires are softened by heating, the increase or decrease in the magnetic moment, which was coincident with the hardening, disappears. Experiments to answer this were made by softening wires, the magnetic moment of which when hard had been determined, and then remagnetizing them; the specific magnetism was found to change in each case in the direction which would be expected from the experiments given in the foregoing pages, and the magnets were capable of having their moments increased or decreased, as the case might be, by a second hardening.

* Chas. Ruths, Ueber den Magnetismus weicher Eisencylinder, Dortmund, 1876.

12. Before leaving this part of the subject the result of some experiments should be stated, which were made to ascertain what care was necessary to be taken to prevent a loss of magnetism while the magnets were being adjusted, etc. A large loss of magnetism was observed in all cases when the magnets were subjected to any sudden jarring; so that, as may be seen from the following table, great care had to be exercised between the magnetization and the determination of the magnetic moment.

	Wire.	Falling.	Loss of original magnetism.
1	Steel, soft	1·5m	30 per cent.
2	" mechanically hard	2·0	44
		3·0	57
3	" soft	3·0	55
4	" mechanically hard	2·0	52
5	Iron, " "	2·0	84
6	" " "	3·0	84
7	" soft	2·0	83
8	" "	2·0	97
9	Steel, heat-hardened	3·0	6
10	" " "	3·0	4

As is well known the heat-hardening does much to render a magnet less sensitive to jarring, etc.; it was not discoverable, from the experiments made, that the mechanical hardening produces even in a small degree a similar effect.

II.—Experiments with unsaturated Magnets.

13. *Apparatus.*—The apparatus was arranged as is usual in cases where the temporary magnetic moment is to be determined by the deflection of a magnetometer needle; the method having been so often described by others,* it would seem unnecessary to enter into any minute description here.

The effect of the magnetizing helix on the magnetometer was counterbalanced by a second one, the helices being placed, the one to the north, the other to the south of the instrument. The course of the current was as follows: from the battery through the two coils and a variable resistance to a key, and finally through a tangent-compass back to the battery.

By means of a commutator, the direction of the current in the tangent-compass could be reversed.

The constants of the magnetizing helix were as follows:

Length	223mm
Internal radius	19
External radius	52
Number of windings per layer	55
Number of layers	10

As an accurate and at the same time convenient method of adjusting the magnets, a glass tube, with an internal diameter

* Compare Ruths, Ueber den Magnetismus weicher Eisencylinder. Dortmund, 1876.

somewhat larger than that of the magnets, was held firmly by corks in the axis of the coil, and the magnets pushed into position by a glass rod.

The tangent-compass was made with a single ring of copper, having a mean diameter of 404^{mm}.

The compass needle, being but 20^{mm} long, was provided with a glass pointer; the scale, which was divided into degrees, was cut on mirror glass.

The order of the observations was as follows: (1.) reading of the magnetometer with the circuit open; (2.) with the circuit closed; (3.) with the circuit closed and the magnet in the coil; (4.) the deflection of the tangent-compass was then determined [commutated]; (5.) and lastly the magnetometer reading was taken with the circuit open and the magnet in the coil.

The difference between the readings (3) and (2) gives the deflection due to the temporary magnetism; that between 5 and 1, the deflection due to the permanent magnetism.

14. *Calculation of the Experiments.*—The calculation resolves itself into (a) that of the magnetic intensity in the coil, and (b) that of the resulting temporary and permanent magnetism.

(a.) *Intensity of the magnetic force.*—This resolves itself again into two, the calculation of the intensity of the current and that of the constant for the magnetic working of the coil.

The intensity of the current was calculated by the formula: $i = A \operatorname{tg} \varphi$. The reduction factor $\left(A = \frac{Tr}{2\pi n}\right)$ of the tangent-compass to the absolute system was calculated 62·7.

The correction to the above formula, due to the cross-section of the windings and the length of the needle lay within the errors of observation, and was therefore not considered.

(b.) *Intensity of the magnetic field in the coil.*

The formula,

$$\text{(I)} \qquad X_x = \frac{i\pi n}{a}\left[\frac{a-x}{\sqrt{(a-x)^2+r^2}} + \frac{a+x}{\sqrt{(a+x)^2+r^2}}\right]$$

gives the magnetic effect of a coil, of the length 2a, the radius r and n windings traversed by a current of intensity i, on a point situated in the axis of the helix at a distance from its center.

To obtain the mean intensity of the field for a bar, with the length 2b, and with a cross-section so small that we may consider the bar as lying wholly in the axis, we divide formula (I) by $2b$ and after multiplying by dx, integrate between the limits $x = -b$ and $x = +b$.

We thus obtain,

$$\text{(II)} \quad X_{2b} = \frac{1}{2b}\int_{x=-b}^{x=b} X_x dx = \frac{\pi n i}{ab}\left[\left\{(a+b)^2+r^2\right\}^{\frac{1}{2}} - \left\{(a-b)^2+r^2\right\}^{\frac{1}{2}}\right]$$

Finally to obtain the effect of the (c) layers of windings, the external and internal radii being respectively r' and r'. we can multiply formula (II) by $\frac{c}{r''-r'}dr$ and integrate the product with respect to r, from $r=r'$ to $r=r''$. We thus obtain,

$$\text{(III)*} \quad \frac{X}{i}=\tfrac{1}{2}\frac{\pi n}{ab}\cdot\frac{c}{r''-r'}\Big[(a+b)^2\cdot\log\frac{r''+\sqrt{(a+b)^2+r''^2}}{r'+\sqrt{(a+b)^2+r'^2}}$$

$$+(a-b)^2\log\frac{r'+\sqrt{(a-b^2)+r'^2}}{r''+\sqrt{(a-b)^2+r''^2}}+r''\{\sqrt{(a+b)^2+r''^2}$$

$$-\sqrt{(a-b)^2+r''^2}\}+r'\{\sqrt{(a-b)^2+r'^2}-\sqrt{(a+b)^2+r'^2}\}\Big]$$

The value of $\left(\frac{X}{i}\right)$ calculated by (III) for the magnetizing helix used was found to be 29·23, for $2b=100$.†

(c.) *Calculation of specific magnetism.*—In these experiments the magnets were situated so that the prolongation of the undeflected magnetometer needle was perpendicular to them at their middle point, and hence the specific magnetism is to be calculated by the following formula:

$$s=\frac{M}{m}=\left[\frac{r^3 T\,\mathrm{tg}\varphi}{1-\frac{3}{8}\frac{l^2}{r^2}}\right]\cdot\frac{1}{m}\cdot \mathrm{mm}^{\frac{5}{2}}\mathrm{mg}^{-\frac{1}{2}}\cdot\mathrm{sec}^{-1}$$

The various quantities have the same meanings as in the corresponding formula in part I.

15. *Experiments.*

"ENGLISH SILVER STEEL." WIRE 1 a. HARD. SUBJECTED TO A STRETCHING WEIGHT OF 81 kgs. LENGTH 100mm. $\frac{\text{LENGTH}}{\text{DIAMETER}}=69{\cdot}0$.

Perm. mag.		Temp. mag.			
Deflection.	Sp. mag.	Deflection.	Sp. mag.	Tangent-compass Deflection.	Magnetic force.
0·1	3·75	0·3	11·2	0°·90	28·8
0·8	29·9	2·4	89·9	2·55	81·6
1·4	52·4	4·6	172	3·55	114
2·8	105	6·2	232	4·50	144
4·8	180	10·1	378	6·45	207
7·8	292	16·7	625	10·65	345
9·8	376	26·8	1004	19·55	651
10·9	408	32·0	1202	31·45	1125
11·0	412	33·6	1258	37·55	1410

* Compare W. Weber, "Elektrodynamische Massbestimmungen, insbesondere über Diamagnetismus," p. 547. Ruths, Magnetismus weicher Eisencylinder, p. 7.

† All the magnets used were 100mm long.

WIRE 1 b. SOFT. LENGTH=100mm. $\frac{\text{LENGTH}}{\text{DIAMETER}}=67\cdot6$.

Perm. mag.		Temp. mag.			
Deflection.	Sp. mag.	Deflection.	Sp. mag.	Tangent-compass Deflection.	Magnetic force.
0·1	3·66	1·6	58·6	1°·30	41·6
1·8	65·9	4·1	150	2·45	78·4
3·6	132	7·1	260	2·80	89·7
8·0	293	13·2	483	4·45	143
11·9	436	19·3	706	6·40	206
14·0	512	23·1	845	8·45	272
18·8	688	30·8	1127	18·20	603
20·0	732	34·4	1259	28·70	1004
20·1	736	35·4	1295	35·90	1327

"ENGLISH SILVER STEEL." WIRE 2 a. HARD (HAMMERED). LENGTH=100mm. $\frac{\text{LENGTH}}{\text{DIAMETER}}=69\cdot9$.

Perm. mag.		Temp. mag.			
Deflection.	Sp. mag.	Deflection.	Sp. mag.	Tangent-compass Deflection.	Magnetic force.
0·7	24·3	2·2	76·4	2°·15	68·8
2·0	69·5	5·0	174	3·45	110
3·5	122	8·4	292	4·20	135
7·3	254	14·4	500	6·00	193
10·0	347	21·2	736	9·80	317
11·9	413	25·7	893	13·50	440
14·0	486	31·8	1105	23·45	795
15·5	538	35·9	1247	40·30	1554

WIRE 2 b. SOFT. LENGTH=100mm. $\frac{\text{LENGTH}}{\text{DIAMETER}}=70\cdot9$.

Perm. mag.		Temp. mag.			
Deflection.	Sp. mag.	Deflection.	Sp. mag.	Tangent-compass Deflection.	Magnetic force.
0·2	7·10	1·9	67·5	1°·40	43·8
1·1	39·1	4·1	146	2·30	73·6
3·7	131	7·8	277	3·00	96·1
7·3	259	13·0	462	4·35	140
10·1	359	17·1	607	5·30	170
13·8	490	23·7	842	8·40	271
16·5	586	28·7	1020	12·95	422
18·2	647	32·3	1143	18·05	597
19·9	707	35·5	1260	28·05	977
19·8	703	36·9	1310	35·70	1318

"ENGLISH SILVER STEEL." BAR 3 a. HARD (HAMMERED). LENGTH=101·5mm. $\frac{\text{LENGTH}}{\text{DIAMETER}}=14\cdot5$.

Perm. mag.			
Deflection.	Sp. mag.	Tangent-compass deflection.	Magnetic force.
1·0	1·61	1°·35	43·2
3·5	5·62	3·10	99·3
5·1	8·19	4·45	143
9·3	13·9	6·90	222
13·1	21·0	9·60	310
20·3	32·6	14·20	464
33·3	53·5	33·50	1103
35·5	57·0	37·65	1416

"ENGLISH SILVER STEEL." BAR 3 b. SOFT. LENGTH=100mm. $\frac{\text{LENGTH}}{\text{DIAMETER}}=14{\cdot}3.$

Perm. mag.		Tangent-compass deflection.	Magnetic force.
Deflection.	Sp. mag.		
3·2	5·10	2°·25	72·0
4·9	7·81	3·30	106
6·9	11·0	4·30	138
9·0	14·3	5·50	177
12·6	20·1	8·50	274
18·0	28·7	12·85	418
23·1	36·8	17·85	590
32·2	51·3	31·90	1140
34·3	54·1	38·45	1450

IRON. WIRE 4 a. HARD ("PULLED"). LENGTH=100mm. $\frac{\text{LENGTH}}{\text{DIAMETER}}=139.$

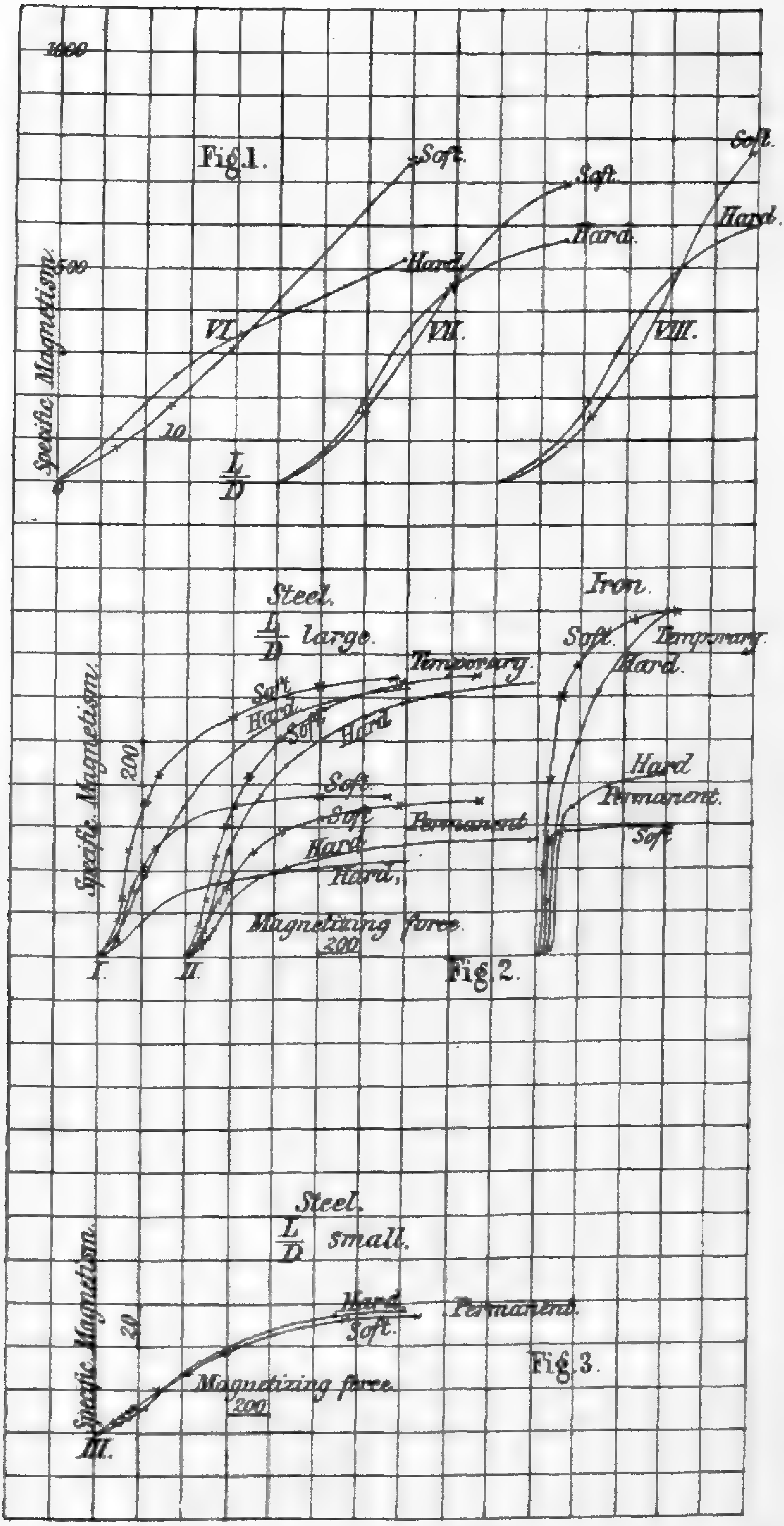
Perm. mag.		Temp. mag.		Tangent-compass deflection.	Magnetic force.
Deflection.	Sp. mag.	Deflection.	Sp. mag.		
0	0·0	0·7	91·9	1°·85	59·1
0·2	26·3	1·6	110	2·10	67·2
4·1	539	5·9	775	4·20	135
5·1	670	7·2	946	5·40	173
5·9	775	9·2	1208	8·35	269
6·3	827	12·5	1642	18·10	599

IRON. WIRE 4 b. SOFT. LENGTH=100mm. $\frac{\text{LENGTH}}{\text{DIAMETER}}=139.$

Perm. mag.		Temp. mag.		Tangent-compass deflection.	Magnetic force.
Deflection.	Sp. mag.	Deflection.	Sp. mag.		
1·8	245	2·8	380	1°·25	40·0
2·7	367	4·0	543	1·45	46·4
3·8	516	5·9	801	1·90	60·8
4·2	570	8·8	1195	4·15	133·0
4·3	584	9·9	1344	5·60	179·7
4·3	584	11·4	1548	13·60	443
4·3	584	11·8	1603	19·55	651

The results are graphically represented in figs. 2 and 3 on the following page.

16. *Conclusions.*—If we compare the curves (Fig. II), representing the temporary specific magnetism of steel and iron as dependent on the magnetizing force, we see, as was to be expected, that the mechanical hardening to some extent hinders the turning of the molecules by the magnetic force. From the curves (Fig. I), representing the permanent specific magnetism of steel we see, that, where the quotient $\left(\frac{L}{D}\right)$ is greater than (a_0), the softer magnet has the advantage, without reference to the intensity of the magnetizing force. If on the other hand $\left(\frac{L}{D}\right)$ is less than (a_0) (Fig. III), the softer magnet has the advantage up to a certain value of the magnetizing force, when the specific magnetism of the harder magnet overtakes that of the softer, and is ahead at the saturation point, as we saw in the first part of this article.


1000
Fig.1.
Soft.
Soft.
Soft.
Hard.
Hard.
Hard.
500
Specific Magnetism.
VI.
VII.
VIII.
10
L/D
Steel.
L/D large.
Iron.
Soft.
Temporary.
Hard.
Temporary.
Soft
Hard
Soft
Hard
200
Specific Magnetism.
Soft.
Soft
Permanent.
Hard
Hard.
Hard
Permanent.
Soft.
Magnetizing force.
200
I.
II.
Fig.2.
Steel.
L/D small.
Specific Magnetism.
20
Hard.
Permanent.
Soft.
Fig.3.
Magnetizing force.
200
III.

The same holds for the permanent specific magnetism of iron,* as for steel where $\left(\frac{L}{D}\right)$ is less than a_0. These results are in entire accordance, qualitatively, with the results obtained by Ruths† and others with heat hardened magnets.

Differences between the mechanical and heat hardening.—We have thus seen that both mechanical and heat hardening bring about changes in steel and iron, which, for the most part, affect their magnetic properties similarly, and the question naturally arises whether there is any reason for believing the conditions caused by each to differ, other than in degree.

A comparison of their effects on some of the physical properties of steel would seem to require an affirmative answer.

Thus the specific resistance of steel has been shown to be very materially altered by the heat hardening, a change of 200 per cent taking place at times,‡ while the specific resistance of steel wires hardened by "pulling" is thereby altered, at the most, a few per cent.

Thus also, if we consider the change of specific gravity by hardening and that of the corresponding specific magnetism, we are led to believe the two conditions to be different; steel, if heat hardened, has the smallest specific gravity§ when hardest and the largest specific magnetism [pre-supposing $\frac{L}{D}$ small], so that the largest specific magnetism corresponds to the smallest value of the specific gravity; when steel is hardened by hammering, on the other hand, the specific magnetism $\left[\frac{L}{D}\text{small}\right]$ and specific gravity increase together, as I have repeatedly found by experiment.

It would seem also to follow from the foregoing that the magnetic moment is not dependent on the specific gravity, as at times has been supposed.‖

Physical Institute. University of Würzburg, Nov. 1, 1881.

*Compare remarks at end of paragraph 10.

†Chas. Ruths, Ueber den Magnetismus weicher Eisencylinder. Dortmund, 1876.

‡ Compare Strauhal and Barus, Ueber Anlassen des Stahles und Messung seines Härtezustandes, Wied. Ann., vol. xi, p. 976. 1880.

§Carl. Fromme, Wied. Ann., vol. viii, p. 352. 1879.

‖Compare the remarks of Ruths on this point, p. 48.

ART. XXII.—*The Deerfield Dyke and its Minerals;* by BEN. K. EMERSON, Professor of Geology in Amherst College.

Description of the dyke.—The most northern of the large dykes of diabase associated with the Connecticut River sandstone commences in Gill, and after running southwestwardly a short distance, swings round to the south and runs down the west side of the Connecticut through Greenfield and Deerfield, and turning eastward crosses the river and ends in Mt. Toby.

It has thus the elongated U-shape characteristic of the Triassic dykes of the basin, which appears on a scale so much larger in the Holyoke Range. It is worthy of note that the high western border of the valley corresponds in direction to both these dykes, being set back in Greenfield and Northampton so as in each case to present a reëntrant angle to the N.W. corner of the dykes with W.E. and W.S. sides parallel to the corresponding portions of the respective dykes. The dyke is about twenty miles long and at Cheapside, in the north part of Deerfield where the Deerfield River breaks through it, is about 30m. thick. The rock is intercalated in the red sandstone and dips eastward with it, but would seem to follow this direction only a little way before coming to the fissure through which it was erupted, as an artesian well sunk on their property in Turner's Falls by the Montague Paper Co. went down in sandstone 274m. below the level of the Turner's Falls dam, while immediately opposite on the west and separated only by the width of the river, about 200m., the trap is about 30m. above the dam, and dips toward the well with an angle of 32°.

Fault at the mouth of Fall River.—The best point for the study of this dyke, as indeed for the study of the Connecticut River sandstone in Massachusetts, is at Turner's Falls, and opposite this village at the mouth of Fall River, at the chlorophæite locality the dyke is beautifully faulted. It comes down from the north to the water's edge, and directly in continuation of it in the Connecticut is a sandstone island, while the dyke is offset ten rods to the westward on the other side of Fall River. The proof of the faulting is complete. The sandstones above and below agree bed for bed in all particulars and the outcrops are peculiarly good. This is the only fault in the sandstones which I have been able to prove with certainty.

The dyke rests to the west on coarse granitic sandstone which it has baked for an inch into a black hornstone and influenced for a foot. The diabase is compact in its lower part and amygdaloidal above, and the soft red shales which rest upon it are wholly unaltered—are never included in the trap—

but fold around all small protuberances in its upper surface as if it were a later deposit. This is shown in an almost unbroken outcrop a mile long opposite Turner's Falls, where the river has notched into the trap and exposed the junction. These facts can hardly be explained except by supposing the trap to have been poured out upon the lower sandstone, and to have been covered by the upper shales. The same state of things holds with regard to the great Holyoke dyke, and in addition the extensive tufa beds intercalated in the sandstones above the latter and described by President Hitchcock * can not but strongly reinforce this conclusion. I am aware that it has been suggested that the beds described by President Hitchcock as tufa beds have been explained as bands of the common sandstone indurated by steam escaping during the ejection of the lavas between the layers of the sandstone, but I have cut sections from the blocks of diabase enclosed in this stratum at the most accessible locality of it, the roadside below Smith's Ferry in Northampton and find it to be identical with that of the Holyoke range immediately north. The blocks are large, angular and abundant, and are mixed with granitic material and I cannot doubt that they have come from the erosion of the great dyke, which must thus antedate them.

Similar tufa beds are exposed above the amygdaloid of the dyke under discussion at the west and highest point of the outcrops on the Greenfield road. They are here of finer grain and closely resemble the Nassau Schalsteine.

Lithology.—The rock is a typical diabase, ranging from aphanitic varieties to those where the flat white feldspars are 2–4^{mm} square, and from compact to very coarse amygdaloidal. The different varieties are of very uniform texture and always in an advanced stage of decomposition though appearing quite fresh; plagioclase apparently of two species; augite, magnetite and olivine are uniformly present. Apatite cannot be detected.

The common plagioclase, probably labradorite, is always by far the most abundant constituent, and the angle of extinction of its long rod-like crystals is commonly 12°. Several varieties of the rock are sub-porphyritic by the development of white spots made up of groups of stout crystals of a second triclinic feldspar apparently distinct from the first whose angle of extinction is 21°. Both feldspars are thoroughly decomposed commonly from the center, and sometimes show only aggregate polarization.

The augitic constituent has for the most part gone over into a mixture of green and brown chloritic minerals, here and there an exceptionally large crystal remains in whole or part

* Geology of Mass., 1841, p. 442.

intact. The olivine is often the freshest looking mineral in the slide except the magnetite.

The rock at the new cutting and southward is very fine grained, breaking with conchoidal fracture, dark gray and compact at the base of the dyke, and there distinguished by the abundance of the well-known feathery aggregations of the magnetite grains, while in the whole upper portion it is coarsely amygdaloidal, the amygdules filled commonly with diabantite, calcite, or both—when one penetrates below the deep layer of rusty scoriaceous rock from which all the secondary minerals have been removed,—and here the magnetite is never arranged in feathery groups. At the old cutting on the other side of the Deerfield river, a few rods north, the rock becomes more granular in texture, grayish and reddish varieties occur, sub-porphyritic, and abounding with flattened steam cavities filled now with diabantite which arranged in layers give the rock an indistinct fluidal structure. These varieties continue northward and are exposed in great force for nearly a mile of fresh cuttings, where the road from Greenfield to Turner's Falls crosses the dyke, and from the Suspension bridge, at the end of this road, along the river side for a mile north to the mouth of Fall River and beyond. Through all this area prehnite and the products of its decomposition occupy the amygdaloidal cavities in very great quantity accompanied everywhere by traces of copper minerals, in place of calcite and chalcedony which abound farther south. The most interesting variety is a very coarse one abundant on the Greenfield road, which contrasts pleasantly with the somber gray of the prevailing types. Broad white plates of the feldspar stand out upon a dark red background of decomposed augite, the whole sprinkled with the amygdules of prehnite and diabantite. That this coarse variety is younger than the greenish gray sub-porphyritic trap, is clear from a large slab from the middle of the slope on the Greenfield road, showing a contact of the two upon which the latter is cut off immediately and sharply and without change, while the former has a layer of deep red, very fine grained rock 15^{mm} wide adjacent to the contact plane. It seemed to me, however, to represent only a slight difference in age and to be probably a case of "schlieren" in the sense of E. Reyer.*

An exceptional rock occurs abundantly in bowlders on the south side of the Deerfield, but I have not met it on the north or in place. It is a clear, light gray rock, with roundish blotches of white, and it looks like a weathered leucitophyr. Under the microscope the blotches are seen to be made up of aggregated stout crystals of plagioclase, and the rest of the mass between, of rod-like plagioclase and magnetite with almost no

* Tschermak, Min. Mitth.

augite. The rare amygdules in this rock are filled with a fine silky radiated mineral, apparently an altered prehnite resting upon diabantite, or more rarely lined with glassy crystals of albite, with datolite, pyrite or globules of zinc blende.

Historical.—Already in 1818* President Hitchcock noticed several of the zeolitic minerals enumerated below, with a word in each case as to mode of occurrence, and mentions as localities one mile E. 2° 15′ S. from Deerfield Academy, and the copper veins opposite Turner's Falls. In 1826† he described a mineral from the mouth of Fall River near Turner's Falls as the chlorophæite of Macculloch. In the final report on the Geology of Massachusetts, pp. 203, 660, he enumerates the minerals there known without increasing the former list: barite, copper, malachite, chalcocite, chalcopyrite, chlorite, chlorophæite, calcite, prehnite, augite, quartz and varieties, selenite, chabazite, lincolnite.

A few years ago railroad cuttings on the north side of the Deerfield River at Cheapside exposed veins of massive datolite 3 to 4^{cm} wide, which showed no distinct crystals and occurred without the minerals which commonly accompany it, excepting prehnite.

During the summer of 1880, a heavy cut was made through the corresponding portion of the dyke on the south side of the river for the extension of the Canal Railroad, and opened up veins carrying the usual trap minerals in great abundance and beauty. These veins run nearly vertically, with a thickness not above 10^{cm}, and were exposed to a depth of above 18^{mm}. I propose to describe the minerals in the order of their occurrence in the veins and to discuss at some length their paragenesis and the crystallography of several of them.

Diabantite.—The chloritic mineral, so uniformly and abundantly disseminated in the diabase of the valley, was entered in the catalogue of the State collection by Dr. Hitchcock as foliated chlorite, Turner's Falls, and a paler pulverulent variety, as earthy chlorite, Springfield. A third mineral, intimately associated with these follows them in the collection under the name chlorophocite, a misprint for chlorophæite, Gill. The latter is for the sake of symmetry made to follow prehnite, it being a product of the decomposition of the latter mineral. That the former mineral is chemically identical with that analyzed by Hawes and named diabantite by him, is extremely probable in view of their identity in all physical and especially optical properties, and of the monotonous similarity of the many diabase dykes of the Connecticut basin, in which both occur. That the mineral is distinct from delessite, as the word is used by Zirkel, Rosenbusch and Heddle, is much less certain.

* This Journal, i, 115, 116. † This Journal, x, 393.

It is the earliest product of the decomposition of the diabase, and proceeded doubtless from the alteration of the augite. In one case I found a mass having the shape of an augite crystal filled with magnetite toward the outside and polarizing as a single individual but possessing the bright green color and the strong dichroism of diabantite. It is disseminated in comparatively small amount through the mass of the rock between the feldspar crystals and thus in the place of the augite, much more abundantly in the steam cavities and shrinkage cracks with which the rock abounds. It generally coated the empty amygdaloidal cavities first with a quite thick ($\frac{1}{2}$–1^{mm}) foliated-radiated layer with minute, delicate botryoidal surface. Several such layers sometimes followed each other, and then the center became filled with a confused granular mass of the same material, the whole making a very pleasing effect under the microscope with its bright green color and striking dichroism. Under crossed Nicols this central granular portion often assumes a deep chlorite green studded with bright colorless spots (calcite?) and maintains this color through a whole revolution of the object, the bright spots being alternately extinguished. Sometimes, in the gray mottled diabase, a layer of magnetite or coal grains was interposed between the layers of diabantite, and rarely large distinct crystals of magnetite appear wholly surrounded (in section) by diabantite, and in one case a fine, large feather of magnetite projected into the diabantite. The long feldspar crystals, also, which border the cavity, often project freely into it and are then perfectly and more complexly terminated than when in the mass. The diabantite folds around and does not penetrate them. Often the center of the cavity is filled with calcite, impregnated with diabantite, so as to produce a pegmatitic appearance on cleavage faces, or with finely fibrous prehnite and this also is for a greater or less distance toward the center blackened by the abundance of the diabantite which it has enclosed.

On the other hand where over the botryoidal layer of diabantite there appear quartz, datolite, natrolite, sphalerite or other sulphurets, they are entirely free from this impregnation. In the broad mineral-bearing fissures, the diabantite often so impregnates layers of scaly or fibrous prehnite 1–5^{mm} thick over considerable surfaces that a black or blackish-green mass results, often abundantly slickensided, which so resembles a very fine grained scaly or fibrous schist that I supposed it to be formed by the pulverizing of the trap by friction and the cementing of the powder by prehnite, until the microscope made known its true character.

Farther north on the dyke opposite Turner's Falls the large flattened cavities are lined with a botryoidal layer 1^{mm} thick, of black-green diabantite with crystals of chalcopyrite, blende and albite upon it. The interior is very often filled with a dark olive-green, fine-granular mixture of crystals of diabantite which can be shaken out of the cavity as a fine powder, each grain of which appears, under the microscope, as beautifully vermicular as the helminth of the older rocks.

The paragenesis of the mineral is thus quite definitely fixed. It was the first product of the decomposition of the diabase and its formation ceased not very long after calcite and prehnite began to be deposited in the cavities and fissures. As the formation of the latter minerals was attended by quite energetic decomposition of the trap, the formation of the diabantite occurring still earlier may well have been promoted by the increased chemical activity of the waters during the cooling of the trap after its solidification. The mineral seems to me plainly of secondary formation, and I can see no good ground for thinking that it was formed and deposited where we find it during the rise of the lava through the sandstones. The cavities flattened and fluidally arranged in the lower part of the mass with well terminated feldspars projecting into them, and growing very abundant, and graduating into long vertically placed tubes in the upper portions, have been certainly formed, by steam, and cannot have been filled till after solidification of the rock. This is much more certainly the case with the broad fissures which extend across the whole dyke, which seem for a time to have furnished a passage-way for boracic acid springs, and in which the diabantite must have been formed much as were the calcite and prehnite which it has impregnated. The filling of the cavities also with several concentric and botryoidal layers sometimes separated by calcite would indicate slow deposition from water.

The great amount of protoxide of iron in the mineral does not seem to me to need for its explanation the assumption that it is an original constituent of the rock. The waters brought up in the lava, on becoming liquid, or the waters which reached the bed after percolating through the bituminous sandstones of the valley may have been deprived of oxygen and able to exert strong solvent activity, without peroxidizing the iron of the augite. In discussing a mineral, which seems to be identical with our diabantite and which forms the first coating of the amygdules of the phillipsite-bearing feldspar-basalt of Salesl, von Zepharovich* derives the same from sphærosiderite, the radiated and concentric structure and the botryoidal surface resembling in miniature that common in the carbonate. A cellular structure and traces of rhombohedral forms were also observed. I have seen here no traces of any such crystal forms.

* Zeitsch. Kryst., v, 98, 1880.

The cellular or excavated structure occurs frequently and can be produced in fresh specimens by acid, by the removal of calcite. The occurrence of the mineral in fresh prehnite and calcite would militate against its being here a pseudomorph after siderite.

Products of the decomposition of diabantite.—From its great content of ferrous oxide the mineral is very prone to decomposition and in sections cut near the weathered surface of the rock its color has become red-brown, its strong dichroism is gone, and it shows only the faintest aggregate polarization. Sometimes a cavity shows the exterior changed and brown, the interior bright green, with sharp lines of demarkation. In the large amygdules masses of gold or bronze-yellow, sometimes light straw-yellow, can be obtained, which exfoliate voluminously under the blowpipe and then by a sharp explosion throw off the exfoliated portion, and begin the operation anew. It is a *diabantite-vermiculite.* At the end of this series of changes only a small quantity of limonite remains.

When a slide of the diabase is treated with hydrochloric acid both the fresh and the altered diabantite are decomposed and white silica remains behind in plates having still the shape and arrangement of the original mineral. This is also the case with the vermiculite out of the primary rocks in Pelham.

Similar amygdules occur in the compact diabase having a white color or being in part still green and dichroic, and having exactly the arrangement of the diabantite. These are, I have no doubt, silica, and have been produced by some natural process analogous to the artificial one employed above. The white portions show marked aggregate polarization in white and black but without bright colors.

ALBITE.—In the cavities in the amygdaloid from the shores opposite Turner's Falls, which are often only partly filled with the vermiferous diabantite (vide p. 199) and out of which the latter may be shaken as a deep green powder, there occur minute crystals loosely seated upon the diabantite, or in the powder shaken out from the cavities and scarcely attached at all. They are ·005 to ·01mm. in diameter, transparent, perfectly fresh crystals, twinned in accordance with the albite law. They are combinations of the form i-$\bar{\imath}$, O, i-$\breve{3}'$, i-$\breve{3}$, I', I, i-$\bar{\imath}$, 2-$\bar{\imath}$, flattened by the large development of i-$\breve{\imath}$, and much elongated in the direction of the axis $\breve{a}$, by one end of which they are uniformly attached. Examined with the polarizing microscope the line of extinction makes with the edge $O \wedge i$-$\breve{\imath}$ an angle of $+4°$ to $+4° 30'$ on the face O. When lying upon the face i-$\breve{\imath}$ the minute twins gave varying results. The first result indicates that the crystals are albite according to the determinations of Max Schuster,* the second is explained by the multiple twinning of the crystals.

When placed in a delicately graduated Thoulet's fluid, so prepared that orthoclase will rest near the surface and labradorite near the bottom, the crystals found the exact level of fragments of transparent albite from Haddam, sp. gr. 2·62, and remained attached to them as if they were so delicately freed from outward attraction that they gravitated toward each other. Some of the crystals having diabantite adherent to them sank to the level of quartz, sp. gr. 2·64, but all were separated by a broad interval from the other triclinic feldspars. The position of these crystals is interesting from a paragenetic point of view. The cavities are tapestried on all sides by the diabantite and the albites rest, often very loosely, upon it, and while forming projected freely into the interior as is shown by their glassy clearness and perfection of form and polish. The last of the diabantite seems sometimes to fill the cavities into which the albites project, but this could not be made certain. As the albite probably demands elevated temperature and increased pressure for its formation, the diabantite upon which it rests must be assigned to the time following immediately upon the consolidation of the lava, while its heat still intensified the chemical activity of the water it contained.

(To be continued.)

ART. XVIII.—*On the Löss and associated Deposits of Des Moines*; by W. J. McGEE, of Farley, Iowa, and R. ELLSWORTH CALL, of Des Moines, Iowa.

[Read before the Iowa Academy of Sciences, May 31, 1882.]

THE occurrence of typical löss at Des Moines has already been noted by F. M. Witter,† the junior author of this paper,‡ and a number of local geologists. Late in 1881 the junior author observed that in certain sections that deposit appeared to be overlain by a bowlder-bearing stratum; and the present communication embraces the results of a series of investigations suggested by this observation.

In its leading geographical features the accompanying map is a copy of a part of the map of Polk county in Andreas's Atlas;§ though a few minor details have been added from observation.

* Tsch. Min. Mitth., iii, 117, 1880.

† Paper read before the Muscatine Academy of Sciences, Muscatine Tribune, Feb. 10, 1879.

‡ American Naturalist, xv, Oct., 1881, p. 782; loc. cit., xvi, May 1882, p. 369 *et seqq.*

§ A. T. Andreas' Illustrated Historical Atlas of the State of Iowa, 1875, p. 181.


Des Moines, Iowa, and Vicinity.
Drift.
Alluvium.
On North Hill, West Hill, Capitol Hill, and South Hill the Drift is underlain by Löss.
Contours 20 ft apart.
North Hill
West Hill
Capitol Hill
South Hill
Sand Ridge
Des Moines
Sevastopol
Ashawa
Commerce
Beaver
Raccoon
Four Mile
Jordan
Yellow
79 N.
78 N.
25 W.
24 W.
23 W.

The cenological* and hypsometrical features were made out during the progress of the present investigation. In the projection of the contours, as well as in the construction of the profile, use was made of all measured railway, roadway and street elevations within the area shown. These data were supplemented by observations and estimates made on the ground and from the dome of the State capitol; from which point nearly the whole area is distinctly visible. Neither the contours nor the profile are, accordingly, strictly accurate, though in a general way they are reliable.

It may be explained that in this latitude in Iowa the drift is everywhere superficially modified to some extent; the upper portion being fine, homogeneous, free from bowlders and pebbles but sometimes containing calcareous nodules, and löss-like in structure, aspect and topographical configuration, but graduating imperceptibly into unmodified glacial drift within a few feet below the surface. The term "drift" is herein applied only to the *upper till*, i. e., to the glacial deposit overlying the *forest bed.* The *lower till* has not been seen within the area shown.

The cartography and the preparation of the cuts are the work of the senior author; the determination of, and remarks on, the fossils enumerated are by the junior author; while the field work was jointly performed.

I.

East of Four Mile creek lies a gently undulating plain of drift slightly modified superficially, but exhibiting the characteristic drift topography. On the west rises a prominent ridge capped with löss at its southern end but exposing drift in ravines and road-cuttings, formed of fine stratified sand to a depth of at least fifteen feet in its medial portion, and exposing only drift with rounded and worn erratics cropping out on its summit to the northward. It probably has a nucleus of Carboniferous strata, overlain throughout by drift; the sand and löss being superimposed upon the drift stratum. This ridge is apparently analogous to the åsar of eastern Iowa. West of it lies a uniform plain formed of drift with little superficial modification, so low and level as to be almost without natural drainage. As a broad trough, this plain connects the angles in the valley of the Des Moines river above and below the confluence of the Raccoon in so marked a manner as to have given rise to the general (but erroneous) popular impression that it is an

* We prefer the term cenology to "surface geology," "superficial geology," "glacial geology," "post-tertiary geology," or any of the numerous compound names that have been applied to the branch of geology treating of terrestrial, fluviatile and lacustral deposits.

abandoned channel of that river. From its western border rise two insulated plateaus of characteristic löss topography but with numerous erratic bowlders scattered over their summits; the southernmost, known as "Capitol Hill," being the higher. Both have nuclei of Carboniferous rocks forming perhaps three-fourths of their altitudes; and both are manifestly separated from the high land to the westward by the erosion of the Des Moines valley.

West and north of the Des Moines and Raccoon rivers lies the most elevated plateau of this region; two-thirds of its height being formed of Carboniferous strata. It is deeply scolloped on all sides by steep-sided labyrinthine ravines such as characterize löss areas; but interiorly it undulates gently in quaquaversal slopes forming mounds and basins manifestly not due to Post-quaternary erosion, while over all its higher portions numerous erratic bowlders, sometimes smoothed and striated, lie on or near the surface. Northwestward the surface declines gently, and the plateau merges into the drift-plain covering most of the State. Northward and westward Beaver creek and Walnut creek wash its base, and sharply separate the rolling and broken highland from the gently undulating drift-plain beyond. Over this plain, as over the plain east of Four Mile creek, the drift is somewhat modified superficially. Still farther westward rises a smaller insulated plateau of löss-like topography, and outside of the area mapped are similar plateaus, all extending N.N.W. from the Raccoon valley in a series of lobes each of which resembles somewhat the ridge east of Des Moines.

South of the two rivers and east of the westernmost Four Mile creek, the topographical configuration and the superficial deposits are the same, in the immediate vicinity of the river bluffs, as on the central plateau above the confluence of the rivers; the Carboniferous strata forming perhaps three-fourths of the height of the bluffs. The altitude here is rather less

Profile along dotted line, Fig. 2.

than on the central plateau, from which this region has manifestly been separated by the erosion of the valley of the Raccoon river. Southward from the river bluffs the bowlder-bearing deposit merges into the superficially modified drift extending to the Three Rivers, and the general altitude gradually diminishes. Ascending the Raccoon the elevated range of bluffs rather suddenly dies away at the westernmost Four Mile creek; and above are the more gentle slopes characteristic of drift areas —the slope here being toward, instead of away from the river.

Summing up the predominant physiographical features of the region under consideration, it appears (1) that the Des Moines and Raccoon rivers have avoided uniform plains and have corraded their channels through the most elevated plateau of sedimentary strata existing within many miles; and (2) that there has been an unusual accumulation of Quaternary deposits over this plateau about the confluence of the rivers.

These features conform to laws which the senior author has found to obtain over much of eastern Iowa; for not only do the North Maquoketa, South Maquoketa, Buffalo, Wapsipinnicon, Cedar and Iowa rivers avoid low-lying plains and seek elevated plateaus and ridges of both sedimentary rocks and quaternary deposits in many localities, but the general course of all these rivers is at right angles to the mean slope of the surface which they drain.

II.

The following are a few only of the sections examined. Each is located on the map, and numbered as in the text. The altitude is to the top of the section. The probable error in altitude refers to the city datum of low water at the confluence of the Des Moines and Raccoon rivers, which is assumed to be 780 feet above sea level.* In the lists of fossils, species not now living in the vicinity are marked with an asterisk.

Section 1.

S.W. cor. Walnut and E. 9th Sts.—Altitude, 860 ± 2 feet.

1.—Löss, light drab, fine, homogeneous, without distinct stratification, with vertical structure and cleavage, and with two or three irregular zones yielding a profuse calcareous efflorescence. It contains tolerably abundant löss-kindchen,† tubelets (or slender, irregularly ramifying calcareous tubes), and characteristic löss fossils disseminated throughout. Ten feet.

* Gannett (Lists of Elevations, 4th ed., 1877, p. 70) gives 779 feet as the low-water altitude of the Des Moines river at Des Moines.

† Over 2800 löss-kindchen, mainly from sections 1, 2 and 9, were recently examined and in part figured and described, by the junior author.—American Naturalist, xvi, May, 1882, p. 373. Plate V.

2.—An undulating ferruginous band an inch or two broad, constituting a false line of separation, sloping with, but less rapidly than the surface, most distinct in downward modulations, where there are unusual numbers of löss-kindchen immediately above, and of cylindrical ferruginous concretions immediately below it.

3.—Löss, ashen or bluish, containing löss-kindchen, tubelets and fossils identical with those of No. 1, as well as cylindrical concretions. Below it becomes silty, pulverulent, and obscurely laminated parallel with the base; and fossils, tubelets and löss-kindchen disappear within one or two feet from its lower limit. Four feet.

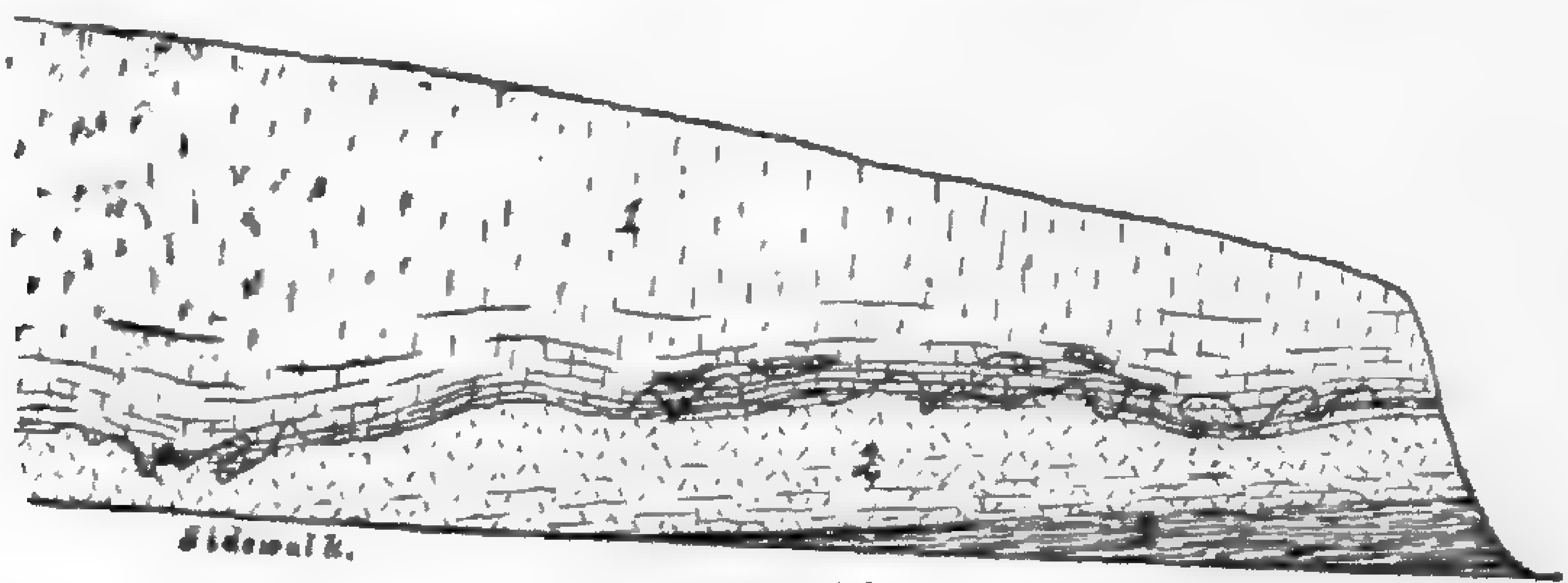
4.—Vermilion-red clay, as in the following section. One foot.

This section, which is the typical löss-section of this part of the State, is exposed in a street cutting near the summit of Capitol Hill. The depth of the cutting is about ten feet, but the slope of the street is such as to expose over fifteen feet in depth of strata. The ferruginous band marks the limit of secular oxidation, and is not structural, though it generally follows the obscure lines of stratification which occasionally occur in this deposit wherever it is found in Iowa. In no respect, indeed, is the löss of this section distinguishable from that of typical exposures along the Missouri river, save perhaps in the smaller size of its fossils. It has now stood in an absolutely vertical wall for nearly two years, and has formed but a very slight talus. The fauna is identical with that of the following section.

Section 2.

E. side E. 9th St. bet. Walnut St. and Court Av.—Alt. 858 ± 2 ft.

1.



10 ft. = 1 in

Fig. 3.

1.—Löss, ashen or light drab, compact, vertically cleft, and containing löss-kindchen, tubelets, and rare fossils above, obscurely laminated, pulverulent, silty, unfossiliferous and with minute ochreous specks below. The laminæ follow the major undulations of the irregular base, but in part pass through the minor projecting knobs of the subjacent member; and a few lenticular or irregular masses of this member occur intercalated within the löss. The principal vertical cleavage planes of the löss pass through its basal portion and into No. 2.

2.—Vermilion-red clay, tenacious when wet, friable and granular when dry, massive below and obscurely laminated above, containing a few small exfoliated pebbles of shale and more abundant minute reniform nodules of impure limonite, and exhibiting occasional dark-red ochreous stains.

3.—Arenaceous Carboniferous shale, gray, blue, yellowish and drab in color.

The löss in this section is continuous with that in the last, and is identical with it in every particular except that the false line of separation is here absent. The red clay is the product of decomposition *in situ* (preglacial) of the subjacent shale. Though the junction between the löss and clay is quite distinct, owing to the difference in color, there is some interstratification of the two deposits. The löss here yielded the following fossils:

Succinea obliqua Sar.
Limnophysa humilis Say.
**Helicina occulta* Say.
Mesodon clausa Say.
Patula striatella Anth.
* *Vallonia pulchella* Müll.

SECTION 3.

N. SIDE COURT AV. BET. E. 10TH AND E. 11TH STS.—ALT. 880 ± 3 FT.

1.—Light reddish-buff unstratified drift clay containing numerous rounded, subangular and angular pebbles, mainly erratic, up to six inches in diameter, bits of coal and a lenticular mass of Carboniferous clay three feet long and six inches thick. Seven feet.

2.—The same, obscurely and irregularly stratified, interstratified with bands of löss, and sometimes contorted, containing löss-kindchen, tubelets and fossils (often fragmentary), in the drift strata in direct association with pebbles, as well as in the bands of löss. Five feet.

3.—Löss, similar to and continuous with that observed in sections 1 and 2, abounding in löss-kindchen, tubelets and fossils; the following species being represented:

Succinea obliqua Sar.
Limnophysa humilis Say.
**Helicina occulta* Say.
Mesodon clausa Say.
Stenotrema monodon Rackett.
Hyalina arborea Say.

Workmen were engaged in making this excavation at the time of examination; and it was accordingly perfectly fresh and unaltered. The interstratification described was perfectly distinct. The fauna here was found to be identical with, but less abundant than, that of the undisturbed löss, which was exposed for only about a foot at the base of the section. The löss here is confidently coördinated with that of sections 1 and 2 on paleontological, lithological and stratigraphical grounds; for not only are faunas and physical characters identical, but actual continuity was traced in the street excavations. The next following section is on the opposite side of the street, and the principal members were unquestionably continuous with those in this section before the street was graded. It was not fresh when examined, and the transition from drift to löss was obscure.

Section 4.

S. Side Court Av. bet. E. 10th and E. 11th Sts.—Alt. 882 ± 3 ft.

1.—Reddish-yellow sandy clay containing numerous rounded, subangular and angular pebbles up to twelve inches in diameter, associated toward the base with löss-kindchen and fossils. About eight feet.

2.—Löss, light buff, somewhat sandy and pebbly above, containing numerous löss-kindchen, tubelets and fossils. Six feet. The following are some of the species here found:

Succinea obliqua Sar.
Succinea avara Say.
**Helicina occulta* Say.
Limnophysa humilis Say.
Limnophysa desidiosa Say.
**Pupa muscorum* Linn.
Pupa pentadon (?) Say.
Hyalina arborea Say.
* *Vallonia pulchella* Müll.
**Patula strigosa* Gould.
Patula striatella Anth.
Patula alternata Say.
Strobila labyrinthica Say.
Mesodon clausa Say.

A like sequence was observed in a number of other sections in the vicinity; and drift, sometimes modified superficially, but containing many erratic bowlders up to three feet in diameter on or near the surface, was found to prevail over the entire summit of Capitol Hill. The proportion of pebbles in this drift is less, however, than is usual in this latitude; the clay presents a somewhat löss-like aspect, contains calcareous concretions and yields a calcareous efflorescence; and the topography assumed is essentially identical with that of löss areas.

The plateau north of Capitol Hill (generally known as North Hill) is similarly capped with drift of the aspect described; and in like manner löss crops out along the bluffs overlooking the Des Moines river. A general section here by the junior author* exhibits typical löss reposing on drift on both sides of the river. That on the east yielded the following fossils:

Succinea obliqua Sar.
Limnophysa humilis Say.
Limnophysa desidiosa Say.
**Helicina occulta* Say.
Patula alternata Say.
Patula striatella Anth.
**Patula strigosa* (?) Gould.
Pupa fallax Say.
Pupa armifera Say.
Pupa pentadon Say.
Hyalina arborea Say.
* *Vallonia pulchella* Müll.
Stenotrema monodon Rack.
Helicodiscus lineatus Say.
Strobila labyrinthica Say.
Undetermined fish spine.

* American Naturalist, xv, p. 783, Oct., 1881.

Section 5.

N. side Center St. bet. W. 7th and W. 8th Sts.—Alt. 877 ± 2 ft.

1.—Brownish-yellow drift clay containing rounded, sub-angular and angular pebbles, mainly erratic, up to ten inches in diameter, and a few irregular, tortuous and discontinuous lines of stratification, together with löss-kindchen and tubelets, below; where it passes by both interstratification and insensible gradation into löss. Above it is finer, less pebbly and more homogeneous.

2.—Löss, light buff, with a few irregular and tortuous lines of clay, sand or gravel intercalated above, but undisturbed and in all respects typical below, where it contains abundant tubelets, rather few and small löss-kindchen, and rare fossils of the following species:

Succinea obliqua Sar.
Succinea avara Say.
Limnophysa humilis Say.
**Helicina occulta* Say.

The cutting (which was not fresh at the time of examination) is nine feet deep; its summit being approximately level for half a block. The line of junction of 1 and 2 slopes west, exposing only the löss at the middle of the block, and only drift at the northeast corner of Center and Seventh streets. The drift has manifestly been removed by erosion toward the east. Within half a block to the north the superficially modified drift has been removed to a depth of two feet from a considerable area, exposing some dozen crystalline bowlders up to three feet in diameter; one, of green stone, being polished. Over this area, as in the löss of the section, there is a profuse calcareous efflorescence.

Section 6.

Cistern on N.W. Cor. Park and Jefferson Sts.—Altitude 970 ± 12 feet.

In this excavation, fourteen feet deep, only drift is exposed. It is rather fine, clean and homogeneous for the first three feet, then abounds in pebbles of stone with a few of sand for eight feet, and toward the base exposes mainly sand, pebbles associated with small stone pebbles, löss-kindchen, tubelets, and rare fossils; but these phases graduate into each other—there being not the slightest trace of stratification from bottom to top. The stone pebbles vary in size from ten inches downward, are mainly erratic, though a few, including bits of coal, are local, are generally round or sub-angular, and are occasionally smoothed and polished. One, two inches in diameter, is finely striated on both sides; the two sets of striæ on one side diverging by 30° and 60° respectively from the single set on the other side. To another, a calcareous concretion is attached. Most of the sand pebbles (of which a score or more appear in the sides and bottom of the cistern) are rounded, and vary from one to six inches in diameter. They are sometimes composed of fine sand, either massive or laminated, again of uniformly coarse sand or fine gravel, and at other times of a mixture of all. The two largest are lenticular in cross-section, each about two feet long and eight inches thick; one consisting of fine laminated sand, and the other of coarse ferruginous gravel. None of these pebbles, except the last mentioned, are at all cemented. About eight feet from the surface is a distinct dark-brown ferruginous band one or two inches thick, above which the drift is brownish-yellow and free from cylindrical ferruginous concretions. Below it is quite blue and abounds in the ferruginous concretions for three feet, then irregularly mottled and with rare concretions for two feet, while for the last part it is again brownish-yellow and without the concretions. The fossils occur only near the base associated with smoothed pebbles, sand-pebbles, löss-kindchen, and tubelets, and are mainly fragmentary. The following species, in addition to many indeterminate fragments, were observed:—

Succinea obliqua Sar.
Succinea avara Say.
Limnophysa humilis Say.
Patula striatella Anth.

The excavation was examined while in progress, and immediately after completion. Erratic bowlders up to five feet in diameter were exposed in contiguous street cuttings. Throughout the drift presents a löss-like aspect in color, constitution and structure. On exposure it hardens exteriorly and yields a calcareous efflorescence.

Section 7.

S.W. Cor. Washington St. and Cottage Grove Av.—Altitude 975 ± 5 feet.

1.—Brownish-yellow drift clay containing rather numerous erratic, and a few local pebbles and bowlders. Fifteen (?) feet.

2.—Löss, light buff, containing löss-kindchen, tubelets, and the following fossils:

Succinea obliqua Say.
Limnophysa humilis Say.
Pupa, sp. undt., probably *P. pentadon* 10 (?) ft.

3.—Irregularly stratified gravel, sand and pebbly drift clay, brownish-yellow. Two feet.

The section was based on the materials thrown from a well just completed and walled, the sequence being determined by the arrangement, and the thickness of each member estimated from the amount of such material in the annular heap surrounding the well. It supplements the adjacent section 6 in showing that on this plateau the drift is unquestionably underlain by löss, which in turn reposes upon another drift stratum. Careful search for fossils was not made; a number of individuals of the shells enumerated being found in a single clod.

SECTION 8.

ROAD CUTTING NEAR S.E. COR. S.W. S.E. 1, 78 N., 25 W.—ALTITUDE 950 ± 20 FEET.

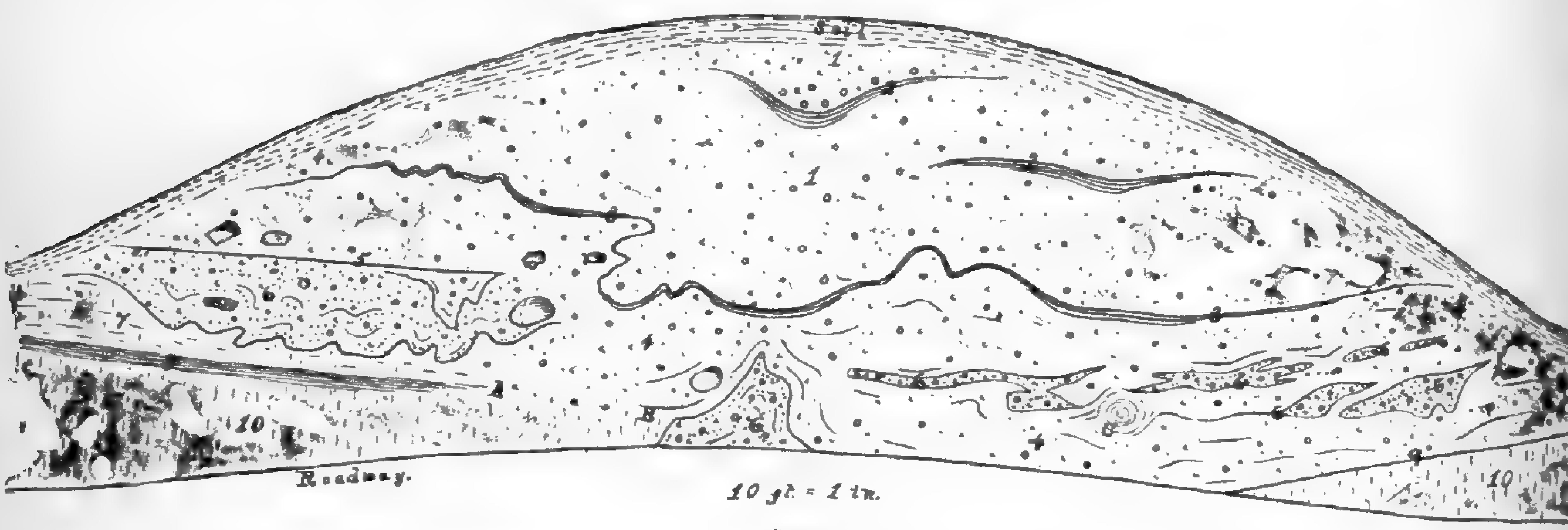


Fig. 4.

1.—Brownish-yellow drift clay, without stratification except as indicated, containing a few sub-angular and rounded pebbles and bowlders, mainly erratic, gradually becoming fine, clean and homogeneous above. Toward the base it yielded a few large löss-kindchen, a *Succinea obliqua*, a *Stenotrema monodon*, and several fragments of shells.

2.—Irregular and tortuous bands of unusual löss-like aspect.

3.—An irregularly undulating ochreous band separating the brownish-yellow from the mottled and bluish division of the drift. Obscure toward the extremities, and most distinct medially.

4.—Bluish, brownish-blue and mottled drift clay, identical with number 1 except in color, containing bowlders as indicated up to fifteen inches in diameter, rounded sand and gravel bowlders up to ten inches, many erratic pebbles of which several are polished, one striated, and one cemented to a calcareous concretion, a few local pebbles including bits of coal, a spherical mass of löss fifteen inches in diameter, a few cylindrical ferruginous concretions, numerous löss-kindchen and tubelets, and a similar fauna to that of number 10, but with most of the shells crushed and fragmentary. Below it is contorted, is obscurely interstratified with bands of löss, and contains intercalated layers and masses of stratified or laminated sand and gravel in which the laminæ are broken and contorted. From A to B, it graduates insensibly into number 10.

5.—A well-marked line of division.

6.—Brown and yellow sand and gravel, generally coarse, stratified and irregularly contorted. Unfossiliferous.

7.—Identical with base of No. 3.
8.—A band of fine, massive, homogeneous marl.
9.—A distinct line of separation, somewhat ferruginous.
10.—Löss, bluish for one-half foot from the summit, light drab to brownish-buff below, yielding a calcareous efflorescence, exhibiting typical structure and constitution in all respects, containing cylindrical ferruginous concretions (most abundant in the blue portion), löss-kindchen and tubelets, and affording the following fauna:

Succinea obliqua Sar.
Succinea avara Say.
Limnophysa desidiosa Say.
Limnophysa humilis Say.
**Helicina occulta* Say.
Hyalina arborea Say.
Patula striatella Anth.
**Patula strigosa* Gould.
**Vallonia pulchella* Müll.
Stenotrema monodon Rack.
Helicodiscus lineatus Say.
Mesodon clausa Say.
Mesodon multilineata Say.
Pupa corticaria Say.
**Pupa muscorum* Linn.
Pupa armifera Say.
Strobila labyrinthica Say.

Though the section was not fresh at the time of examination, it was little obscured by weathering or talus and exhibited the details very clearly. A syenite bowlder nearly three feet in diameter was partially imbedded in the drift within a few feet of the section.

Section 9.

Railway Cutting on Fair Ground siding in N.W.S.W. (?) 7, 78 N., 26 W.—Alt. 875 ± 15 ft.

1.—Brownish-yellow drift clay containing erratic pebbles and bowlders up to four feet, yielding *Succinea obliqua* and *Limnophysa humilis* toward the base, where it passes into number 2 by both interstratification and insensible gradation. About fifteen feet.
2.—Typical löss, containing ferruginous concretions, löss-kindchen, tubelets, and the following fossils:

Succinea obliqua Sar.
Succinea avara Say.
Limnophysa humilis Say.
Hyalina arborea Say.
Hyalina minuscula Bin.
**Patula strigosa* Gould.
Patula striatella Anth.
Patula alternata Say.
**Pupa muscorum* Linn.
Pupa corticaria Say.
**Helicina occulta* Say.
**Vallonia pulchella* Müll.
Helicodiscus lineatus Say.
Mesodon clausa Say.
Mesodon multilineata Say.
**Mesodon thyroides* (?) Say.
Strobila labyrinthica Say.
Conulus fulvus Drap.
Vertigo ovata Say.
Carychium exiguum Say.

The section was much obscured by a heavy talus and by debris from near the surface at the time of examination.

Like phenomena were observed in a number of sections not here described; and over the entire plateau lying between the

Des Moines and Raccoon rivers, just as on that constituting Capitol Hill, a fine, compact, superficially modified drift clay, yielding a calcareous efflorescence on exposed surfaces, and bearing erratic bowlders sometimes four or five feet in diameter, was found to prevail. The finer upper portion, which, notwithstanding its comparative freedom from smaller pebbles, contains the largest bowlders, has been removed from a total area of several acres (to be employed in the manufacture of brick), leaving abundant bowlders lying on the surface. One of these, of green stone, two or three feet in greatest diameter, was found to be deeply striated longitudinally on two parallel sides: and another, of like material and equal size, was finely polished on one side. The topographical configuration is in general similar to that of löss areas; but the erosion has thus far been mainly peripheral.

Section 10.

Brick-clay Pit S. of cor. Jefferson St. and Indianola Av.—Alt. 845 ± 6 ft.

1.—Light brown, coarse, friable loam, free from pebbles, massive, but graduating into number 2. Three feet.
2.—Light brown and gray stratified sand in slightly sinuous but generally horizontal bands one-third inch thick, each massive. Eight feet.
3.—Löss, blue and ashen-blue, obscurely laminated horizontally, with rather rare löss-kindchen, abundant tubelets and cylindrical ferruginous concretions, and very rare fossils; only fragments of *Succinea* and *Pupa* appearing on hasty examination. Four feet.
4.—Arenaceous shale of the Coal Measures, partially decomposed at the summit.

The two uppermost members form a portion of a nearly destroyed terrace. A very few pebbles and two or three bowlders one or two feet in diameter, probably derived from them, lie about. A distinct ferruginous band apparently separates numbers 2 and 3; but in reality there is some interstratification about the line of junction. Immediately below this band cylindrical ferruginous concretions occur in greatest abundance. The löss is slightly silty in aspect and friable in texture, as toward the base in sections 1 and 2.

A sequence, substantially identical with that noted on Capitol Hill and on the central plateau, was observed in two or three sections near the summit of the bluff; and in S.E.N.W. 21, 78 N., 24 W., where the surface is formed of drift, a cellar is reported to have entered a löss-like deposit. The topography is labyrinthine, and the drift is as löss-like and calcareous as on the north side of the river; but no bowlders more than two feet in diameter were here seen.

The desirability of tracing the superior and inferior surfaces of the löss toward the periphery of the once continuous plateau on which it is found, and to their termini, was fully realized; but it was found impracticable to do so. Drift materials were however found beneath the löss in section 7; and this is known to be the normal sequence of these deposits. Moreover, the superincumbent drift-sheet has been traced uninterruptedly, in different directions, to localities in which no löss occurs beneath it. The stratigraphical relations of the löss of this vicinity must, accordingly, be as shown in the accompanying ideal section, in which erosion is not taken into account.

5.

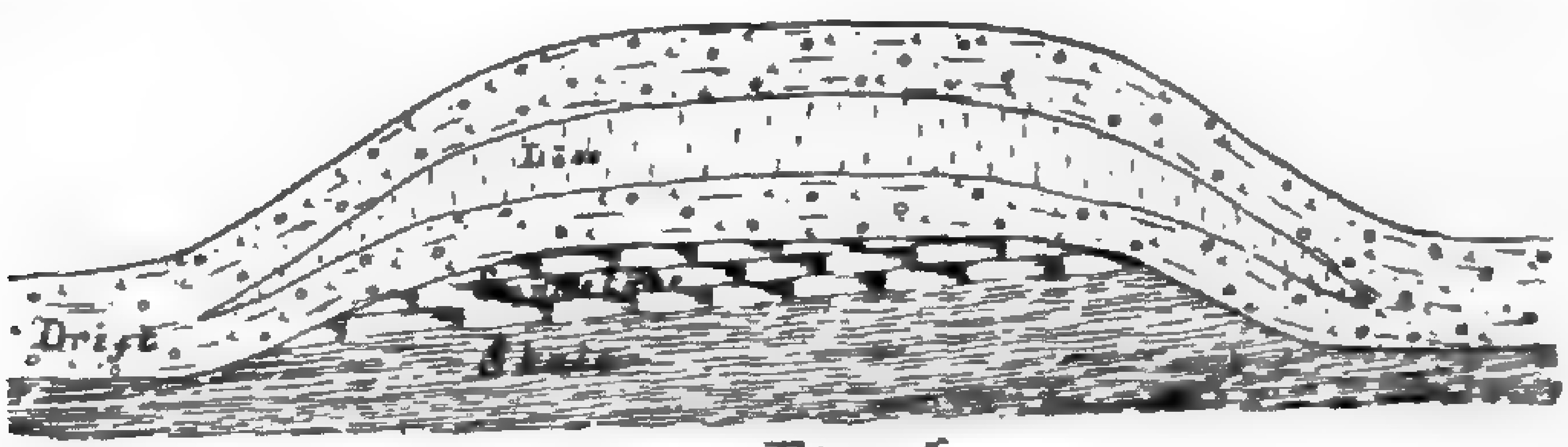


Fig. 5.

Recapitulating the salient stratigraphical features of the region under consideration, it appears, (1) That the löss is confined to elevated plateaus; (2) That its upper portion is broken up, contorted and interstratified and commingled with glacial drift; and (3) That the whole is overlain by unmodified glacial drift.

The first of these features is consonant with the phenomena observed by the senior author in northeastern Iowa, where the löss similarly affects the highest summits and divides; but the others are unknown elsewhere.

III.

The accompanying synoptical faunal tables will afford the means of determining the relative abundance and variety of molluscan life during the formation of the deposits studied as compared with the present. The twenty-four species listed in table I are unequally distributed among fifteen subgenera, and these again unequally among five families. The *Helicidæ*, *Pupadæ* and *Helicinidæ** are terrestrial groups, the *Limnæidæ* a fresh-water family, while the remaining one, together with the subgenus *Succinea* of the *Helicidæ* may be quite properly considered semi-aquatic.† Table II contains nearly twice the number of forms found in table 1, the exact number being

* These last are not *Pulmonata*, however.

† In the case of *Succinea* this statement should not be taken too literally. Though it prefers extremely damp or moist stations it is often found far removed from such localities and in even very dry situations. Nevertheless its optimum habitat appears to be a moist one.

Synoptical Table. I.—*Löss Fossils.*

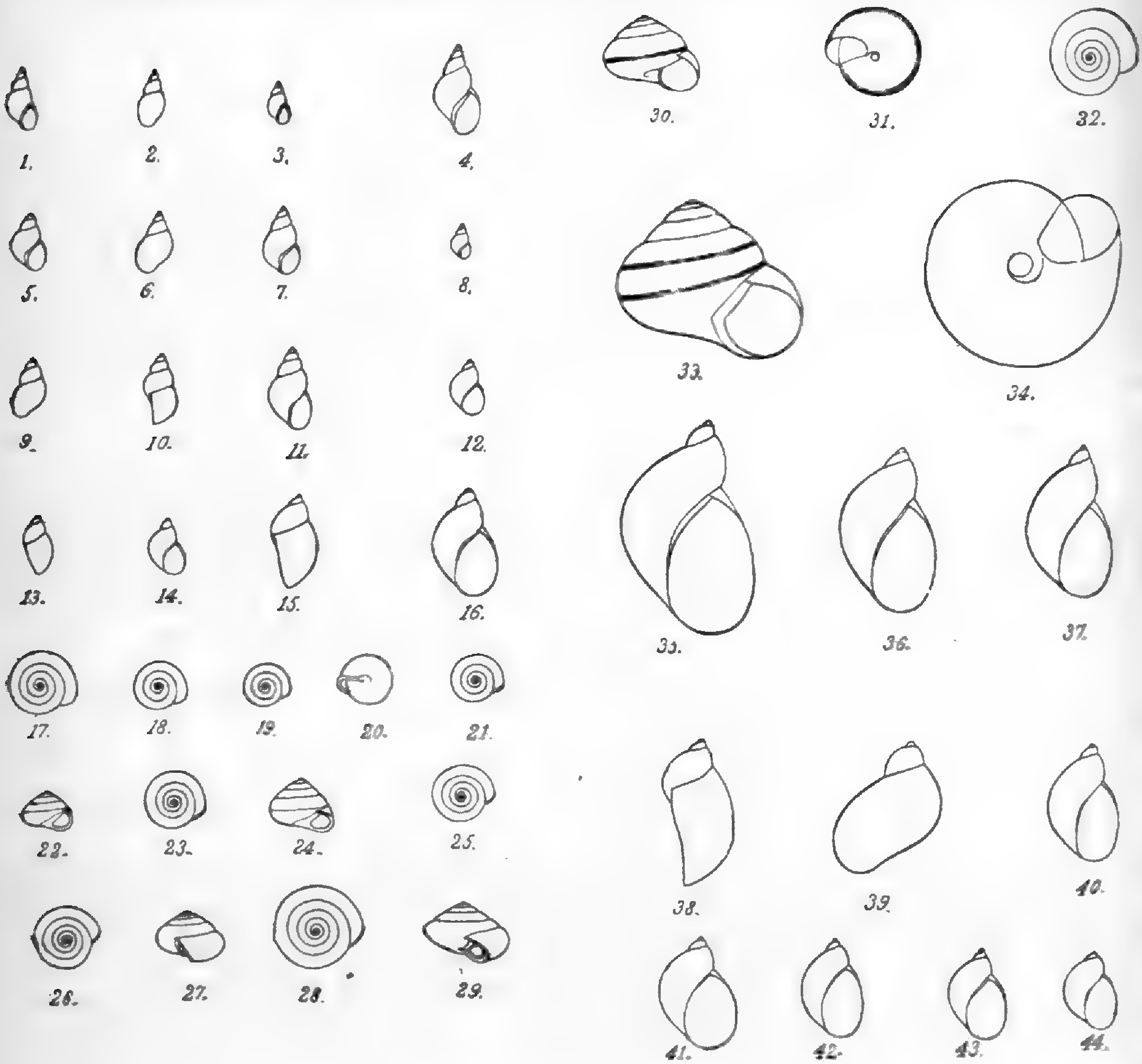
(Species now extinct in this locality in *italics*.) (Number of specimens measured in parenthesis.)

Families.	Sub-Genera.	Species.	Number in each sub-genus	Number in each Family.	Measurements.	Normal measurements. Given in descriptions.
Limnæidæ.	Limnophysa	humilis.			Largest $\frac{6}{20}$ inch. Smallest $\frac{1}{10}$ + inch. (19)	$\frac{7}{20}$ inch.
		desidiosa.	2	2	Largest $\frac{23}{48}$ inch. Smallest $\frac{6}{48}$ inch. (63)	$\frac{7}{10}$ inch.
Helicidæ.	Succinea	obliqua.			Largest 19^{mm}. Smallest 6^{mm}. (200+) Average 13½^{mm}.	18^{mm}.
		avara.	2		Largest 5·5^{mm}. Smallest 2^{mm}. (37) Average 4·54^{mm}.	Extreme length 6^{mm}.
	Mesodon	clausa.			Greater diam. 7^{mm}. Height 6$\frac{3}{5}$^{mm}. (2)	Greater diam. 11½^{mm}. Height 11½^{mm}
		multilineata.			Greater diam. 19·5^{mm}. Height 13·5^{mm}. (13)	Greater diam. 23^{mm}. Height 14^{mm}.
		thyroides. (?)	3		A single specimen, much *below* normal if identification be correct.	Greater diam. 22^{mm}. Height 13^{mm}.
	Stenotrema	monodon.	1		Greater diam. 8^{mm}. Height 6^{mm}. (11)	Greater diam. 11^{mm}. Height 6^{mm}.
	Patula	alternata.			Greater diam. 16^{mm}. Height 9·5^{mm}. (6)	Greater diam. 21^{mm}. Height 10^{mm}.
		strigosa.			Greater diam. of largest specimen 19^{mm}. Height 15^{mm}. (59) Average diam. 16^{mm}.	Greater diam. 21^{mm}. Height 10^{mm}.
		striatella.	3		Greater diam. 5·5^{mm}. Height 3^{mm}. (109)	Greater diam. 6^{mm}. Height 3^{mm}.
	Strobila	labyrinthica.	1		Slightly less than normal. (6)	Greater diam. 2½^{mm}. Height 1$\frac{3}{4}$^{mm}.
	Conulus	fulvus.	1		Greater diam. 4^{mm}. Height 2·8^{mm}. (15)	Greater diam. 4^{mm}. Height 3^{mm}.
	Helicodiscus	lineatus.	1		Greater diam. of largest specimen 3·175^{mm}. (20) Average diam. 3·4^{mm}.	Greater diam. 3½^{mm}. Height 1½^{mm}.
	Vallonia	*pulchella.*	1		Average of 50 specimens about equal to the *normal.*	Greater diam. 3^{mm}. Height 1½^{mm}.
	Hyalina	arborea.			Slightly less than normal. (44) Average *height* 2·8^{mm}.	Greater diam. 5^{mm}. Height 2$\frac{3}{4}$^{mm}.
		minuscula.	2	15	No measurements. Specimens all imperfect.	Greater diam. 2¼^{mm}. Height 1^{mm}.
Pupadæ.	Pupilla	pentodon.			See context.	Length 2^{mm}. Diam. 1^{mm}.
		muscorum.	2		See context.	Length 4^{mm}. Breadth 1½^{mm}.
	Leucochila	armifera.			See context.	Length 4$\frac{3}{5}$^{mm}. Diam. 2$\frac{3}{5}$^{mm}.
		corticaria.	2		See context.	Length 2¼^{mm}. Diam. 1^{mm}.
	Isthmia	ovata.	1	5	See context.	Length 3^{mm}. Diam. 1½^{mm}.
Helicinidæ.	*Oligyra*	*occulta.*	1	1	Diam. 6½^{mm}. Height 5·25^{mm}. (350)	Diam. 9^{mm}. Height 6^{mm}.
Auriculidæ.	Carychium	exiguum.	1	1	See context.	1$\frac{3}{5}$^{mm}.
5	15	24	24	24		

Synoptical Table. II.—*Recent Mollusca* (*Gasteropoda*).

Families.	Sub-Genera.	Species.	Number in each sub-genus.	Number in each Family.	Distribution.*
Limnæidæ.	Limnophysa	humilis.			Interior & Eastern provinces.
		reflexa.			Int. prov., northern half.
		desidiosa.	3		Int. & Eastern prov.
	Physa	heterostropha			Int. & Eastern prov.
		gyrina.	2		Int., northern half.
	Helisoma	trivolvis.			Int. & Eastern prov,
		bicarinatus.	2		North-Int. & Eastern prov.
	Gyraulus	parvus.	1		Int. & Eastern prov.
	Menetus	exacutus.	1	9	North- & East-Int. & East'n.
Ancylinæ.	Ancylus	tardus.			Int. & Eastern prov.
		parallelus.	2	2	Int. & Eastern prov.
Viviparidæ.	Campeloma	subsolidum.	1	1	North-Int. prov.
Valvatidæ.	Valvata	tricarinata.	1	1	North-Int. & Eastern prov.
Rissoidæ.	Bythinella	obtusa.	1		North-Int & Eastern prov.
	Amnicola	limosa.			North-Int. & Eastern prov.
		parva.			Int of Eastern prov.
		porata.	3		North-Int. & Eastern prov.
	Somatogyrus	subglobosus.	1	5	North-Int. & Eastern prov.
Helicidæ.	Hyalina	arborea.			All of North America.
		minuscula.	2		West-Eastern, Central, & Pacific. Also extra-limital.
	Patula	striatella.			Northern prov. & Pacific.
		alternata.	2		All over Eastern prov.
	Succinea	obliqua.			Northern & Int. Region of Eastern prov.
		avara.			Eastern & Central prov.
		ovalis.	3		Northern & Int. Regions of Eastern prov.
	Helicodiscus	lineatus.	1		Eastern, Central, & Pacific prov.
	Ferussacia	subcylindrica.	1		Northern Region of Eastern prov. Circumpolar.
	Stenotrema	monodon.			Eastern prov.
		hirsutum.	2		Northern-Eastern prov.
	Macrocyclis	concava.	1		Eastern prov.
	Strobila	labyrinthica.	1		Eastern prov.
	Conulus	fulvus.	1		Circumpolar. All over Eastern prov.
	Mesodon	albolabris.			Eastern prov.
		profunda.			Int. Region of Eastern prov.
		clausa.			Int Region of Eastern prov.
		multilineata.	4	18	Int. Region of Eastern prov.
Pupadæ.	Isthmia	ovata.	1		Eastern & Central prov.
	Pupilla	pentodon.	1		Northern-Eastern prov.
	Leucochila	armifera.			Eastern prov.
		corticaria.			Eastern prov.
		fallax.	3	5	Central portions of Eastern prov.
Auriculidæ.	Carychium	exiguum.	1	1	Interior & Eastern portions of Eastern prov.
8	25	42	42	42	

* The *provinces* are those defined by W. G. Binney, *vide* "Terr. Moll." v, p. 17, *et seqq.* It is, of course, understood that all such divisions are more or less arbitrary.



EXPLANATION OF PLATE V.

Figs. 1– 4. *Limnophysa desidiosa* Say.
4. Recent.
Figs. 5–11. *Limnophysa humilis* Say.
9–11. Recent.
Figs. 12–16. *Succinea avara* Say.
15–16. Recent.
Figs. 17–19. *Patula striatella* Anth. Fossil.
Figs. 20–24. *Helicina* (*Oligyra*) *occulta* Say.
23–24. Recent.
Figs. 25–29. *Stenotrema monodon*, Rack.
28–29. Recent.
Figs. 30–34. *Patula strigosa* Gould.
33–34. Recent.
Figs. 35–44. *Succinea obliqua* Say.
35–36. Recent.

NOTE ON THE TABLES.—No species has herein been listed, either of recent or fossil forms, on tradition or authority. Local examples of every form mentioned have been under examination in framing them.

forty-two. These forms are distributed among twenty-five subgenera comprised in eight families. Of the families not included in table I, the *Ancylinæ*, *Viviparidæ* and *Valvatidæ* are exclusively fresh-water in distribution, while the *Rissoidæ* comprise both fresh-water and marine genera. Those enumerated are fresh-water only. The facies of molluscan life seems therefore to have become decidedly more aquatic in recent times.*

Some of the forms indicated in table I are widely distributed both in time and space, while several of the subgenera attain a very high antiquity.† Of the families the oldest terrestrial group is the *Helicidæ*‡ represented by *Strophites grandævus* Dawson, from the Erian plant-beds of St. John, New Brunswick. The subgenus *Conulus* dates back to the Carboniferous, being represented by *Conulus priscus* Carp., from the South Joggins, Nova Scotia. Of equal age is the subgenus *Pupa*, represented by four species described in the paper last above cited. *Vallonia pulchella* and *Strobila labyrinthica* have each a great antiquity, the last named having, however, the widest distribution. The former is circumpolar, is a hardy species, and is known to abound at comparatively great altitudes.§ Binney quotes Prestwich (Quart. Jour. Geol. Soc., xxvii, p. 493) as authority for this species in the Red and Norwich Crag.‖ Its wide distribution is suggestive of its great antiquity. The second of these species, *Strobila labyrinthica*, is a representative of a now almost exclusively American subgenus, one of whose species, however, occurs in Jamaica. It is distributed over all the Eastern provinces of Binney. From the Eocene of England is recorded an extinct *Helix* referable to this species. According to Bland the fossil *Helix labyrinthica* from France "is apparently identical with our species." Binney¶ quoting Whiteaves (Can. Nat., vol. viii, p. 56,) records *H. labyrinthica* from the Upper Eocene at Headon Hill, Isle of Wight, and in the Paris Basin. *Helicina* (*Oligyra*) *occulta* may be properly considered the characteristic fossil of all löss-deposits in the valley of the Mississippi.

In similar deposits to that now under consideration in Belgium many of the same genera and some few of the same species are found. This is really an important fact as establishing the former wide geographical distribution of forms now confined almost solely to one or the other of the two continents.

* For some interesting generalizations respecting the *origin* of our land-mollusks as illustrated by the fossils of the Mississippi Valley, *vide* Binney "Terr. Air-Breathing Moll., vol. v, pp. 28–30."

† *Vide* this Journal, vol. xx, pp. 44–49.

‡ *Vide* Dawson on "Palæozoic Land-Shells," this Journal, vol. xx, p. 414.

§ *Vide* Hemphill, Quart. Jour. of Conch., p. 128, 1877.

‖ *Vide* "Terr. Air-Breathing Moll.," vol. v, p. 343.

¶ *Op. cit.*, p. 259.

From the recent alluvium and löss-like beds at Thiede, near Wolfenbüttel, the following genera, found in our area, have been taken, along with others confined to Europe:* *Pupa*, *Cionella*, *Helix*, *Vallonia*, *Patula*, *Hyalina*, *Succinea* and *Limnæa*. The *Succineæ*, like those of our area, are pretty abundant (Ziemlich haüfig). The species common to the two localities are *Pupa muscorum*, *Helix* (*Vallonia*) *pulchella*, and *Cionella lubrica*.† In the löss deposits at Würzburg,‡ the same species and the following genera were found: *Lymnæa*, *Pupa*, *Cionella*, *Helix* and *Succinea*. From a third locality, "Die Fuchelöcher am Rothen Berge bei Saalfeld," was obtained but a single species—*Pupa muscorum*—and four genera—*Patula*, *Hyalina*, *Pupa* and *Succinea*—common to our area. A similar comparative paucity is noted in the list from the löss of the Rhine at Unkelstein, near Remagen, where were found *Helix*, *Pupa* and *Succinea*, with *Helix* (*Vallonia*) *pulchella* and *Pupa muscorum* common. In every case in these localities were found the fossil remains of vertebrata, comprising bones of mammals, fishes, batrachians and birds.

Independent of its geological bearing, table I affords some data of great interest from a zoological stand-point. A comparison of the columns of measurements will lead to the important generalization that the fossil forms enumerated are depauperate. Only those specimens were measured which were perfect, or nearly so; the entire number of measured specimens being over one thousand. The forms of *Stenotrema monodon* present some important differential characters, the apices being more elevated, the whorls more convex and somewhat loosely coiled, with apertures more lunate than in recent specimens. The reflected portions of the lip and the parietal teeth are also less calcareous. In all other respects they correspond generally with the variety of the recent form known as *Stenotrema monodon*, var. *Leaii*. The *Patula strigosa* present, in a remarkable degree, those features determined by Professor Alpheus Hyatt§ as characteristic of lessened vitality or even of traumatism. The average diameter of this species, as is seen by the table of measurements, falls far below the normal. The form described as *Patula Cooperi*, but now quite properly placed in the synonymy of *P. strigosa*, is in excess of all the others assumed by this protean species, all of which, however, are much smaller

* *Vide* "Zeitschrift der Deutschen geologischen Gesellschaft, vol. xxxii, p. 472, (1880).

† We have here retained the nomenclature adopted by the author quoted. The weight of authority, however, would make this species a synonym of *Ferussacia* (*Cionella*) *subcylindrica*, and hence identical with the American form.

‡ *Op. cit.*, pp. 494, 496, 503 and 508, for this and the following lists.

§ "On the Tertiary species of Planorbis at Steinheim." Anniversary Mem. Bost. Soc. Nat. Hist., 1880, p. 13 *et seqq.* This memoir is a most important and valuable contribution to the literature of evolution.

than the specimen serving as the type.* None of the measurements of the *Pupadæ* are given in the table, partly because in attempting to measure them many were broken, and partly, again, because the differences in size appeared to be so small as to be almost inappreciable and hence do not appear to affect the general value of the observations. *Succinea* seems to have attained a most luxuriant development, and is exceeded in numbers only by *Oligyra occulta.* This last species is of remarkable interest from the fact of its recent discovery living in great numbers in the vicinity of Iowa City. In all the recent specimens examined, upwards of one hundred and fifty, the smallest of the living forms were larger than the largest of the fossil ones. The two aquatic species, *Limnophysa humilis* and *Limnophysa desidiosa*, present the same depauperate features and lead us to the same general conclusions. Plate V figures both recent and fossil forms of these several species in juxtaposition, the specimens figured illustrating quite well the most common variations and the relative sizes. (See explanation.)

In this connection it will be found of great interest to consult the remarks of Semper‡ on the influence exerted on animal life by low temperatures. That author experimented on *Lymnæa stagnalis*, and the results of his long continued observations led to the statement that the *Lymnæa* may be quite frozen up without being killed. Extremely low temperature had no influence on the animal life, but entirely prevented growth.‡ In this way a permanently diminutive race might arise. At all events the fossil material studied by the junior author, comprising many hundred examples, presents the *fact* of such depauperate races whatever may have been the cause.

IV.

In order to state intelligibly the working hypothesis suggested by the foregoing facts, it will be necessary to briefly state the conclusions as to the formation of åsar and the determination of river courses reached by the senior author after a practically exhaustive survey of the cenology of the northeastern quarter of Iowa.§

The ice-sheet over this region was thin; not more than five hundred feet in average thickness. Each pre existing plateau or ridge accordingly produced a relatively considerable attenuation of the sheet. Three results followed: (1) The motion of

* *Vide*, "Terr. Air-Breathing Mollusks," vol. v, p. 158, fig. 64.

† *Vide* "Animal Life, as affected by the Natural Conditions of Existence," 1881, p. 108–109, and elsewhere.

‡ *Op. cit.*, p. 108. *Vide*, also, Darwin "On the Origin of Species by means of Natural Selection." Edition of 1877, p. 54.

§ A memoir embracing the results of this survey is approaching completion.

the ice was retarded along the ridge, and the pressure was reduced, thereby not only diminishing the rate of erosion, but heaping up an unusual thickness of morainic debris along the ridge in what may be styled a *submedial morain.* (2) The attenuation of the ice brought the fine debris undoubtedly disseminated throughout the lower portion of the ice to the surface in unusual quantities, thereby facilitating superficial melting along the ridges, and thus determined the course of a supra-glacial stream. (3) The rapid melting of the ice along such lines so reduced its thickness and diminished its pressure upon the subjacent surface as to divert thither all sub-glacial water, which accordingly formed sub-glacial streams coincident and finally confluent with the supra-glacial rivers. These streams formed cañons in the ice, and when eroded through, either formed basins or extended their corrasion into the subjacent deposits, according to the slope of the surface. In either case, when the cañons were long, the streams so deeply corraded their beds before the bounding walls of ice disappeared as to permanently retain the water-ways in the ridges over which they were first defined; while, when the cañons were short, the streams left the ridges as soon as they reached the margin of the ice.

Passing now to the region shown in the accompanying map, we find to the eastward a typical *as* in which the ice-cañon was too short to define a water-way, and about the confluence of the rivers a plateau which formerly existed as an ice-bound basin, and through which the rivers corraded their valleys before the final disappearance of the ice. In such a basin the löss was deposited, just as was all of that of eastern Iowa; the coldness of the waters and the low temperature of the air being attested by the depauperate shells found imbedded in it. Here, however, a re-advance of the glacier occurred before the ice was melted from the plains east of Capitol Hill and west of Walnut Creek, which disturbed, contorted and broke up the superficial portions of the löss, and mingled its materials with the clays and bowlders of a super-imposed sheet of drift; the re-advance being too slight to completely remove the löss even from exposed localities.

Apropos to the re-advance of the ice-sheet here suggested is Upham's discovery that Des Moines lies approximately in the course of the southernmost lobe of the great terminal moraine.* Now, if the phenomena are coincident, as is forcibly suggested, it follows that, as has already been urged by Chamberlin,† this moraine was formed, not during an independent ice-period,

* Ninth Annual Report of the Geological and Natural History Survey of Minnesota, p. 304, Plate VI (1880).

† Geology of Wisconsin, 1873–1877, ii, pp. 214, 218.

but during a temporary halt and slight re-advance of the slowly retreating ice-sheet which formed the drift without its limits.

Incidentally the observations herein recorded indicate (1) from the essentially homogeneous and unquestionably unipartite character of the drift-sheet above the löss, especially in section 6, that the Torrellian hypothesis of the deposit of a *ground-moraine* and a *superficial moraine* by each glacier is invalid; (2) from the disappearance of the blue coloration downward in sections 6, 8 and 10, that this blue color is not normal and changed to brown or yellow by oxidation from above, as urged by Hawes,* Julien,† Von den Bruch,‡ Shaler,§ and others, but is in some way acquired.

May 31, 1882.

ART. XXIV.—*Orthocynodon, an animal related to the Rhinoceros, from the Bridger Eocene;* ‖ by WM. B. SCOTT and HENRY F. OSBORN.

ORTHOCYNODON is the name given to designate a new genus of the Rhinoceros line from the Bridger Beds of Wyoming. It was discovered by the Princeton Expedition of 1878, in the Bad Lands of Bitter Creek. It carries the Rhinoceros line farther back than it has been supposed to exist. The oldest representative of this line known hitherto is *Amynodon*, a genus found by Professor Marsh ¶ in the Uintah beds which overlie the Bridger. Orthocynodon was at first referred to the latter genus, until important differences in the molar dentition were discovered.

Generic characters.—The lower canines are erect and functional, giving the name to the genus. The lower incisors are two on each side and semi-procumbent. The lower premolars, with the exception of the first, are somewhat simpler than the molars, but have the Rhinoceros pattern of two inward-opening crescents directed forwards. The upper premolars have distinct posterior crescents and small postero-internal cusps. The post-glenoid and post-tympanic processes apparently do not unite to surround the external auditory meatus. There is a sagittal crest separating the temporal fossæ.

This genus differs from *Amynodon* in the erect canines, in

* Geology of New Hampshire, 1878, iii, p. 333.

† Proc. A. A. A. S., 1879, xxviii, p. 352.

‡ Mémoire sur les Phénomènes d'Altération des Dépots superficiels par l'infiltration des eaux Météoriques, 1881, pp. 147–168.

§ Glaciers, 1881, p. 165.

‖ Description from specimens in the E. M. Museum of Geology, Princeton, N. J.

¶ This Journal, III, vol. xiv, p. 251.

the possession of a posterior crest, and distinct though small postero-internal cusp on the second and third upper premolars; finally, in the fact that the premolar pattern in both jaws is like that of the molars. In *Amynodon* the canines are nearly procumbent and the premolars are all unlike the molars. It is singular that this genus, belonging to a more recent geological formation than *Achaenodon*, should have less of the typical Rhinoceros structure in its molars.

Orthocynodon antiquus, gen. et sp. nov.,

$$\text{Dental formula, } i\,\frac{2\text{–}2?}{2\text{–}2},\ c\,\frac{1\text{–}1}{1\text{–}1},\ pm\,\frac{3\text{–}3?}{4\text{–}4},\ m\,\frac{3\text{–}3}{3\text{–}3}$$

The specimens consist of the skull and lower jaw of one individual, and a portion of the skull containing the molar series of another. In each the upper canines and incisors are wanting. The lower incisors are close to the canines; they are semi-erect in position and placed in a quarter circle. They have slight fangs and sharp crowns, with low cingula posteriorly. The canines are almost trihedral in section and curve upwards and slightly backwards, worn at the back of their pointed tips by the upper teeth. A diastema of two inches separates them from the premolars. The lower premolar-molar series differs only in size and minor details from that of a young specimen of *Rhinoceros Indicus.* The first premolar has a simple crown rising to a single point and supported on two fangs. The inner face is irregularly concave, as in the Rhinoceros. Each of the remaining teeth presents two forward opening crescents of similar pattern. The third and fourth upper premolars are preserved in our specimens, and the upper molars are complete. The premolars present an external longitudinal ridge; from it arise a broad anterior and a narrow and somewhat low posterior crescent, opening backward; the postero-internal cusps are small. The molars are like those of the Rhinoceros in the proportion and disposition of their crescents.

The *Skull* is about fourteen inches long and five inches deep. The occipital condyle resembles that of the Indian Rhinoceros. There is a recurved *paroccipital* process having a long forward union with the post-tympanic. The *post-tympanic* and *post-glenoid processes* do not unite as in the modern Rhinoceros. In common with all the Eocene Ungulates there is quite a high thin sagittal crest, and somewhat deep temporal fossa, quite unlike the Indian Rhinoceros. The skull in fact does not resemble that of its modern relative. The *parietals* are narrow and compressed; the *frontals* expand into a broad well-rounded snout. We cannot ascertain from our specimens whether the nasals bore protuberances for the support of horns. It seems probable that they did not.

This animal will be fully described and figured in a later publication. The above is intended merely as a preliminary notice. *Orthocynodon* may be briefly described as an Eocene perissodactyle Ungulate with the premolar-molar dentition of a Rhinoceros, and somewhat resembling *Amynodon* in the possession of canines and loss of the median incisors. It has little of the rhinocerotic character in the skull, but the resemblances in the dentition points it out as related to *Amynodon*, with which it belongs, among the group of Eocene progenitors of the Rhinocerotidæ.

MEASUREMENTS.

	M.
Total length of molar series of the lower jaw	·192
Antero-posterior diameter of the first lower molar	·038
Transverse diameter of the first lower molar	·022
Vertical diameter of the crown of the canine	.040
Transverse diameter of the first upper molar	·035
Antero-posterior diameter of the first upper molar	·035
Total length of the upper molars, estimated	·165

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Atomic Weight of Carbon.*—ROSCOE has re-determined the atomic weight of carbon by the method employed by Dumas and Stas, which consists in the direct combustion of the diamond. For this purpose diamonds from the Kimberley mines, South Africa, were used, those burned by the French chemists having come from Brazil. The method employed was the same, carefully purified oxygen being conducted over the diamonds contained in a tarred platinum boat placed in a glazed tube of Berlin porcelain, which was heated in a charcoal fire. The products of combustion were absorbed (1) by a weighed U-tube containing pumice moistened with sulphuric acid, (2) by two series of Geissler-Liebig potash bulbs, containing potash solution; (3) by three U-tubes containing pumice wet with a solution of caustic potash, and (4) two small U-tubes containing pumice and sulphuric acid. Six separate experiments were made. In the first, six small transparent stones of a pale yellow color were used; in the second eight small dark stones; in the third one large dark stone; in the fourth four dark stones; in the fifth four colorless stones, and in the sixth a piece of the black diamond known as carbonado. Assuming Stas's atomic weight for oxygen 15·96, the values obtained for carbon in the six experiments were as follows: 11·970, 11·978, 11·970, 11·976, 11·966, 11·995; mean, 11·9757. The mean value obtained by Dumas and Stas in 1840 is 11·9708. With the exception of the sixth experiment, in which the black variety of carbon was used, the hydrogen obtained

did not exceed as a mean one seven-thousandth part of the weight of the diamond, and was probably derived from moisture in the apparatus. In presenting this memoir to the Academy, Dumas called attention to the fact that if the atomic weight of oxygen be assumed as 16, that of carbon is 12·002, or within one-six-thousandth of a whole number.—*C. R.*, xciv, 1180, May, 1882.—*Ann. Chem. Phys.*, V, xxvi, 136, May, 1882. G. F. B.

2. *On the Determination of Chromium as Phosphate.*—CARNOT has proposed to determine chromium as phosphate. When a feebly acid solution of a chromium salt is boiled with sodium acetate and phosphate, the whole of the chromium is thrown down as phosphate. The method succeeds not only with the green salt but also with the violet ones, and with chlorides, sulphates and acetates, but not with oxalates. The chromium in chromates may be determined in this way if sodium thiosulphate be added simultaneously to reduce the chromic acid. The precipitate is a green hydrate having the formula $Cr_2P_2O_8$, $(H_2O)_6$ when dried at 100°. It may be washed with boiling water, in which it is nearly insoluble, or better with hot solutions of ammonium acetate and nitrate. On ignition it loses its water and becomes $Cr_2P_2O_8$, containing 51·86 per cent of chromium. Aluminum and chromium are readily separated by converting the latter into chromate, precipitating the former as phosphate, then reducing and precipitating the chromium as phosphate, as already described. The chromium phosphate the author believes to have a commercial value as a green pigment.—*Bull. Soc. Ch.*, II, xxxvii, 482, June, 1882. G. F. B.

3. *On the Earth-metals of Samarskite.*—ROSCOE has made a study of the rarer earth-metals occurring in samarskite. About 1·5 kilos. of the coarsely-powdered mineral were treated in portions of 100 grams, with 250^{cc} commercial hydrofluoric acid, diluted with an equal volume of water. The solution was decanted from the precipitate, and this after being well dried was heated with sulphuric acid, and after separation of the uranium the earths were precipitated as oxalates. The oxalates on ignition yielded oxides which were converted into nitrates, fused, dissolved in water, the solution precipitated with potassium sulphate, converted into neutral sulphates and by a series of fractional precipitations separated into two groups. One of these gave a sulphate soluble in 30 parts of a cold saturated solution of K_2SO_4. Its oxide was of a fawn color, and it contained philippia, yttria, terbia, and traces of erbia. The other sulphate was soluble only in 200 parts of the K_2SO_4 solution, and gave a brown oxide. It contained didymium, decipium, β-yttrium, etc. The oxides from the former portion weighed 60 grams; from the latter 25 grams. The first group of these oxides were converted into formates and these submitted to a long and systematic series of fractional precipitations, the powdered mass being extracted with successive small volumes of hot water, each extract being evaporated to dryness and analyzed. In this way a large num-

ber of fractions were finally obtained, one of which was richest in philippia, another in terbia and another in yttria. All attempts, however, to obtain a formate possessing a constant atomic weight of 121–123 failed entirely. In view of the curious fact that the formate which yields an atomic weight nearest to 122 possesses distinctly different physical properties from the formates obtained from oxides of much higher or much lower atomic weight, some direct experiments were made. To test the question whether this result was due to the crystallization together of the higher and lower formates, a mixture was made of the formates of yttrium and terbium, in three solutions, each containing different proportions. One of these solutions yielded rhombic crystals exactly like those previously obtained. Hence it appears that the formates of terbium and yttrium are capable of crystallizing together in a form ascribed to philippium.—*J. Chem. Soc.*, xli, 277, June, 1882. G. F. B.

4. *On the Precipitation of Glycogen.*—It is well known that in the preparation of glycogen from animal tissues the amount of material precipitated on the addition of alcohol is often very slight. KÜLZ has examined this question and found that as the product is purified by repeated precipitation, the yield becomes less. Having prepared 49 grams of glycogen from a dog's liver it was analyzed and found to contain 0·16 per cent of ash. After drying at 110° C., it was dissolved in water. But the addition of even 4 or 5 times the volume of absolute alcohol produced no precipitate. That the drying had no effect was shown by the fact that a glycogen, containing 1·3 per cent of ash and so dried, dissolved in the proportion of 0·5 to one gram to 100^{cc} of water, and was readily precipitated by absolute alcohol. But on repeating the process on the same sample a point was soon reached where its purity was such that no precipitation took place. The addition of a minute quantity of salt, even 0·002 gram, produces a precipitate at once. The author calls attention to the similarity in the behavior of this body to the salt-free soluble serum-albumin of Aronstein.—*Ber. Berl. Chem. Ges.*, xv, 1300, June, 1882. G. F. B.

5. *On the Transformation of Urea into Cyanamide.*—Many chemists have studied the conditions under which cyanamide, through the influence of dilute acids, takes up the elements of water to form urea, $CN_2H_2+H_2O=CON_2H_4$. But the dehydration of urea into cyanamide has not hitherto been effected. FENTON however, after numerous experiments in this direction, has succeeded in accomplishing it by means of sodium. If urea be gently heated with metallic sodium the reaction is violent and a large amount of hydrogen is evolved. On dissolving the solid residue in water, the solution gives the reactions of cyanamide. The crystallized product gave on analysis the formula CN_2H_2. The reaction by which it is formed is as follows:

$$(CON_2H_4)_2+Na_2=(CN_2H_2)_2+(NaOH)_2+H_2.$$

Sodium acts upon ammonium carbamate and carbonate in the same way and produces cyanamide, though the yield is not as abundant as with urea.—*J. Chem. Soc.*, xli, 262, June, 1882.

G. F. B.

6. *Oscillation of the plane of polarization by the discharge of a battery.*—BICHAT and BLONDOT have studied the effect of a Leyden jar discharge in producing a rotation of the plane of polarization in a transparent medium. The body is placed between the polarizer and analyzer, arranged for extinction in a bobbin, which is wound round with a long fine wire. A discharge takes place when the difference of potentials is sufficient; at this instant a bright reappearance of light is seen by the eye situated in front of the analyzer, showing a rotation of the plane of polarization. A mirror, rotating on a vertical axis, was now placed before the optical apparatus; the polarizer was provided with a vertical slit whose image was observed in the rotating mirror by a telescope, the arrangement being such as to cause the appearance of the spark at the right instant. In general, a series of broad luminous bands was observed corresponding to the oscillatory currents of the discharge. Further, it was observed that the rotation of the analyzer through a small angle in one direction caused the even bands to grow weaker and the odd ones to increase, and *vice versa* for a rotation in the opposite direction. From this it is concluded that the plane of polarization undergoes successive rotations alternately in opposite directions, or in other words, it oscillates about its normal position, each oscillatory discharge corresponding to an oscillation of the plane of polarization.

The authors also arranged the apparatus so that there could be seen at once in the rotating mirror, the bands furnished by the light of the spark, and those due to the oscillation of the plane of polarization. The two systems of bands, alternately bright and dark, were seen one above the other. It was found that the two systems corresponded exactly, so that the two phenomena must be considered to be simultaneous; no difference in time as great as $\frac{1}{30\,000}$ second could be observed.—*C. R.*, June 12, 1882.

II. GEOLOGY AND NATURAL HISTORY.

1. *On the relative ages and classification of the Post-Eocene Tertiary deposits of the Atlantic Slope;* by ANGELO HEILPRIN. 36 pp. 8vo. (Proc. Acad. Nat. Sci. Philad., June, 1882.)—Mr. Heilprin reviews the facts respecting the post-Eocene fossils both geographically and stratigraphically, by comparisons between those of Maryland, Virginia, North Carolina, and South Carolina. He finds that of 103 lamellibranchs found in South Carolina about 74 per cent occur also in North Carolina, showing probable equivalence of deposits; while in Virginia only 42 per cent of the S. Carolina species occur, and 46 of those of N. Carolina, and but 33 to 34 per cent in Maryland, indicating apparently a difference in horizon. Again, of the Virginia lamellibranchs, 109 species, only 40 per cent are common to South and 44 to North

Carolina; and of the Maryland, 98 in number, the percentage in the Carolinas is 35 to 37 per cent; while 42 per cent are common to Maryland and Virginia. These facts sustain the inference that the deposits of North and South Carolina are of one horizon, while those of Virginia and Maryland are of another or two others.

Again, of the South Carolina species, about 33 per cent (omitting six doubtful) are recent forms and of the North Carolina, 30 per cent. Of the 109 Virginia species, the recent are only 16 in number or 15 per cent; and of the 98 Maryland, only 13. These facts further corroborate the view of two distinct horizons. The conclusions are sustained though less strikingly, by a review of the gasteropod fauna. Mr. Heilprin hence concludes that the Virginia deposits belong to a horizon older than that of the Carolinas, and that the Maryland indicates two horizons of which the upper one corresponds to the Virginian. Finally, the subdivisions of the Tertiary of the Atlantic and Gulf border are thus tabulated.

PLIOCENE.	?	?	
MIOCENE.	CAROLINIAN (Upper Atlantic Miocene).	Deposits of South and North Carolina ("Sumter" epoch of Dana).	
	VIRGINIAN (Middle Atlantic Miocene).	Deposits of Virginia, and of the "Newer" group of Maryland ("Yorktown" epoch, in part, of Dana).	Probably equivalent of the "Second Mediterranean" of Austria, and of the fahluns of Touraine.
	MARYLANDIAN (Lower Atlantic Miocene).	Deposits of the "Older" group of Maryland, and possibly the lower Miocene beds of Virginia ("Yorktown" epoch, in part, of Dana).	Probably (or at least partially) equivalent of the "First Mediterranean" of Austria, and of the fahluns of Léognan and Saucats.
OLIGOCENE.	ORBITOITIC.	Strata characterized by species of *Orbitoides*, etc. Vicksburg beds, Florida beds, etc.	
EOCENE.	JACKSONIAN.	Jackson beds of Mississippi—"White Limestone" of Alabama.	
	CLAIBORNIAN.	Fossiliferous arenaceous deposit of Claiborne, Ala., etc.	Age of the "Calcaire Grossier" of France (Parisian).
	BUHRSTONE.	Beds below the true Claibornian on the Alabama River. "Chalk Hills" of the southern portion of the State, etc. "Siliceous Claiborne" (Hilgard) of Mississippi.	Londonian?
	EO-LIGNITIC.	Lignite, sands, and clays situated at the base of the Tertiary series in Alabama, etc. Eocene beds of Maryland?	Thanetian?

2. *On the Classification of Lake Basins*, by WM. M. DAVIS.—This paper makes nearly 70 pages of vol. xxi of the Proceedings of the Boston Society of Natural History. It reviews the kinds of lake-basins and considers their modes of origin. Among the conclusions presented are the following: that the Great Lakes of North America are not a result of glacial excavation; that while there are rock-basins of moderate size which are presumably of glacial origin, these are far outnumbered by drift-barrier basins and drift basins; that the presence of drift and alluvial barriers below the Swiss lakes, so far as effective, obviate the necessity of considering them orographic or glacier-erosion basins; that the kettle-holes and other depressions over the drift deposits, unstratified and stratified, may in part have originated in hollows occupied by isolated ice-masses during drift deposition, as suggested for American examples by Upham (an explanation applied by Peschel, as Mr. Davis states, to account for the preservation of Lake Neufchatel and its neighbors), or they may be spaces which the drift in its uneven accumulation failed to fill.

3. *The Catskill region.*—A paper on the Little Mountain, east of the Catskills, by WM. M. DAVIS, giving instructive sections of the rocks of these elevations and of the region between the Catskills and the Hudson, is contained in vol. iii of Appalachia, No. 1.

4. *Address before the Geological Society at the anniversary meeting in February*, 1882; by ROBERT ETHERIDGE, Esq., F.R.S., President of the Society. 204 pp. 8vo.—This presidential address of Mr. Etheridge consists chiefly of a memoir "on the analysis and distribution of the British Jurassic fossils." The subject is discussed with great thoroughness, both stratigraphically and paleontologically. The number of genera recognized is 513, of species 4488; and of these species 6 are Mammals, 132 Reptiles, 219 Fishes, 115 Belemnites, 477 Ammonites, 6 Teuthids, 21 Nautili, 1 Ancyloceras, 1015 Gasteropods, 924 Dimyaries, 444 Monomyaries, 275 Brachiopods, 51 Bryozoans, 64 Crustaceans, 45 Annelids, 216 Echinoderms, 175 Cœlenterates, 100 Rhizopods, 11 Amorphozoans and 191 Plants. The address closes with a review of the modern classification of Ammonites.

5. *Artificial forms of Silica.*—Some curious artificial forms of silica, interesting as illustrating the structure of agates and chalcedonies, have been described by J. I'ANSON and E. A. PANKHURST. To illustrate the stalactitic, or exogenous, type of agates, the best results are obtained as follows:

"A strong solution of an alkaline silicate is taken, containing a certain amount of alkaline carbonate, and a strong acid (sulphuric seems to give the best results) is introduced by means of a pipette to the bottom of the vessel in which the solution is contained. Bubbles of carbonic acid gas immediately arise, carrying with them a certain amount of the stronger acid. Round the stream of ascending bubbles silica is deposited by the decomposition of the alkaline silicate, and in a very few minutes a tube is formed reaching from the bottom to the surface of the solution. This tube is at first very thin, and through its walls the ascending acid continues to act upon the surrounding silicate, the walls of the tube in consequence constantly growing in thickness by the deposition of additional silica on its outer surface. As long as the flow of acid is kept up, so long does the tube grow in diameter by the deposit of successive layers, and the result is a hollow stalactite ringed in cross section.

"The carbonic acid evolved from the carbonate in the solution is essential to the successful commencement of the tube, but when this is once formed, the sulphuric or other acid can be itself forced through it, and by the application of pressure to the surface of the fluid in the pipette, the action can be kept up for a long time, and stalactites of $\frac{3}{4}$ inch in diameter can be formed with little difficulty. The same result can be produced by passing an acid gas, or even air highly charged with an acid, through the alkaline silicate solution, and it will easily be seen that analogous effects can be produced by the action of any other reagents capable of separating the silica, such as acid salts of various metals. In fact, the process can be varied in a hundred different ways. In natural siliceous stones, where stalactitic forms enter into the structure, we constantly observe a central core, frequently of iron or other oxide, which appears to represent the original tube which has subsequently been filled up, whilst sometimes the cavity remains more or less completely as such. These stalactites of course do not grow up by any means in constantly straight regular forms, but assume irregular and branched ones, more like those of coral than anything else, according to the direction in which the bubbles of gas or the acid escapes from the end, or from points of least resistance in the sides of the tube. Glauber's "Iron tree" is one form of this stalactitic growth. * * *

"We consider, then, that the stalactitic productions thus made are the analogues of all the group of banded stalactitic growths which enter so largely into the constitution of many siliceous stones, where the growth appears to have proceeded from a central cavity, now frequently only a core by reason of subsequent filling in.

"If the action is carried so far that the surrounding fluid becomes saturated with acid reagent, the whole of this surrounding fluid gelatinizes by the precipitation of amorphous gelatinous silica, and if we suppose a case in which such stalactitic forms have been produced in nature in an enclosed rock cavity containing an alkaline silicate solution, by the infiltration of an acid solution, a like result would occur. In point of fact, as we have already stated, such natural forms constantly occur with a surrounding mass of crystallized unbanded silica, and this we are led by many observations to regard as the analogue in nature of the gelatinous silica resulting from the saturation of the fluid in which the stalactites have been formed. Whether in nature this crystalline silica has been originally deposited in a gelatinous form, and subsequently crystallized, is a little out of the scope of this paper; but analogy leads us to regard this as most probable."

With reference to the banded or endogenous type of agates the authors remark:

"Assuming hypothetically a rock cavity containing a solution of alkaline silicate, and the rock in which this cavity is situated permeated with an acid solution or gas, we should naturally expect to find a layer of silica deposited on the walls of such a cavity, and, as the action continued, more and more silica would be deposited; and if the solution were *enclosed* in the rock cavity, the central portion would, when the action had continued to a certain point, set in an amorphous mass. This action is very completely paralleled in some of the preparations which we have made, and in some of these we have found that a central vacant space was left, owing to there not being enough silica in the solution to fill the whole cavity when precipitated in the gelatinous form. This is precisely what occurs in many natural agates, where we find a deposit of crystalline unbanded silica within the banded portion, with a vacant space in the center of all."

By the use of acid solutions containing various metallic and earthy salts the coloring of natural stones can be imitated, that is, jaspers, moss agates, onyx and so on. The horizontal banding frequently met with in natural agates has been also very completely reproduced. When the precipitated silica in these preparations is exposed to the air it, for the most part, dries up and crumbles away, although some forms closely like common opal in appearance but of lower specific gravity have been produced. Under suitable conditions as to heat and pressure the authors think that the natural agates and allied varieties might be imitated, not only as here in form but also in hardness and stability.—*Min. Mag.*, May, 1882.

6. *The Origin and Relations of the Carbon minerals*, by Professor J. S. NEWBERRY. 24 pp. 8vo. From the Annals of the N. Y. Acad. Sci., vol. ii, 1882.—Professor Newberry, on reviewing the relations of the carbon minerals, considers the question as to the origin of the mineral oil, and opposes the view that it is indigenous in the sand-rocks which hold it, expressed by Professor Lesley (Proc. Amer. Phil. Soc., x, 33, 187), on the ground that the fossil remains of plants in such sand-rocks are very few, if not often wholly absent. He presents the old view as the most probable—that the sandstones through their porosity were convenient receptacles for the oil which flowed from some stratum of organic matters below.

7. *Lehrbuch der Mineralogie* von Dr. GUSTAV TSCHERMAK, II. Lieferung, pp. 193–368. Vienna, 1882 (Alfred Hölder).—This second part of the valuable new Mineralogy by Professor Tschermak (see this Journal, xxiii, 68) contains the remainder of the physical portion of the subject, the chemistry, the discussion of method of occurrence and of paragenesis of minerals, the classification, and the beginning of description of species.

8. *New Swedish Minerals.*—Professor L. I. IGELSTRÖM has recently described two new minerals from Wermland, Sweden. MAN-

GANBRUCITE occurs at the manganese mines of the Jakobsberg together with hausmannite, jakobsite, piedmontite, manganophyllite, braunite, etc. It is found in granular form, of the size of hemp seed, in the hausmannite ore, consisting of hausmannite more or less thickly imbedded in calcite. Massive, without cleavage; color from honey-yellow to brownish-red, perhaps originally nearly colorless; translucent in thin splinters. An analysis gave, after deducting a very little silica and calcite:

MgO	MnO	H_2O
57·81	14·16	28·00 = 99·97

This corresponds approximately to the formula (Mg, Mn) H_2O_2, or a manganesian variety of brucite.

TALKTRIPLITE is from Horrsjöberg in Wermland, where it occurs with lazulite, svanbergite which it much resembles, and other phosphates. It is found in grains of the size of a pin-head; color yellow to yellowish-red; transparent; hardness about 5. An analysis of 0·85 gram of the mineral mixed with matrix (0·585 insoluble in HCl) gave:

P_2O_5	FeO	MnO	CaO	MgO
32·82	16·12	14·86	14·91	17·42 = 96·13

It contains some fluorine, which, however, was not determined. The calculated formula is $(Fe, Mn, Mg, Ca)_4P_2O_9+CaF_2$, but the analysis is too imperfect to determine the composition with certainty. The author suggests that perhaps the true formula is $R_3P_2O_8+RF_2$, and then the mineral would be essentially a triplite containing lime and magnesia. The name given has reference to this supposition.

9. *The female Flowers of Coniferæ.*—Professor Eichler's paper on this subject, reviewed in the May number of this Journal, has induced Professor CELAKOVSKY to re-investigate this subject, morphologically so important, and to which he had already devoted much attention. In the Abhandl. d. K. Boehm. Ges. d. Wiss. he has recently published his present views, in an extensive article, illustrated by a plate. After reviewing the different theories and explanations enunciated since Robert Brown's time, he dwells emphatically on the great importance of the study of the *anamorphoses* (as he calls those monstrosities which are the result of retrograde metamorphosis, in contra-distinction to mere pathological alterations) and of the teachings they convey. He comes to the conclusion that these are a much safer guide than the microscopic study of the genesis of the organs, which has often misled those who too implicitly relied on its teachings. Investigating the anamorphoses of the Norway spruce, he finds the two lateral carpellary leaves distinctly indicated and more or less separated and developed. In more evolved cases an anterior and then a posterior bract make their appearance; these, Professor Eichler had taken for a third and fourth lobe of his ligula. It must be stated here that normally the posterior bract is the third and the anterior the fourth in order. Celakovsky comes to

the conclusion that, at least in *Abietineæ*, Eichler's theory (that the carpellary scale is a mere emergence or ligule of the bract) is quite wrong, and that Mohl's view (1871)*—that the carpellary scale of these plants consists of the two connate lowest leaves of an axillary, otherwise undeveloped, bud connate at their upper edge and producing the ovules on their back,—is amply vindicated by all known morphological facts and is antagonistic to none of them.

He further concedes that the same explanation may possibly be the true one for all conifers, and that all morphologists who have treated this question thus far, have, whatever their views, assumed a conformity in this respect in all the tribes of conifers, and a complete homology of their female organs. But he thinks that this is not necessarily so, and that Sachs' and Eichler's emergence- or ligular theory may be true as to *Araucarieæ*, and that thus the cone of these plants is really and truly a single flower. In regard to *Taxodineæ* and *Cupressineæ* he is convinced that an inner fruit scale really exists, completely adnate to the bract and soon outgrowing it, but he does not venture to pronounce on its nature, because he thus far has no ocular demonstration of it through any anamorphosis.† Professor Celakovsky concludes that the arillus of *Taxaceæ* corresponds with the ligula of *Araucarieæ*. He speaks of the *terminal* position of the ovule in this tribe as of very little morphological importance, being really a lateral ovule pushed to the top of an axis.‡

It will be of interest to those who have been misled by contrary statements, to learn that O. Heer, the celebrated phyto-paleontologist, has shown that geologically *Abietineæ* and *Taxodineæ* are the oldest conifers now known, appearing already in the Carboniferous period, while *Araucarieæ* come up much later in the Trias and Jurassic formations. But relative geological age of the different tribes of plants is of much less importance for the appreciation of their degree of development and their position in the system than some suppose. Thus the *Cycadeæ*, the Phænogams

* It appears now that A. Braun has expressed the same view as early as 1842 in the French *Congrès scientifique* at Strasburg, in the report of whose proceedings it is published. He often threw out such hints from the rich treasures of his investigations, but with characteristic modesty he gave them to science without urging them or claiming scientific property or priority in them.

† The writer of this is in possession of a proliferous cone of *Sequoia gigantea* which seems to prove, not only that the fruit scale in this species (and consequently in the whole tribe) is homologous with that of *Abietineæ*, in so far as it consists of leaves of an axillary shoot, yet that these leaves are not a single pair, but, as A. Braun has long ago suggested, in regard to *Cupressineæ*, that there is a number of leaves, laterally coördinate and connate, bearing a number of ovules on their back.

‡ It might be well to draw attention to the singular fact, that in the allied gymnospermous family of *Gnetaceæ*, the female flower (for such it is now assumed to be, the outer integument or utricle being considered as a two-leaved carpel) is always referred to as "terminal," whether single, double or triple, while a terminal organ can not be otherwise than single. The fact is that the female flowers are here axillary in the axils of one or more of the uppermost bracts, and, if single, are pushed to the top of the shoot.

most closely allied to the vascular cryptogams, are, as Professor Heer states, very uncertain in the Carboniferous, and make their decided appearance first in the Permian rocks; therefore much later than the higher developed conifers. G. E.

10. *Report by* S. I. Smith *on the Crustacea*, Part I, Decapoda. One of the Reports on the results of Dredging under the supervision of A. Agassiz, on the east coast of the United States, during the summer of 1880, by the U. S. Coast Survey Steamer "Blake." 108 pp. 8vo, with 16 plates. Cambridge, June, 1882.—This report forms No. 1, vol. x, of the Bulletin of the Museum of Comparative Zoology. Among the new species described in this excellent paper, there are a Lithodes, *L. Agassizii*, and a remarkable species of the family Eryontidæ, *Pentacheles sculptus*, besides others of much interest. Four new genera of Macrurans are made out, *Rhachocaris* of the Crangonidæ, *Meningodora* and *Eumiersia* of the Pandalinæ, and *Amalopenæus* of the Penæidæ. The plates have the perfection which comes from accurate drawings copied by photolithography.

11. *Fragments of the coarser anatomy of Diurnal Lepidoptera*, by Samuel H. Scudder. 84 pp. 12mo. 1882. Reprinted from volume iii of Psyche.—The anatomical notes contained in this little volume are on the larves and pupæ of *Danais Plexippus*, *Aglais Urticæ* and *Hamadryas Io*, and the larves of *Polygonia C. album*, *Callophrys Rubi*, *Eurymus Philodice*, *Euphœades Troilus* and *Epargyreus Tityrus*. The author speaks of the very few articles which have thus far appeared on the internal anatomy of Lepidoptera, and observes that the accounts here contained of his dissections of caterpillars and chrysalids are published "more in the hope of calling attention to the need of work of this kind than of directly contributing to general statements deducible from the observations."

12. *Memoirs of the Boston Natural History Society.*—The third volume of the quarto Memoirs of this Society thus far published, contain the following papers: on *Distomum crassicolle*, by C. S. Minot, 20 pp., with one plate, 1878; Early Types of Insects, by S. H. Scudder, 9 pp.; Palæozoic Cockroaches, by S. H. Scudder, 112 pp., with five plates; New Hydroids from Chesapeake Bay, by S. F. Clarke, 8 pp., 8vo, with three plates, January, 1882; *Archypolypoda*, a subordinate type of spined myriapods from the Carboniferous Formation by S. H. Scudder, 40 pp., with four plates, May, 1882.

III. Miscellaneous Scientific Intelligence.

1. *Berliner Astronomisches Jahrbuch für* 1884 *mit Ephemeriden der Planeten* (1)–(220) *für* 1882.—This the 109th volume of the series is prepared, as for several years past, under the direction of Dr. Tietjen. The ephemerides of the small planets form as usual the distinctive feature.

In the Jahrbuch for 1883 there was a great increase in the number of stars of which the apparent or mean places were given. The mean places are now given for 622 stars, and the apparent places of 450 of these at least as often as each ten days. The preparation of the large catalogue of the *Astronomische Gesellschaft* makes desirable this increase in the number of the fundamental stars, whose places are fully given.

In the Appendix Dr. Auwers compares the places of the stars given in the Jahrbuch with those in the Am. Ephemeris, the Nautical Almanac, and the Connaissance des Temps, all for the epoch 1883·0. The numbers in the several almanacs are as follows:

	Total.	B. J.	A. E.	N. A.	C. T.	Common to all.
Ephemeris stars,	599	450	208	197	309	111
Total stars given,	791	622	383	197	309	133
South of −32 Dec.,	51	---	44	15	18	---

The right ascensions and declinations of the whole 791 stars are compared individually, and both the systematic and irregular small differences are shown between the Jahrbuch and the other three Ephemerides. H. A. N.

2. *Transit of Venus.*—The three missions designated for observation of the Venus transit in Patagonia left on the 20th ult. in the Messageries steamer from Bordeaux, for Buenos Ayres. The arrangement is as follows:—*Rio Negro* (41° S.), M. Perrotin, director of Nice Observatory, accompanied by Lieutenants Tessier and Delacroix, and M. Guénaire, photographer to the Observatory; *Chubut* (43° S.), M. Hatt, hydrographic engineer, assisted by Lieut. Leygue and M. Mion, engineer; *Santa Cruz* (50° S.), Capt. Fleuriais, assisted by Lieutenants Le Pord and de Royer de Saint Julien, and M. Lebrun, naturalist. Arrived at Monte Video, the first two missions will probably embark in the advice boat *La Bourdonnais*, the third in the advice boat *Le Volage*. In the course of observations, detachments from the *Volage* will try to ascend the Rio Santa-Cruz at least to the point reached by Darwin in the Beagle expedition. The Chili mission, composed of Lieut. de Bernardière, assisted by Lieut. Barnaud and Ensign Favereau, embarked on the 15th ult. in an English steamer going by the Straits of Magellan.—*Nature*, Aug. 3.

From the United States, a party goes to *Santa Cruz*, Patagonia, in charge of S. W. Very, U. S. Navy, with O. B. Wheeler, assistant astronomer, Wm. Bell, photographer, and Irvin Stanley, assistant photographer.

3. *Report upon Experiments and Investigations to develop a System of Submarine Mines for defending the Harbors of the United States*—submitted to the Board of Engineers by Lieut.-Col. Henry L. Abbott, Corps of Engineers. 444 pp. 4to, with 27 plates. Washington, 1881. (Professional papers of the Corps of Engineers, U. S. A., No. 23.)—This valuable volume contains a portion of the results of a long series of experiments and investigations carried on under the charge of General Abbott since 1869, and bearing upon the general subject of submarine

mining. The topics discussed in the three chapters of the work now made public are: sub-aqueous explosions, electrical fuses, and modes of ignition. The remaining chapters of the complete report will treat of kindred topics, relating to submarine mines, torpedo cables, fish torpedoes, and so on; being of a confidential nature they will be printed only for the use of the School of Submarine Mining at Willets Point.

Chapter I, having the general head of Sub-aqueous Explosions, contains a description of the apparatus used for the measurement of the force of the explosion; the physical phenomena observed; a mathematical analysis giving an expression for the available kinetic energy developed by explosions of various kinds for the unit of surface exposed; and a discussion of the various kinds of explosive mixtures and compounds with which experiments were made. In chapter II, the subject of electrical fuses is exhaustively treated of; the fuses are divided into three classes: the low tension fuses used with powerful electrical currents of low potential where the effect is accomplished by the heating of a very fine wire, through which the current is passed; the "high tension" fuses used with electricity of high potential, the sensitive priming being ignited by a spark which jumps across a break in the metallic circuit; and finally the fuses of "medium tension" specially designed for use with magneto-electric machines where the electricity generated has a higher potential than that of the voltaic current but less than that of the frictional machine; in the last case also the ignition is accomplished by the passage of a spark at a break in the circuit. The fuses of the second and third classes differ from each other in the chemical composition and electrical resistance of the priming. In Chapter III, the various forms of igniting apparatus are described; these are, the frictional apparatus of various types with a generator of frictional electricity and a condenser; the voltaic induction apparatus involving the familiar principles of the induction coil; the many kinds of magneto-electric and dynamo-electric machines; and finally, the voltaic batteries. Appendices A, B, C, contain details of experiments made with the rings, crate, and iron target.

This general statement as to the contents of the volume will give some idea of its scope. The experiments and investigations of General Abbott have been carried on with so much judgment and energy, and the results are here discussed with so great thoroughness, that the importance of the volume can hardly be overestimated; it is of value not only in its bearing upon harbor defenses in case of war, but also to all engaged in harbor improvements, rock blasting and other similar work. The frontispiece is a heliotype reproduction of one of a series of six instantaneous photographs taken during the destruction of a schooner blown up at Willets Point by the simultaneous explosion of two torpedoes, containing each 50 pounds of mortar powder, suspended 10 feet apart and 3 feet below her bottom amidships.

This picture was taken one-tenth of a second after the explosion, and shows the bow and stern plunged in the water and the middle of the vessel raised about 16 feet; the masts were still vertical and the jet of water had reached a height of about 70 feet. Another picture, taken after 1·5 seconds, showed a water column 160 feet high; and a third, 2·3 seconds after the explosion, showed the jet at its maximum height of 180 feet, the air being full of fragments not yet descending. At the end of 4·3 seconds all evidences of violent action were gone.

4. *Professional papers of the Signal Service.*—The U. S. Signal Service has begun the issue of what promises to be a most valuable series of papers under the above title. The first number is by Professor Abbe and consists of the Signal Service Reports on the Total Solar Eclipse of July, 1878. The second is a series of twelve maps of the monthly isothermal lines deduced from the observations of the years 1871–80, by Lieutenant A. W. Greeley. The third is a chronological list of Auroras observed from 1870–1879, compiled by Lieutenant A. W. Greeley. The fifth is on the construction and maintenance of time balls, and contains ten or twelve letters of persons who have had special experience in managing these time signals. The sixth paper is by Mr. H. A. Hazen on the reduction of air pressure to the sea level at elevated stations west of the Mississippi River.

5. *Celebrated American Caverns, especially Mammoth, Wyandot and Luray, together with historical, scientific and descriptive notices of caves and grottoes in other lands*; by HORACE C. HOVEY. 228 pp. 8vo, with maps and illustrations. Cincinnati. 1882. (Robert Clarke & Co.)—The author of this volume is an enthusiastic explorer of caverns. He has spent much time in the study and enjoyment of the scenes they afford, the discovery of new passages, and the examination of the various objects of interest by the way; and his cave-wanderings have extended to numerous caverns besides those mentioned in the title. Moreover, in the preparation of his work he has gathered material from a wide range of literary and scientific accounts of caverns, cavern products and cavern inhabitants. His volume, therefore, while popular in style, and dealing much in the marvelous, and in scenic descriptions manifesting his intense appreciation of his subject, has also a scientific importance. The maps of the underground passages of the Mammoth Cave and others are of special interest. The complicated reticulations through so great areas present a difficult problem to the geologist, for which he has now only the most general explanations—such as are contained in a reference to joints; bedding, harder and softer or impurer layers alternating; erosion by corroding carbonated waters, by direct abrasion, and to some extent through nitrification and the products of pyrites-decomposition. The facts of scientific interest are partly given in Mr. Hovey's paper in volume xvi (1878) of this Journal. Luray cavern in Luray Valley, near the village of Luray, Page County, Virginia, was little explored or known before 1878. It is much

smaller than the Wyandot, but is more remarkable for its stalactitic hangings and the consequent beauty of its passages and chambers.

The illustrations of the volume in general present well, and not extravagantly, some of the scenes of the caverns.

6. *Scientific Survey connected with the Northern Pacific railroad.*—The directors of the northern Pacific railroad and of the Oregon railway and Navigation Company selected, nearly a year ago, Professor Raphael Pumpelly, as director of a survey of the lands in the vicinity of the railroads crossing the continent westward, entitled the "Northern Trans-continental Survey." The objects in view are the discovery and testing of deposits of coal or ores or other useful materials, the examination of timber lands, the investigation of soils, and the study of whatever may affect the resources and value of the region. Professor Pumpelly's head-quarters at the present time are Helena, Montana. He has associated with him Professor E. W. Hilgard in the department of soils; Dr. H. A. Hazen of Harvard, entomologist, with S. Henshaw as assistant; Professor A. D. Wilson, chief topographer, with L. Nell and R. U. Good, assistants; Professor Sargent of Harvard, department of forestry; Professor W. M. Canby, department of forest plants; and B. Wilson, G. H. Eldridge and B. T. Putnam as geologists. The laboratory of the survey is at Newport, Rhode Island, where Dr. F. A. Gooch is chief chemist, and W. T. Richmond assistant. A communication to the New York Sun, from which the above facts are taken, states that "by the time the northern route to the Pacific is open, on the 1st of July, 1883, it is probable that the results of the survey will in part be given to the public.

Mémoire sur la Géologie de la partie Sud-est de la Pennsylvania. Thesis présentées a la Faculté des Sciences de Lille. Université de France, pour obtenir le grade de Docteur ès-sciences naturelles, par PERSIFOR FRAZER, A.M. 176 pp. roy. 8vo, with plates and maps. Lille. 1882.

The Elements of Forestry, particularly adapted to the wants and conditions of the United States, by Franklin B. Hough, Ph.D. 382 pp. 8vo. Cincinnati. 1882. (Robert Clarke & Co.)

Forest Trees of California, by A. Kellogg, M.D. 148 pp. 8vo. State Mining Bureau, Henry G. Hanks, State Mineralogist, State Office, Sacramento. 1882. A popular treatise.

DARWIN MEMORIAL.*

Large additions are due from America to the Darwin Memorial Fund. All naturalists, and all thinkers with few exceptions, know that they have been greatly enriched in knowledge, and raised to a higher level of thought and study, as a consequence of Darwin's labors in science. Feelings of gratitude are hence natural; and the memorial affords an opportunity for their substantial expression. There is special satisfaction in honoring one who sought only truth—not honor—in his life-work. J. D. D.

* Page 159 of the last number of this Journal.

OBITUARY.

General Gouverneur Kemble Warren.—General Warren died at Newport, Rhode Island, on the 8th of August, in his sixty-fourth year. On graduating at the West Point Military Academy in 1846, he was assigned to the Corps of Topographical Engineers. With the exception of two years—from 1859 to 1861—as Professor of Mathematics at West Point, and active service in the war from 1861 to April, 1865, his labors were chiefly in connection with the department of United States Engineers, and they comprise many of the most important and responsible works carried forward by the department. The surveys of the Mississippi and other rivers with reference to improvement of navigation, construction of breakwaters, bridging, and reclamation of alluvial lands, became under him a source of important geological discussions on the formation of sand bars, the relations of deposition to the flow of meeting streams, the changing courses of rivers, and other related subjects. In the study of the Upper Mississippi, the surveys were extended, in 1876, along the chief northern tributary, the Minnesota; and the observations made were the basis of a Report to the Chief of Engineers the following year, and more fully later, on the former discharge of Lake Winnipeg through the Minnesota and Mississippi valleys. General Warren found in the facts evidence of a great change of level in the land over the interior of North America. The paper is one of the most important contributions to geology and physical geography that has appeared, and will have far-reaching effects on the science.

General Warren received the commission of Brevet Major-General United States Army, in view of his gallant and meritorious services in the war.

George P. Marsh, long American Minister to Italy, eminent as a linguist, and an able statesman, author of "The Origin and History of the English Language," "Man and Nature," "The Earth as Modified by Human Action," and other works, died in July at Vallambrosa, near Florence, at the age of eighty-one. He was born at Woodstock, Vermont, on the 27th of March, 1801, and graduated at Dartmouth College in 1820.

Professor M. F. Balfour, author of a "Treatise on Embryology" and other works, the "ablest member" of the School of Science of Cambridge, England, lost his life in July, on Mont Blanc. As the Athenæum of July 29 states, though only thirty-one years of age, Mr. Balfour had taken the first place among English men of science.

Edward Desor.—A full list, by Dr. Geinitz, of the publications of Mr. Desor, whose death was announced on page 422 of the last volume of this Journal, is contained in Part 4 of Isis (Dresden) for 1882. The first appeared in 1840, and related to the glaciers of Monte Rosa and Monte Cervino: the last, in 1881, on the Fossil Man of Nice.

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XXV.—*Notes on Physiological Optics.* No. 5. *Vision by the Light of the Electric Spark;* by W. LECONTE STEVENS.

IN previous papers the phenomena of optic divergence have been discussed, and also various peculiarities of vision under controllable physiological conditions. Among them was stereoscopy from a pair of perfectly similar figures, produced by so varying these in relative position that the retinal images of them were dissimilar. A geometric explanation of this was given, in which it was assumed that freedom of motion was allowed the eyes; but with the reservation that such motion is not necessary in obtaining the perception of binocular relief from stereographs constructed in the ordinary way, and that it was probably necessary only to the completeness of the perception in the present case when the dissimilarity of retinal images was very considerable.

In continuing this investigation the electric spark has been employed as a means of illuminating the pair of pictures. These were viewed with the aid of a reflecting stereoscope, already described as a device to indicate the value of the optic angle, positive or negative, that results from any possible relation between the visual lines of a pair of eyes. Vision may thus be made normal or abnormal at will. The use of the spark in the study of binocular vision is no novelty; but it seems not to have been employed hitherto in studying abnormal vision with the visual lines divergent, or the peculiar mode of stereoscopy recently devised.

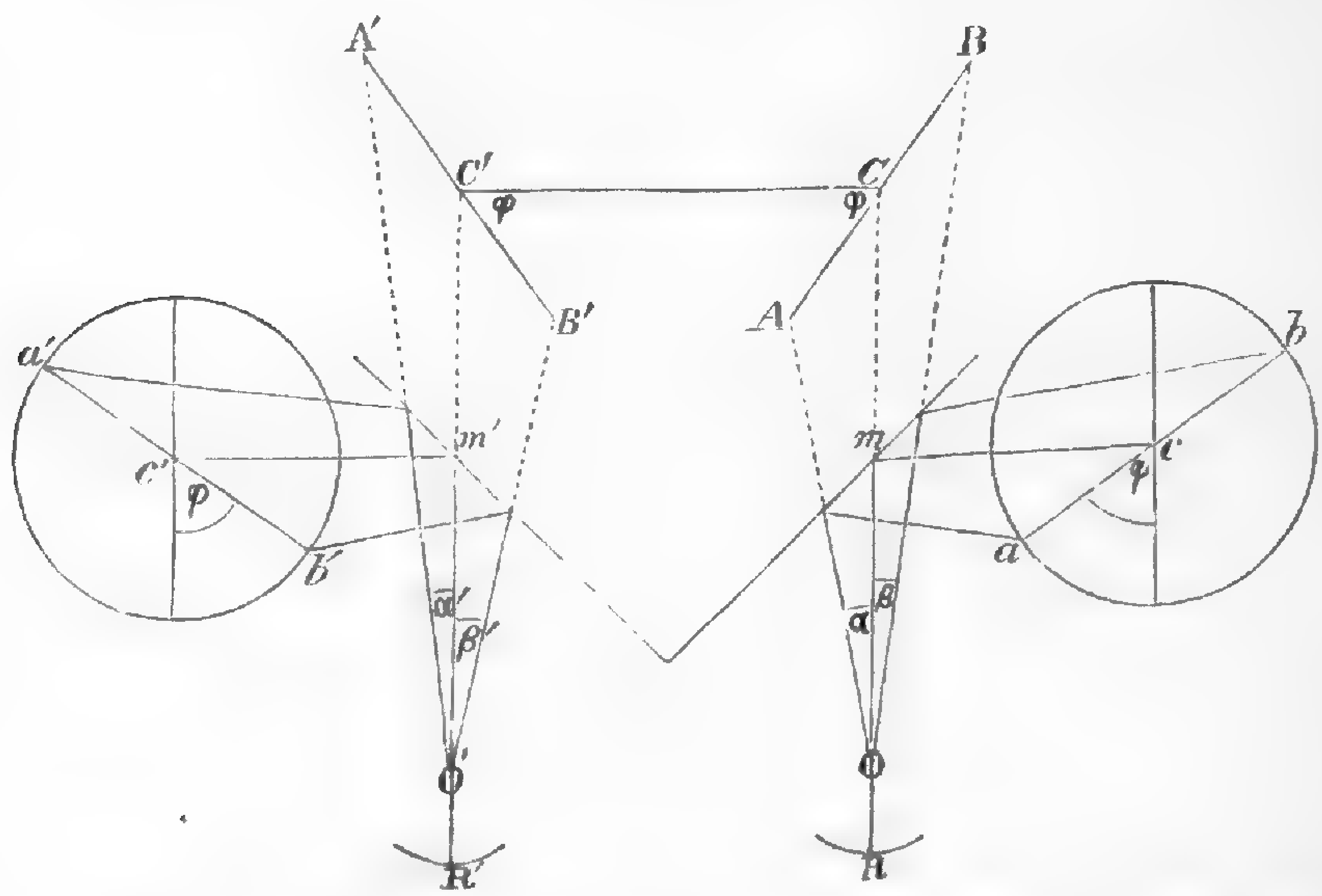
The apparatus employed was a large induction coil, belonging to the physical cabinet of Columbia College, the use of which was kindly granted by Professor O. N. Rood. In the secondary circuit a Leyden jar was interposed, and by means of a pair of lenses the light was separately converged upon each of the pair of pictures, strongly illuminating them momentarily in the dark room. Each picture was kept upon the pivoted arm of the stereoscope at a fixed distance from the oblique mirror that reflected its light into the eye of the observer. The sum of the incident and reflected rays from each to the receiving eye was, as nearly as possible, 25 cm.

The stereograph first employed was one of the moon, the same one formerly used with this instrument in vision by continuous light. By varying the arrangement of the cards the visual effect of binocular combination of images could be made that of either a convex surface, or concave surface, or an indistinct but flat surface. The observer placed himself with closed eyes in proper position before the stereoscope while the manipulator of the apparatus arranged the cards. He was then requested to interpret the combined retinal image produced by illuminating the cards with a single spark, not knowing previously whether to expect convexity, concavity, or flatness in the combined picture, and the interval of illumination being too brief for any possible play of the eyes.

In conducting these experiments I was so fortunate as to secure the coöperation of Mr. W. W. Share, assistant Professor of Physics in Columbia College, who soon acquired more than usual skill in the control of his eyes. Each of us acted successively as observer and as manipulator of the apparatus, the work being distributed through a number of days for the purpose of avoiding fatigue at any one sitting. When the relation between the visual lines was such as to imply no unusual muscular strain, each of us found it possible to interpret the binocular retinal image correctly by the light of a single spark. Many other stereographs were substituted in succession for that of the moon, and with similar results. Some of these consisted of heavy black lines on a white ground, others of white lines on a black ground; in some cases one picture belonged to one of these classes and its mate to the other. At the suggestion of Professor Rood a pair were constructed, one of which consisted of green lines on a red ground, the other of red lines on a green ground. In this case of complementary colors it was a little more difficult to attain a perfectly clear perception by a single spark, but when there was any uncertainty another spark after an interval of a second of time, was usually sufficient to resolve the doubt. These pictures were arranged to give stereoscopic relief, but the nature of this, whether direct or inverse, was what the observer had to determine.

Upon each arm of the stereoscope was now placed a vertical frame, pivoted centrally over a divided horizontal circle (fig. 1), so that the plane of the card that was fitted into it could be made to assume any desired angle (φ) with the direction of the arm. A pair of cards on which were similar series of concentric circles were then introduced, the arms being arranged for parallel vision, and the frames directly across them. The binocular resultant was of course a circular flat plane vertically across the combined line of sight. The manipulator then turned each frame on its pivot through an angle, whose nature, whether positive or negative, was unknown to the observer, and then passed a spark. For values of this angle less than 30° or 40°, the first spark was usually sufficient to enable the observer to determine whether the binocular resultant, due to opposite obliquity of projection upon the two concave retinas, was itself convex or concave. This was tried successively and independently by Professor Rood, Mr. Share, and the writer, with uniform results, the only difficulty consisting in the previous attainment of proper adjustment for the position of the head, and in adaptation of the ciliary muscles. For larger values of the angle between card and visual line, the degree of dissimilarity between the two retinal images sometimes caused a little confusion, but a few sparks, not in quick succession, were enough to clear all doubts. The diameter of the largest

1.



circle being 8 cm. and the sum of the incident and reflected rays from its center to the eye of the observer being 25 cm., it becomes possible to calculate the maximum difference horizontally between the two retinal images. Let m and m' (fig. 1) be the points of incidence for rays from the centers c and c', of the circles whose horizontal diameters are ab and $a'b'$, the cards having been revolved each on a vertical axis through the angle φ. Then to the eyes whose nodal points are o and o', the pictures appear by reflection at A B and A′ B′, the visual lines oc and $o'c'$ being parallel and perpendicular to cc'. But if directed to A and A′ or B and B′, the visual lines become convergent to an extent measured by the difference of the angles α and α' or β and β'. The values of α and α' can be expressed in terms of the variable φ and the known quantities Ac and co, and we are thus enabled to find for what value of φ the difference, $\alpha-\alpha'$, becomes a maximum. For the values just assigned to Ac and oc, this condition is attained when $\varphi=52°\ 25'$. By ordinary methods in trigonometry two sides and the included angle of each triangle being known, α and α' are then determined, and their difference found, which in the present case becomes 1° 25′ 37″. Assuming an average value, 15·75 mm. for the distance from nodal point, o, to retina, R, the linear horizontal displacement on the retina corresponding to 1° 25′ 37″ is a trifle over ·39 mm., or more than 80 times the diameter corresponding to what has been estimated to be the *minimum visibile.* For angles even smaller than 52° 25′ both Mr. Share and myself found it possible to detect double images at the margins of the binocular picture; this, however, did not prevent the perception of the particular kind of relief, whether concavity or convexity, which the arrangement necessitated. In trying the experiment by continuous light many persons have at first been confused, but a few moments of play of the eyes were enough to produce clear perceptions, and the form of the binocular image thenceforth remained distinct even when the gaze was kept as nearly rigid as possible. Unless there has been special training in binocular vision the duplication of these marginal images is rarely perceived at all.

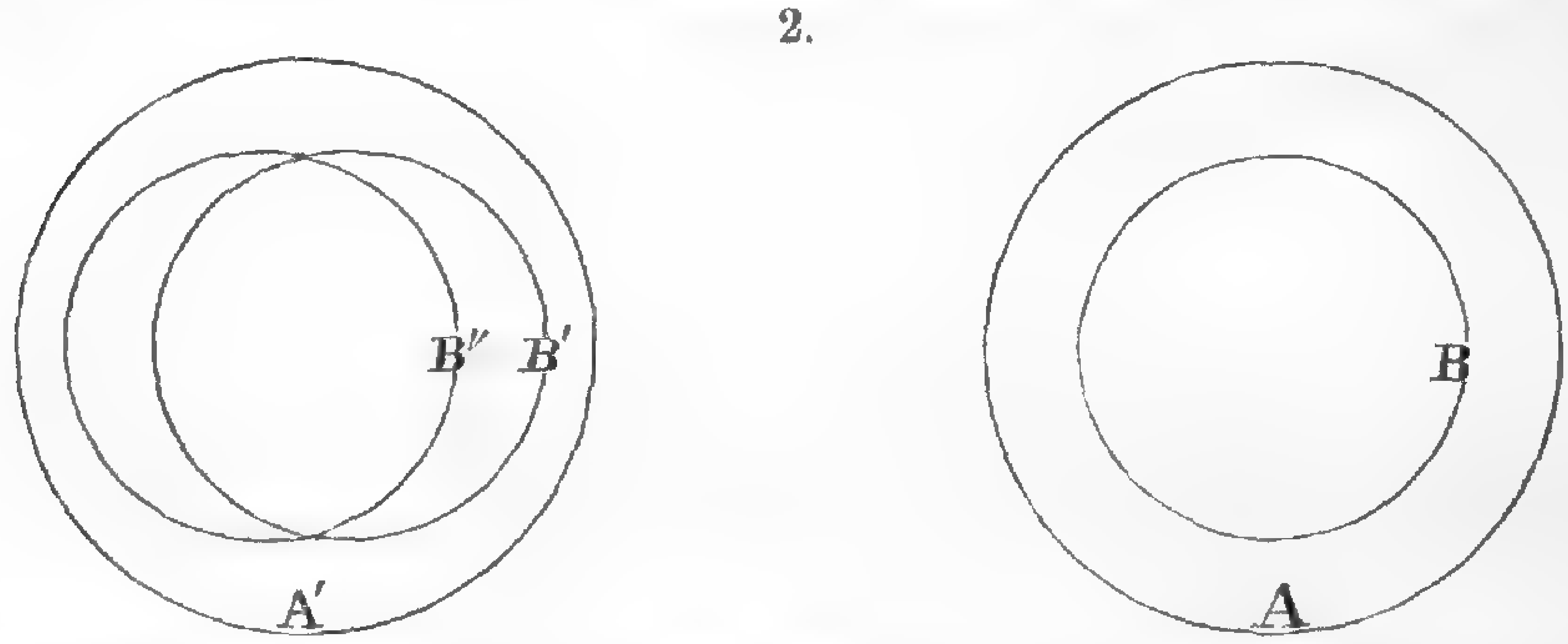
On the other hand, to find the smallest retinal displacement through which change of form in the binocular image can be perceived in this manner, I have substituted series of circles in which the maximum diameter was only 4 cm., keeping the distance unchanged. The plane binocular image became noticeably concave for a rotation of each through only 1°. By calculation the angular retinal displacement is here found to be only 47″, an amount so small that under the most favorable circumstances no double image could be perceived with the acutest vision thus far tested. These experiments therefore tend to confirm the conclusion reached by Helmholtz,* in opposition to many other physiologists, that neither play of the eyes nor the perception of double images is indispensable to the attainment of binocular relief, however important these elements may sometimes be in confirming our visual judgments, whether con-

* Optique Physiologique, p. 1007, *et seq.*

scious or unconscious. They are exceedingly convenient for the purpose of explaining binocular vision, but so limited an explanation can never cover all the facts.

In 1864 Professor C. F. Himes described a pair of pictures which he had devised to illustrate the variation in apparent size of the moon when viewed successively at the horizon and the zenith. Within two equal circles, A and A′, fig. 2, are

2.



placed smaller circles, B, B′ and B″, the latter equal to each other. A and B are concentric, while the centers of B′ and B″ are on opposite sides of that of A′ and aligned with that of A. On combining the two pictures binocularly, A and A′ at once unite; B and B′ when united form a small circle whose plane is nearer, B and B″ one whose plane is farther than that of A and A′, assuming the union to be by diminished convergence of visual lines. The circle BB″ appears as much larger than BB′ as its distance is judged to be greater, despite the fact that the small circles are all of equal size. On the theory of double images, when BB′ is regarded, the circle B″ remains uncombined while AA′ should be seen double; the comparison of the nearer and more remote combinations being attained by regarding them successively. But in fact the appearance of the three circles, each at its proper distance, is instantaneous and simultaneous, not successive. If the observer's eyes are well trained the circle AA′ may be detected as double while the others are seen single. If the gaze be very rigidly fixed upon the center of the combined circle AA′, the others are separated, three small circles are seen, but all apparent variation in distance is lost. This stereograph has been examined under the light of the electric spark by both Mr. Share and myself, the results being entirely analogous to those obtained with continuous light. Each circle was appropriately marked and the cards adjusted by the manipulator in such manner that the observer could have no previous knowledge to aid him in determining which combined circle ought to appear nearest. A single spark was usually sufficient to show each in its appropriate place. The circle B has the same effect on B′ and B″ as if it were simultaneously combined with both of them. This apparent combination of one line with two other lines at the same time was noticed by Professor W. B. Rogers in 1856 and further discussed by Helmholtz in 1867, but its bearing on the theory of binocular perspective has not received sufficient attention. It not only shows the insufficiency of the theory upheld by Brücke and Brewster, but also seems to indicate that, if there be any intuitive power of distinguishing between heteronymous and homonymous double images, this power must be understood to extend to cases in which a single line belongs to both kinds of double image at the same time. If we admit intuition at all in this connection, we must further grant that a distinction can thus be made instantly between these opposite kinds of images, even when they are so minute that the unaided eyes cannot separate them through an act of conscious judgment; and that this is habitually done by thousands who throughout life fail to suspect even the existence of such duplication in any part of the field of view. If there is any perception of double images, even when the interval between the components is wide, it is by an act of special attention. Many of our judgments, not only in vision but in the performance of other bodily functions, are instantaneous and unconscious; but probably we shall never be able to put an exact dividing line between those due to the experience of the individual and those that spring from tendencies transmitted by the race. We learn to see, just as we learn to walk or talk in infancy, by oft-repeated efforts which form a succession of experiences. If passive seeing be a result of mere inheritance, then active looking is superadded as a result of training. The empirical theory, if sufficient to explain all known facts of vision, can leave no room for intuition, and its resources must be exhausted before any resort to intuition can be deemed necessary.

To test the illusions of abnormal vision by the light of the electric spark, a series of experiments has been made in which the optic angle was varied from 3° of divergence to 50° of convergence of visual lines. The graduated reflecting stereoscope was employed, the mode of experiment being the same as that described in a former paper, the manipulator of the apparatus keeping the observer's record of estimates. Mr. Share and myself relieved each other by turns, taking care to avoid fatigue of the muscles of the eyes, each remaining ignorant of his own record until the entire series of experiments was completed. After the arms of the stereoscope had been arranged to necessitate a particular value of the optic angle, the observer opened his eyes, and, by the light of a slow succession of sparks, adjusted them to secure binocular vision of the stereograph of the moon, each picture of which was kept in a fixed position on the arm that carried it. The observer's judgment of the distance and diameter of the combined image was then recorded. Eight estimates for each of thirteen values of the optic angle were made in irregular succession by each observer, the experiments being distributed through two weeks. On examination of the results attained, they were found not to differ materially from those published in a former paper by myself, as secured with continuous light. The limits of error were much wider, as might be expected, showing that any single judgment under such abnormal conditions has very little value; but that, even when there is little opportunity for play of the eyes, the effect of muscular strain on the internal rectus and ciliary muscles is to modify the unconscious interpretation of the retinal image, making the picture look much smaller and nearer but not necessarily at the intersection of visual lines. Mr. Share's judgments of distance and size were almost uniformly a little less than my own. In cases of optic divergence it was more difficult to secure the proper adjustment of visual lines than in those of convergence. Distinct vision was not attainable for divergence of more than $-3°$, though with slight indistinctness I found it possible to attain the perception of binocular relief for values as high as $-7°$. As a limit, therefore, $-3°$ was selected, and this was attained by both observers, through voluntary control of the oculo-motor muscles. Since divergence of visual lines is never necessary in ordinary vision, such adaptation of the eyes, if these be normal and not specially trained, requires usually two external points of fixation, and time becomes an element of more importance than when the coördination of muscular actions is such as habit has made easy.

Art. XXVI.—*On crystals of Monazite from Alexander County, North Carolina;* by Edward S. Dana.

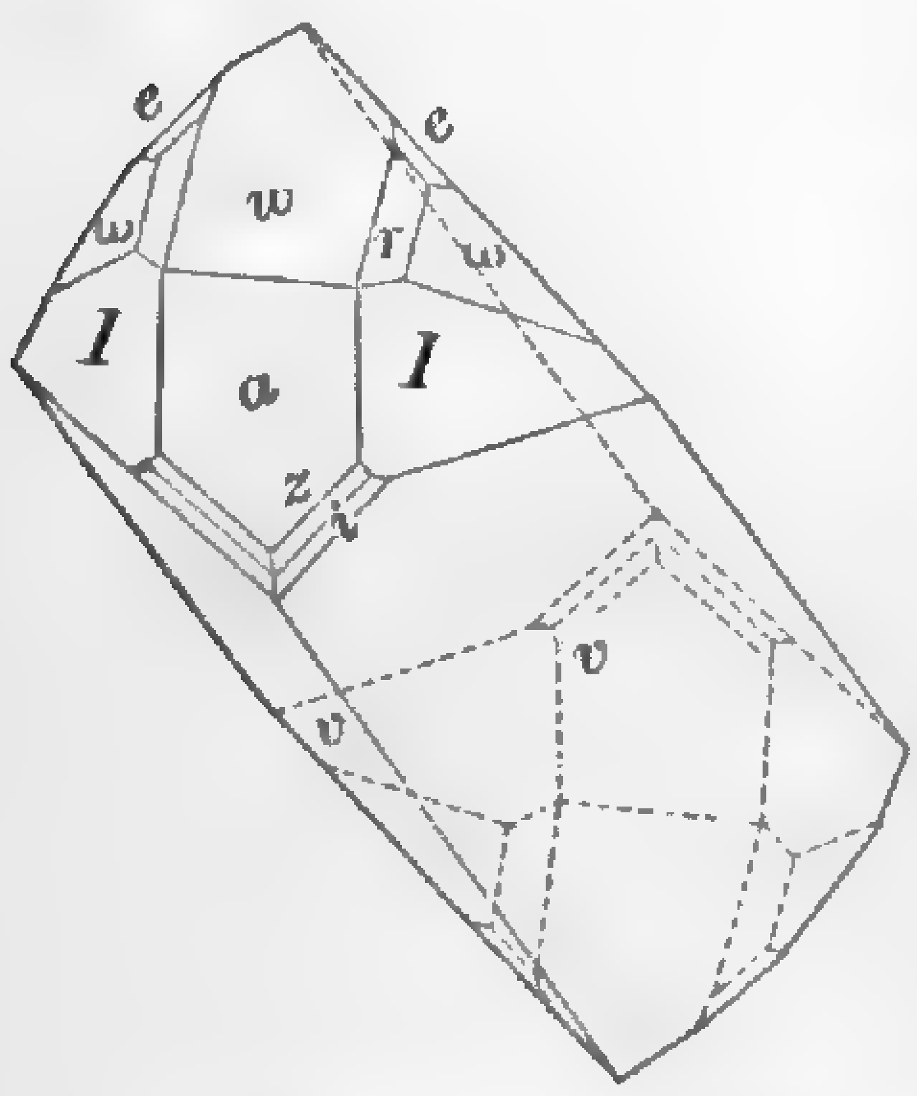
Among the results of the mineralogical investigations in North Carolina, by Mr. W. E. Hidden, one of the most interesting has been the discovery of the rare mineral monazite at a large number of localities. Mr. Hidden remarks* that at Milholland's Mill, Alexander County, he has found, in a vein in a garnetiferous mica schist, a large number of monazite crystals, together with fine geniculated crystals of rutile, quartz crystals, pseudomorphs of limonite after siderite, and muscovite, the last species making up the greater part of the vein. The monazite was obtained by the concentration of the loose material of the vein. Most of the crystals were very minute, of

* This Journal, III, xxii, pp. 21, 22, July, 1881.

several hundred perhaps only half a dozen exceeded $\frac{1}{20}$ inch in diameter; rarely crystals of $\frac{1}{4}$ inch in length were found. The crystals were highly modified, very brilliant in luster, of a rich topaz-yellow color, and perfectly transparent.

It is further stated by Mr. Hidden that he has found large crystals of monazite *in situ* in mica schist at the Deake mica mine in Mitchell County; one of these was $1\frac{1}{2}$ inches in length and $\frac{3}{4}$ inch in width. The same mineral occurs in white orthoclase at the Ray mica mine on Hurricane Mountain in Yancey County. He has also found it very commonly in the auriferous gravels of McDowel, Rutherford, Burke and Polk Counties. It is most abundant at J. C. Mill's gold mine in the Brindletown District, Burke County, "fifty pounds of gravel washings from this mine afforded sixty per cent of monazite." The crystals from this last locality have been analyzed by Mr. S. L. Penfield (see p. 251, in this number.)

A few of the best crystals of the monazite from Milholland's Mill, Alexander County, have been placed in the hands of the writer by Mr. Hidden; and one of these, much superior in luster to the others, has given an opportunity for a tolerably exact determination of the crystalline form. The crystals are generally prismatic (see figure) in habit through the elongation of the planes v (+1), and in this respect they are similar to a variety of the Russian mineral figured and described by von Kokscharof,* as also to crystals from Canton Tessin, Switzerland, described by Seligmann.†



The single crystal, which was subjected to careful measurement, was very brilliant in luster, and most of the planes, with the exception of those lettered v (+1) gave good reflections. The following planes were observed, all of which are common on ordinary monazite:

a	*i-i*	(100)	*v*	+1	($\bar{1}$11)
I	*I*	(110)	*ω*	−2-2	(121)
w	−1-*i*	(101)	*i*	+2-2	($\bar{2}$11)
e	1-*i*	(011)	*z*	+3-3	($\bar{3}$11)
r	−1	(111)			

In addition to the above, three other planes were observed, viz: ξ, replacing the edge ω / v (121, $\bar{1}$11); ψ, replacing the edge ω / v (121, 11$\bar{1}$); and φ replacing the edge r / e (111, 011). The measured angles ($\xi \wedge \omega = 44°$, $\psi \wedge \omega = 56°$, $\varphi \wedge e = 4\frac{1}{2}°$) were only rough approximations, so that no indices could be given to the planes with any degree of certainty.

* Min. Russland, iv, 17.　　† Zeitsch. Kryst, vi, 231, 1882.

The following fundamental angles (supplement) were measured with a Fuess goniometer provided with two telescopes, viz:

$a \wedge w$	$100 \wedge 101$	$=39°\ 12'\ 30''$
$I \wedge I$	$110 \wedge 1\bar{1}0$	$=86°\ 34'\ 20''$
$a \wedge e$	$100 \wedge 011$	$=79°\ 53'\ \ 3''$

Each of these is the mean of a considerable number of independent measurements, whose extremes varied not more than 30″ from the mean given. The axial ratio obtained from them may be regarded as reasonably exact, viz:—

$$\dot{c}\ (\text{vert.}) : \bar{b} : \breve{a} = 0{\cdot}95484 : 1{\cdot}03163 : 1.$$

$$\beta = 76°\ 20'$$

The following table contains a list of the more important angles (supplement angles) calculated from the above data, and also such measured angles as could be obtained with sufficient accuracy to make them of interest. The agreement between the measured and calculated angles is close in the cases where the planes yielding the former gave good reflections, but the planes which give the prismatic habit to the crystals (v) afforded angles on which no dependence at all could be placed.

		Measured angles.	Calculated angles.
$a \wedge c$	$100 \wedge 001$	----	76° 20′
$a \wedge I$	$100 \wedge 110$	43° 17′	43 17
	$100 \wedge 1\bar{1}0$	43 18	
$a \wedge e$	$100 \wedge 011$	79 53*	79 53
$a \wedge w$	$100 \wedge 101$	39 12½*	39 12½
$a \wedge r$	$100 \wedge 111$	47 55 approx.	48 1½
$a \wedge v$	$100 \wedge 11\bar{1}$	----	61 30½
$a \wedge \omega$	$100 \wedge 121$	59 50	59 48½
$a \wedge i$	$100 \wedge 21\bar{1}$	----	38 21
$a \wedge z$	$100 \wedge 31\bar{1}$	26 57 approx.	26 44
$I \wedge c$	$110 \wedge 001$	----	80 6
$I \wedge e$	$110 \wedge 011$	54 4	54 6
$I \wedge w$	$110 \wedge 101$	55 41½	55 40
$I \wedge r$	$110 \wedge 111$	----	33 35
$I \wedge v$	$110 \wedge 11\bar{1}$	----	40 50
$I \wedge \omega$	$110 \wedge 121$	27 25	27 25
$I \wedge i$	$110 \wedge 21\bar{1}$	----	30 42
$I \wedge I$	$110 \wedge 1\bar{1}0$	86 34*	86 34
$e \wedge e$	$011 \wedge 0\bar{1}1$	----	83 56
$r \wedge r$	$111 \wedge 1\bar{1}1$	----	60 40
$v \wedge v$	$\bar{1}11 \wedge \bar{1}\bar{1}1$	73 12	73 19
$\omega \wedge \omega$	$121 \wedge 1\bar{2}1$	99 0	98 58
$i \wedge i$	$\bar{2}11 \wedge \bar{2}\bar{1}1$	----	49 51
$z \wedge z$	$\bar{3}11 \wedge \bar{3}\bar{1}1$	----	35 35
$w \wedge e$	$101 \wedge 011$	53 38½	53 38½
$w \wedge r$	$101 \wedge 111$	30 approx.	30 20
$w \wedge \omega$	$101 \wedge 121$	49 31	49 29
	$101 \wedge 1\bar{2}1$	49 29	
$e \wedge \omega$	$011 \wedge 121$	26 39	26 41

It is a matter of some interest to compare the axial dimensions of the Alexander County monazite with those of the same mineral from other localities. The following table exhibits the relations.

	c (vert.)	*b*	*ǎ*	*β*
Alexander Co., N. C.	0·95484	1·03163	1·	76° 20′
Norwich, Mass., J. D. Dana, Syst. Min.	0·94715	1·0265	1·	76 14
Southern Ural, near R. Sanarka, N. von Kokscharof*	0·95010	1·03037	1·	76 14
Tavetsch, Switzerland (turnerite), G. vom Rath†	0·96166	1·04336	1·	77 18
Laacher See (turnerite), G. vom Rath‡	0·95425	1 03532	1·	76 32

* Min. Russl., iv, 5 et seq. † Pogg. Ann., cxix, 252, 1863.
‡ Pogg. Ann., Erg.-Bd., v, 413, 1871.

The same relation is more clearly brought out by comparing a few of the more important angles in the above cases, as also in some others.

	a ∧ *c*	*a* ∧ *w*	*a* ∧ *I*	*a* ∧ *v*	*e* ∧ *e*	*v* ∧ *v*
	100 ∧ 001	100 ∧ 101	100 ∧ 110	$\bar{1}00 \wedge \bar{1}11$	$011 \wedge 0\bar{1}0$	$\bar{1}11 \wedge \bar{1}\bar{1}1$
Alexander Co., N. C. E. S. Dana	76° 20′	39° 12½′	43° 17′	61° 30½′	83° 56′	73° 19′
Norwich, Conn., J. D. Dana, Syst. Min.	76 14	39 20	43 25	61 47	83 44	73 24
Ural, N. v. Kokscharof*	76 14	39 16	43 18½	61 40½	83 42	73 16
Tavetsch (turnerite), G. vom Rath†	77 18	39 33	43 5	60 47½	83 56	72 32
Laacher See (turnerite), G. vom Rath (l. c.)	76 32	39 19½	43 12½	61 23½	83 45	73 1
Mont Sorel (turnerite), Des Cloizeaux	----	39 20	43 12	----	83 40	73 0

* l. c. and ib., vi, 200, 387. † l. c., also Jahrb. Min., 393, 1876.

In addition it may be stated that Trechmann* has found on monazite (turnerite) from Tavetsch, *a* ∧ *I*=43° 16′, *c* ∧ *e*=84° 47′; and for the same mineral from the Binnenthal, *a* ∧ *w*=40° 6′, *e* ∧ *e*=85° 19′, *v* ∧ *v*=72° 7½′. On crystals from the Ilmen Mountains, von Jeremejef† obtained *a* ∧ *c*=76° 17′.

Art. XXVII.—*On the Occurrence and Composition of some American varieties of Monazite*; by Samuel L. Penfield.

My attention was first directed to the composition of monazite by Professor Brush, who placed in my hands a specimen of an unknown mineral collected by Mr. E. F. Sheldon at Pelton's Quarry, Portland, Conn. It was then suggested that it might prove to be microlite, because of its resemblance to the so-called altered microlite (in fact, monazite, see beyond), from Amelia County, Virginia, specimens of which had just arrived at New Haven. A short chemical examination of the Port-

* Jahrb. Min., 1876, 593.
† Verh. Min. Ges. St. Pet., II, xii, 287 (Zeitsch. Kryst., i, 398.)

land mineral proved, however, the presence of phosphoric acid, and the specimen was identified as monazite. Subsequently a complete chemical analysis was made, the results of which will be given farther on.

The mineral is of a cinnamon-brown color, of rather resinous luster, and shows one perfect cleavage. The specimen was somewhat cracked, and along the fractures showed some signs of alteration which did not, however, penetrate into the solid material. It was easy to obtain for analysis material showing none of this alteration and apparently homogeneous. The original weight of the specimen was three and one-half ounces. The specific gravity was found to be 5·20–5·25. After analyzing this specimen it seemed interesting to investigate another American monazite, and Professor E. S. Dana accordingly gave me a sample of the monazite sand obtained by Mr. W. E. Hidden* from the gold washings in the Brindletown district, Burke County, North Carolina. Almost one-half of the bulk of this sand is composed of resinous-looking monazite grains, from one-sixteenth to one-eighth of an inch in diameter, some showing numerous crystalline planes. Together with the monazite occur spinel, magnetite, garnet, brilliant crystals of zircon, a little quartz, and a few other minerals. The monazite is easily distinguished from the accompanying material, and by careful picking enough was soon obtained, apparently pure, for analysis. Care was taken to select only the larger grains and those of a uniform cinnamon-brown color. The specific gravity of the selected material amounted to 5·10. The analysis is given farther on.

About the time when the analyses of the specimens were completed, a letter was received by Professor Brush from Professor Wm. M. Fontaine, stating that specimens which had been sent up to New Haven as altered microlite, had proved by examination to be monazite.† In connection with my other analyses I thought that it would be interesting to add an analysis of this new variety. The material for analysis was from a specimen in the Yale College collection.

The material selected was perfectly pure as far as the eye could judge. The color and luster were the same as in the Portland specimen, but a little darker than that of most of the Virginia specimens which had been sent here. The analysis will be seen below; the silica and thoria were carefully deter-

* See this Journal, III, xxii, p. 22; also this number, p. 248.

† The monazite from this locality was first mentioned by König (Proc. Acad. Nat. Sci. Philad., 1882, 15), who gives an approximate analysis. Later, a complete analysis was published by F. P. Dunnington (Amer. Chem. Journ., iv, 138, 1882); he shows that excluding the ThO_2 and SiO_2 the remainder corresponds to a normal phosphate of the cerium metals, and suggest that the thorium may perhaps be present as orangite. The last-mentioned article was received by me after this article was in manuscript.

mined, the rest not being carried out in duplicate owing to want of time at my disposal.

Analyses.

1. Portland, Ct. Sp. Gr. 5·20–5·25.

	I.	II.	Mean.	Ratio.
P_2O_5	28·19	28·16	28·18	·199
Ce_2O_3	33·69	33·40	33·54 }	·188
$(La, Di)_2O_3$	28·15	28·51	28·33 }	
ThO_2	8·33	8·17	8·25	·031
SiO_2	1·57	1·77	1·67	·028
Ignition	·36	·38	·37	
	100·29	100·39	100·34	

Hence, $(Ce, La, Di)_2O_3 : P_2O_5 = 1·00 : 1·06 = 1 : 1$, and
$ThO_2 : SiO_2 = 1·00 : 0·90 = 1 : 1$

2. Burke Co., North Carolina. Sp. Gr. 5·10.

	I.	II.	III.	Mean.	Ratio.
P_2O_5	29·45	29·20	29·20	29·28	·206
Ce_2O_3	31·38	31·94	30·77	31·38 }	·190
$(La, Di)_2O_3$	30·67	30·80	31·17	30·88 }	
ThO_2	6·68	6·24	6·56	6·49	·025
SiO_2	1·40	----	----	1·40	·023
Ignition	·20	·20	----	·20	
	99·78			99·63	

Hence, $(Ce, La, Di)_2O_3 : P_2O_5 = 1·00 : 1·08 = 1 : 1$, and
$ThO_2 : SiO_2 = 1·00 : \ ·92 = 1 : 1$

3. Amelia Co., Virginia. Sp. Gr. 5·30.

	I.	II.	Mean.	Ratio
P_2O_5	26·12	----	26·12	·184
Ce_2O_3	29·89	----	29·89 }	·172
$(La, Di)_2O_3$	26·66	----	26·66 }	
ThO_2	14·07	14·39	14·23	·054
SiO_2	2·82	2·87	2·85	·048
Ignition	·67	----	·67	
	100·23		100·42	

Hence, $(Ce, La, Di)_2O_3 : P_2O_5 = 1·00 : 1·07 = 1 : 1$, and
$ThO_2 : SiO_2 = 1·00 : 0·88 = 1 : 1$

A glance at the ratios calculated for these analyses will show that in every case the ratio of $(Ce, La, Di)_2O_3 : P_2O_5 = 1 : 1$. This is the ratio required for a normal phosphate of the cerium metals, $R_2P_2O_8$. It may be added that Rammelsberg* has described and analyzed monazite, from Arendal, which contained no thoria, and agreed with this formula. It will also be seen that each analysis has afforded a certain amount of thoria and silica, and that these also are present in the ratio of 1 : 1, or that required by a normal thorium silicate. When it is considered that oxide of thorium is widely different in its

* ZS. G. Ges., xxix, 79, 1879.

chemical relations from the oxides of the cerium metals, and hence should not be present as an isomorphous replacement of them; and, moreover, that it is present in the above analyses in very different amounts, it will seem natural, from a chemical point of view, to assume that the thoria, often found in monazite, exists in the form of thorium silicate as an impurity.

A careful examination of the Portland mineral with a pocket lens revealed no signs of an impurity which could be identified as thorite, so that a more careful investigation was made. A thin section of the mineral was examined with the microscope; it showed small grains of a darker resinous substance scattered through the section, which are undoubtedly the mechanically mixed thorite. On the fragment of Virginia monazite, from which the material for analysis was obtained, a very little of a resinous-looking mineral could be seen, and a small fragment of this powdered and treated on a watch glass with hydrochloric acid gave evidence of a jelly. Further, two thin sections of this material were examined; both showed dark resinous particles scattered through the section. These were similar to those in the section of the Portland variety, but more abundant. One of these sections was moistened with hydrochloric acid, gently warmed, then carefully washed with water and again examined with the microscope. White blotches were seen to have taken the place of many of the resinous spots, and when a solution of fuchsin was poured over the section, and the excess gently washed away, the gelatinous silica retained the coloring matter. The monazite appeared wholly unattacked by the treatment with hydrochloric acid.

These observations prove beyond question the presence of thorium silicate in monazite, and thus substantiate the above chemical evidence. It is a curious fact that these two rare minerals should be associated in this way together, and it may be hoped that, with the material at our disposal in the United States, good specimens of this silicate of thoria may be found. A glance again at the analyses shows that water is present in small quantity, as indicated by the loss by ignition, and if this belongs to the thorium silicate it amounts to nearly one molecule of water to one of the silicate; this is, nearly, the proportion in which they are united in the minerals thorite and orangite, but their water content is questionable and the material at our disposal was too limited to warrant further speculations.

With reference to the method of analysis it may be stated that phosphoric acid was separated from the bases by fusion with sodium carbonate and extraction with water. Thoria was separated from the oxides of the cerium metals by obtaining all the mixed oxides, free from phosphoric acid, as normal sulphates, dissolving in cold water, adding hyposulphate of soda, and boiling; the precipitated thoria was collected on a filter, washed, ignited and weighed (Hermann's method.)* The amount of cerium was arrived at by determining the excess of oxygen in CeO_2 over Ce_2O_3; this was obtained by dissolving the ignited oxides (free from thoria), in dilute sulphuric acid mixed with oxalic acid; the oxides dissolved and the higher oxide of cerium decomposed the oxalic acid, setting carbonic anhydride free, which was collected in potash bulbs and weighed. Silica was determined by decomposing the mineral with sulphuric acid, evaporating till fumes came off, soaking out with water and filtering.

A determination of sulphuric anhydride in a weighed quantity of the mixed sulphates of the cerium metals from the Portland variety gave for the joint molecular weight of the oxides 328·2, or a joint atomic weight of 140·1, which determination was used in the calculation of the three analyses. It may be stated that great care was taken to prove the identity of the thorium. Besides its giving all the reactions for that element, a weighed quantity of the oxide gave by conversion into sulphate an atomic weight of 238·5. This sulphate was not quite soluble in water, which readily accounts for the result being a trifle higher than that usually accepted for thoria. The atomic weight, 231·5, was used in calculating the analyses.

In closing I wish to express my thanks to Professors George J. Brush and E. S. Dana for kindly providing the material for carrying out this investigation.

Sheffield Scientific School, May 3, 1882.

ART. XXVIII.—*On Irregularities in the Amplitude of Oscillation of Pendulums*; by C. S. PEIRCE.

[Communicated by the authority of the Superintendent of the U. S. Coast and Geodetic Survey.]

THE pendulum experiments conducted by me for the Coast Survey exhibit considerable differences in the rate of descent of the arc on different days. Mr. O. T. Sherman (this Journal, xxiv, 176) having suggested that this might be due to a periodic variation of the amplitude, I feel called upon to say,—what a study of my published observations will show,—that this supposition is inadmissible. For, in order to account, in this manner, for the observed discrepancies, it would be necessary to suppose a periodic variation too great to escape direct observation. In most of my observations, I have used an arc accurately divided into thousandths of the radius. The reading telescope has a sidereal magnifying power of from 60 to

* Journ. f. pr. Chem., xxxiii, 90.

150 diameters, and is usually placed at a distance of about fifteen feet. The observations are made by placing the wire of this telescope successively in coincidence with the different lines of the graduated arc, and accurately noting the moment at which the point of the pendulum is just bisected by the wire at the extremity of its swing. It would thus be quite impossible to overlook a variation of the amplitude amounting to one ten-thousandth of the radius, while that of the pendulum was, say one-thirtieth of the radius.

The motion of a pendulum upon a flexible support has two harmonic constituents. One of these has nearly the natural period of the pendulum, the other nearly the natural period of the oscillation of the support. If the amplitude of the second motion is sensible, an irregularity of the arc of oscillation, often of a plainly periodic character, will necessarily result. The ratio of the amplitude of the second harmonic motion to that of the first depends upon the manner in which the pendulum is started; and upon a very flexible stand it is easy to start the pendulum in such a way as to produce a considerable variation in the amplitude. But theory shows that if the pendulum be started by pushing it to one side by a force applied at the center of oscillation and then letting it go, the second harmonic constituent vanishes. Now, this is the manner in which I always endeavor to start a pendulum. That, in point of fact, the second harmonic constituent is insensible is shown by the fact that it hardly shows itself even in the oscillation of the support, where it is relatively many times larger than in that of the pendulum. The equations showing this are given in my paper appended to the report of the Stuttgart meeting of the International Geodetic Association.

Mr. Sherman deduces the consequences which would result from the motion of the support having a different period from that of the pendulum. But for the considerable number of supports that I have examined in this respect, the mean period of the oscillation of support and pendulum have been the same. This is proved by the fact that, however long the experiment is continued, the oscillations of the one and of the other appear to be synchronous. There may, it is true, be a portion of the motion of the stand which is not synchronous with the main part of the motion of the pendulum; but this circumstance will have no appreciable effect on the period of the pendulum, if the latter is properly started.

Of the periodic phenomena observed by Mr. Sherman, I can propose no explanation, because I am unacquainted with the details of his experiments. But similar phenomena might result from a faulty mode of starting a pendulum upon a very flexible support.

ART. XXIX.—*Stresses caused in the Interior of the Earth by the Weight of Continents and Mountains;* by G. H. DARWIN, F.R.S.*

THE existence of dry land proves that the earth's surface is not a figure of equilibrium appropriate for the diurnal rotation. Hence the interior of the earth must be in a state of stress, and as the land does not sink in, nor the sea-bed rise up, the materials of which the earth is made must be strong enough to bear this stress.

We are thus led to inquire how the stresses are distributed in the earth's mass, and what are their magnitudes. These points cannot be discussed without an hypothesis as to the interior constitution of the earth.

In this paper I have solved a problem of the kind indicated for the case of a homogeneous incompressible elastic sphere, and have applied the results to the case of the earth.

It may of course be urged that the earth is not such as this treatment postulates.

The view which was formerly generally held was that the earth consists of a solid crust floating on a molten nucleus. It has also been lately maintained by Dr. August Ritter, in a series of interesting papers, that the interior of the earth is gaseous.† A third opinion, contended for by Sir William Thomson, and of which I am myself an adherent, is that the earth is throughout a solid of great rigidity; he explains the flow of lava from volcanoes either by the existence of liquid vesicles in the interior, or by the melting of solid matter, existing at high temperature and pressure, at points where diminution of pressure occurs.

There is another consideration, which is consistent with Sir William Thomson's view, and which was pointed out to me by

* This article is cited from the Philosophical Transactions for 1882, Part I. It is the second part only of Mr. Darwin's memoir and has the title "Summary and Discussion. The first part of the paper is entirely devoted to a mathematical investigation based on a well-known paper of Sir William Thomson's. References to the plates are, for the most part, omitted.

† Anwendung der mechanischen Wärmetheorie auf kosmologische Probleme. Carl Rümpler, Hannover, 1869. This is a reprint of six papers in Wiedemann's Annalen.

Dr. Ritter contends that the temperature in the interior of the planet is above the critical temperature and that of dissociation for all the constituents, so that they can only exist as gas. Data are wanting with regard to the mechanical properties of matter at, say 10,000° Fahr., and a pressure of many tons to the square inch. Is it not possible that such "gas" may have the density of mercury and the rigidity and tenacity of granite? Although such a conjectural "gaseous" solid might possess high rigidity, it almost certainly would have great compressibility: but it is proved in § 10 that the compressibility will make exceedingly little difference in the result of the present investigation excepting in the case of the second harmonic inequality.

Professor Stokes. It may be that underneath each continent there is a region of deficient density; then underneath this region there would be no excess of pressure.

For the present investigation it is to some extent a matter of indifference as to which of these views is correct, for if it is only the crust of the earth which possesses rigidity, or if Professor Stokes's suggestion of the regions of deficient density be correct, then the stresses in the crust or in the parts near the surface must be greater than those here computed—enormously greater if the crust be thin,* or if the region of deficient density be of no great thickness.

With regard to the property of incompressibility, which is here attributed to the elastic sphere, it appears from § 10 that even if we suppose the elastic solid to be *very* highly compressible, yet the results with regard to the internal stresses are almost the same as though it were incompressible. I think the hypothesis of great incompressibility is likely to be much nearer to the truth than is that of great compressibility. I shall, therefore, adhere to the supposition of infinite incompressibility, bearing in mind that even great compressibility would not much affect most of the results.

I take then a homogeneous incompressible elastic sphere and suppose it to have the power of gravitation and to be superficially corrugated. In consequence of mathematical difficulties the problem is here only solved for the particular class of surface inequalities called zonal harmonics, the nature of which will be explained below.

Before discussing the state of stress produced by these inequalities, it will be convenient to explain the proper mode of estimating the strength of an elastic solid under stress.

At any point in the interior of a stressed elastic solid there are three lines mutually at right angles, which are called the principal stress-axes. Inside the solid at the point in question imagine a small plane (say a square centimeter or inch), drawn perpendicular to one of the stress-axes; such a small plane will be called an inter-face.† The matter on one side of the ideal inter face might be removed without disturbing the equilibrium of the elastic solid, provided some proper force be applied to the inter-face; in other words, the matter on one side of an inter-face exerts a force on the matter on the other side. Now a stress-axis has the property that this force is parallel to the stress-axis to which the inter-face is perpendicular. Thus along a stress-axis the internal force is either purely a traction

* The evaluation of the stresses in a crust, with fluid beneath, would be tedious, but not more difficult than the present investigation. I may, perhaps, undertake this at some future time.

† This term is due to Professor James Thomson.

or purely a pressure. Treating pressures as negative tractions, we may say that at any point of a stressed elastic solid there are three mutually perpendicular directions along which the stresses are purely tractional. The traction which must be applied to an inter-face of a square centimeter in area, in order to maintain equilibrium when the matter on one side of the inter-face is removed, is called a principal stress, and is of course to be measured by grams weight per square centimeter.

If the three stresses be equal and negative the matter at the point in question is simply squeezed by hydrostatic pressure, and it is not likely that in a homogeneous solid any simple hydrostatic pressure, *absolutely* equal in all directions, would ever rupture the solid. The effect of the equality of the three stresses when they are positive and tractional is obscure, but at least physicists do not in general suppose that this is the cause of rupture when a solid breaks.

If the three principal stresses be unequal, one must of course be greatest and one least, and there is reason to suppose that tendency of the solid to rupture is to be measured by the difference between these principal stresses.

In one very simple case we know that this is so, for if we imagine a square bar, of which the section is a square centimeter, to be submitted to simple longitudinal tension, then two of the principal stresses are zero (namely, the stresses perpendicular to the faces of the rod), and the third is equal to the longitudinal traction. The traction under which the rod breaks is a measure of its strength, and this is equal to the difference of principal stresses.

If, at the same time, the rod were subjected to great hydrostatic pressure the breaking load would be very little, if at all affected; now the hydrostatic pressure subtracts the same quantity from all three principal stresses, but leaves the difference between the greatest and least principal stresses the same as before.

Difference of principal stresses may also be produced by crushing.

In this paper I call the difference between the greatest and least principal stresses the "stress-difference," and I say that, if calculation shows that the weight of a certain inequality on the surface of the earth will produce such and such stress-difference at such and such a place, then the matter at that place must be at least as strong as matter which will break when an equal stress-difference is produced by traction or crushing.

I shall usually estimate stress-difference by metric tonnes (a million grams), per square centimeter, or by British tons per square inch.

In Table VII, § 9,* are given the experimentally determined values of the breaking stress-difference for various substances. The table is divided into two parts, in the former of which the stress-difference was produced by tension, and in the latter by crushing. It is not necessary here to advert to the difference in meaning of the numbers given in the first column and those given in the two latter columns in the first half of the table.

The cases of wood and cast brass are the only ones where a comparison is possible between the two breaking stress-differences, as differently produced. It will be seen that the material is weaker for crushing than for tension. For the reasons given in that section, I am inclined to think that these tables rate the strength of the materials somewhat too highly for the purposes of this investigation. I conceive that the results derived from crushing are more appropriate for the present purpose than those derived from tension; and fortunately the results for various kinds of rocks seem to have been principally derived from crushing stresses.

This table will serve as a means of comparison with the numerical results derived below, so that we shall see, for example, whether or not at 500 miles from the surface the materials of the earth are as strong as granite.

We may now pass to the mathematical investigation. It

* This table of limiting stress-difference is as follows:

TABLE VII.—*Limiting stress-difference.*

Produced by tension.			
Material.	Breaking stress-difference in metric ton'es per square centimeter.	Stress-difference at which permanent set begins in— Met'ic tonnes per square centimeter.	Stress-difference at which permanent set begins in— British tons per square inch.
Sheet lead	·23	·23	1·46
Cast tin	·416	·417	2·64
"	·325 (R)	--	2·06 (R)
Wood (ash)	1·20	1·20	7·61
Cast brass	1·27	1·27	8·05
" iron	·94 to 2·04	1·14 to 1·87	7·23 to 11·86
Drawn copper	4·10	4·00	25·36
English steel pianoforte wire	23·62	23·56	149·6
(R) Brick, cement	·020 to ·021	--	·125 to ·134
(R) Glass	·66	--	1·20
(R) Slate	·68 to ·90	--	4·3 to 5·7

Produced by crushing.		
Material.	Breaking stress-difference in— Met'c tonnes per square centimeter.	Breaking stress-difference in— British tons per square inch.
Strong red brick	·077	·49
Strong sandstone	·39	2·45
(F) Strong limestone	·60	3·80
Marble	·39	2·45
Granite	·39 to ·77	2·45 to 4·91
(F) Granite (Mount Sorel)	·905	5·74
(F) Grauwacke	1·19	7·54
Ash (along the grain)	·63	4·02
Cast brass	·73	4·60
Wrought iron	2·52 to 2·84	16 to 18

NOTE.—The second and third columns give the product of Young's modulus into greatest elastic extension, and this should give the greatest stress-difference when permanent set begins. Rankine does not give the data for this quantity, but the breaking stress-difference is given in both metric and British units, the latter being in the third column. In the second half of the table the results marked F are from Sir William Fairbairn's experiments.

appears therefrom that the distribution of stress-difference is quite independent of the absolute heights and depths of the inequalities. Although the questions of distribution and magnitude of the stresses are thus independent, it will, in general, be convenient to discuss them more or less simultaneously.

The problem has only been solved for the class of superficial inequalities called zonal harmonics, and their nature will now be explained.

A zonal harmonic consists of a series of undulations corrugating the surface in parallels of latitude with reference to some equator on the globe; the number of the undulations is estimated by the order of the harmonic. The harmonic of the second order is the most fundamental kind, and consists of a single undulation forming an elevation round the equator, and a pair of depressions at the poles of that equator; it may also be defined as an elliptic spheroid of revolution, and the absolute magnitude is measured by the ellipticity of the spheroid.

If the order of the harmonic be high, say 30 or 40, we have a regular series of mountain chains and intervening valleys running round the sphere in parallels of latitude.

For the sake of convenience I shall always speak as though the equator were a region of elevation, but the only effect of changing elevations into depressions, and *vice versa*, is to diametrically reverse the directions of all the stresses.

The harmonics of the orders 2, 6, 10, etc., have depressions at the poles of the sphere; those of orders 4, 8, 12, etc., have elevations at the pole.

The harmonic of the fourth order consists of an equatorial continent and a pair of circular polar continents, with an intervening depression. That of the sixth order consists of an equatorial continent and a pair of annular continents in latitudes (about) 60° on one and the other side of the equator. The eighth harmonic brings down these new annular continents to about latitude 45°, and adds a pair of polar continents; and so on.

By a continuation of this process the transition to the mountain chains and valleys is obvious.

In section five the case of the second harmonic is considered. As above explained, the sphere is deformed into a spheroid of revolution. The investigation also applies to the case of a rotating spheroid, such as the earth, with either more or less oblateness than is appropriate for the figure of equilibrium.

It is remarkable that the stress-difference is the same all over the surface. In the polar regions the stress-difference diminishes as we descend into the spheroid, and then increases again; in the equatorial regions it always increases as we descend. The maximum value is at the center, and there the stress-difference is eight times as great as at the surface.

If the elastic solid be highly compressible the stress-differences are not nearly so great as on the hypothesis of incompressibility. In all the other cases considered in this paper compressibility makes practically no difference in the results.

On evaluating the stress-difference, on the hypothesis of incompressibility, arising from given ellipticity in a spheroid of the size and density of the earth, it appears that if the excess or defect of ellipticity above or below the equilibrium value (namely, $\frac{1}{232}$ for the homogeneous earth), were $\frac{1}{1000}$, then the stress-difference at the center would be eight tons per square inch; and, accordingly, if the sphere were made of material as strong as brass it would be just on the point of rupture. Again, if the homogeneous earth, with ellipticity $\frac{1}{232}$, were to stop rotating, the central stress-difference would be 33 tons per square inch, and it would rupture if made of any material excepting the finest steel.

A rough calculation* will show that if the planet Mars has ellipticity $\frac{1}{80}$ (about twice the ellipticity on the hypothesis of homogeneity), the central stress-difference must be six tons per square inch. It was formerly supposed that the ellipticity of the planet was even greater than $\frac{1}{80}$, and even if the latest telescopic evidence had not been adverse to such a conclusion, we should feel bound to regard such supposed ellipticity with the greatest suspicion, in the face of the result just stated.

The state of internal stress of an elastic sphere under tide-generating forces is identical with that caused by ellipticity of figure.† Hence the investigation of § 5 gives the distribution of stress-difference caused in the earth by the moon's attraction.

Computation shows that the stress-difference at the surface, due to the lunar tide-generating forces, is 16 grams per square centimeter, and at the center eight times as much. These stresses are considerable, although very small compared with those due to terrestrial inequalities, as will appear below.

In § 6 the stresses produced by harmonic inequalities of high orders are considered. This is, in effect, the case in a series of parallel mountains and valleys, corrugating a mean level surface with an infinite series of parallel ridges and furrows. In this case compressibility makes absolutely no difference in the result, as shown in § 10.

It is found that the stress-difference depends only on the depth below the mean surface, and is independent of the position of the point considered with regard to ridge and furrow;

* The data for the calculation are, Ratio of terrestrial radius to Martian radius, 1·878. Ratio of Martian mass to terrestrial mass, ·1020. Whence ratio of Martian gravity to terrestrial gravity, ·3596. Central stress difference, due to ellipticity e, $996e$ tons per square inch. "Homogeneous" ellipticity of Mars, $\frac{1}{166}$; and $\frac{996}{166}$ equal to 6.

† This is subject to certain qualifications noticed in section five.

the direction of the stresses does, however, depend on this latter consideration.

The greatest stress-difference depends merely on the height and density of the mountains, and the depth at which it is reached merely on the distance from ridge to ridge, being $\frac{1}{6 \cdot 28}$ of it.

Numerical calculation shows that if we suppose a series of mountains whose crests are 4,000 meters, or about 13,000 feet, above the intermediate valley-bottoms, formed of rock of specific gravity 2·8, then the maximum stress-difference is 2·6 tons per square inch (about the tenacity of cast tin); also if the mountain chains are 314 miles apart the maximum stress difference is reached at 50 miles below the mean surface.

It may be necessary to warn the geologist that this investigation is approximate in a certain sense, for the results do not give the state of stress actually within the mountain prominences or near the surface in the valley bottoms. The solution will, however, be very nearly accurate at some five or six miles below the valley-bottoms. The solution shows that the stress-difference is *nil* at the mean surface, but it is obvious that both the mountain masses and the valley-bottoms are in some state of stress.

The mathematician will easily see that this imperfection arises because the problem really treated is that of an infinite elastic plane, subjected to simple harmonic tractions and pressures.

To find the state of stress actually within the mountain masses would probably be difficult.

The maximum stress-difference just found for the mountains and valleys obviously cannot be so great as that at the base of a vertical column of this rock, which has a section of a square inch, and is 4,000 meters high. The weight of such a column is 7·1 tons, and therefore the stress difference at the base would be 7·1 tons per square inch. The maximum stress-difference computed above is 2·6, which is about three-eighths of 7·1 tons per square inch. Thus the support of the contiguous masses of rock, in the case just considered, serves as a relief to the rock to the extent of about five-eighths of the greatest possible stress-difference. This computation also gives a rough estimate of the stress-differences which must exist if the crust of the earth be thin. It is shown below that there is reason to suppose that the height from the crest to the bottom of the depression in such large undulations as those formed by Africa and America is about 6,000 meters. The weight of a similar column 6,000 meters high is nearly 11 tons.

In § 7 I take the cases of the even zonal harmonics from the second to the twelfth, but for all except the second harmonic only the equatorial region of the sphere is considered.

In § 8 I build up out of these six harmonics an isolated equatorial continent. The nature of the elevation is exhibited in Plate xx, fig. 5, in the curve marked "representation;" no notice need be now taken of the dotted curve. This curve exhibits a belt of elevation of about 15° of latitude, in semi-breadth, and the rest of the spheroid is, approximately, spherical. This kind of elevation requires the second as one of its harmonic constituents, and this harmonic means ellipticity of the whole globe. Now, it may perhaps be fairly contended that on the earth we have no such continent as would require a perceptible second harmonic constituent. I therefore give, in Plate xx, fig. 5, a second curve which represents an equatorial belt of elevation counterbalanced by a pair of polar continents in such a manner that there is no second harmonic constituent.

I have not attempted to trace the curves of equal stress-difference arising from these two kinds of elevation, but I believe that they will consist of a series of much elongated ovals, whose longer sides are approximately parallel with the surface of the globe, drawn about the maximum point in the interior of the sphere at the equator. The surfaces of equal stress-difference in the solid figure will thus be a number of flattened tubular surfaces one within the other.

At the equator, however, the law of variation of stress-difference is easy to evaluate, and Plate xx, fig. 6, shows the results graphically, the vertical ordinates representing stress-difference, and the horizontal the depths below the surface. The upper curve in Plate xx, fig. 6, corresponds with the "representation curve" of Plate xx, fig. 5, and the lower curve with the case where there is no second harmonic constituent.

The central stress-difference, which may be observed in the upper curve, results entirely from the presence of the second harmonic constituent in the corresponding equatorial belt of elevation.

The maximum stress-differences in these two cases occur at about 660 and 590 miles from the surface respectively.

We now come to perhaps the most difficult question with regard to the whole subject—namely, how to apply these results most justly to the case of the earth.

The question to a great extent turns on the magnitude and extent of the superficial inequalities in the earth. As the investigation deals with the larger inequalities, it will be proper to suppose the more accentuated features of ridges, peaks and holes to be smoothed out.

The stresses caused in the earth by deficiency of matter over the sea-beds are the same as though the seas were replaced by a layer of rock, having everywhere the thickness of about $\frac{1\cdot 02}{2\cdot 75}$ or nearly $\frac{4}{11}$ of the actual depths of sea.

The surface being partially smoothed and dried in this manner, we require to find an ellipsoid of revolution which shall intersect the corrugations in such a manner that the total volume above it shall be equal to the total volume below it.

Such a spheroid may be assumed to be the figure of equilibrium appropriate to the earth's diurnal rotation; if it departs from the equilibrium form by even a little, then we shall much underestimate the stress in the earth's interior by supposing it to be a form of equilibrium.

Professor Bruns has introduced the term "geoid" to express any one of the "level" surfaces in the neighborhood of the earth's surface, and he endeavors to form an estimate of the departure of the continental masses and sea-bottoms from some mean geoid.* From the geodesic point of view the conception is valuable, but such an estimate is scarcely what we require in the present case. The mean geoid itself will necessarily partake of the contortions of the solid earth's surface, even apart from disturbances caused by local inequalities of density, and thus it cannot be a figure of equilibrium.

Thus, even if we were to suppose that the solid earth was everywhere coincident with a geoid, which is far from being the case, a state of stress would still be produced in the interior of the earth.

An example of this sort of consideration is afforded by the geodesic results arrived at by Colonel Clarke, R.E.,† who finds that the ellipsoid which best satisfies geodesic measurement has three unequal axes, and that one equatorial semi-axis is 1,524 feet longer than the other. Now, such an ellipsoid as this, although not exactly one of Bruns' geoids, must be more nearly so than any spheroid of revolution; and yet this inequality (if really existent, and Colonel Clarke's own words do not express any very great confidence) must produce stress in the earth. Colonel Clarke's results show an ellipticity of the equator equal to $\frac{1}{13731}$, and this in the homogeneous elastic earth will be about equivalent to ellipticity $\frac{1}{27000}$; such ellipticity would produce a central stress-difference of $\frac{7698}{27000}$, or nearly one-third of a British ton per square inch.

From this discussion it may, I think, be fairly concluded that if we assume the sea-level as being the figure of equilibrium, and estimate the departures therefrom, we shall be well within the mark.

The average height of the continents is about 350 meters (1150 feet), and the average depth of the great oceans is, in round numbers, 5,000 meters (16,000 feet); but the latter data

* Die Figur der Erde. Von Dr. H. Bruns. Berlin. Stankiewicz, 1878.

† Phil. Mag., Aug., 1878.

is open to much uncertainty.* When the sea is solidified into rock the 5,000 meters of depth is reduced to 3,200 meters below the actual sea-level. Thus the average effective depression of sea-bed is about nine times as great as the average height of the land. I shall take it as exactly nine times as great, and put the depth as 3,150 meters; but it is of course to be admitted that perhaps eight and perhaps ten might be more correct factors.

In the analytical investigation of this paper the outlines of the vertical section of the continents and depressions are always sweeping curves of the harmonic type, and the magnitude of the elevations and depressions are estimated by the greatest heights and depths, measured from a mean surface which equally divides the two.

We have already supposed the outlines of continents and sea-beds to have been smoothed down into sweeping curves, which we may take as being, roughly speaking, of the harmonic type. The smoothing will have left the averages unaffected.

The averages are not, however, estimated from a mean spheroidal surface, but from one which is far distant from the mean.

The questions now to be determined are as follows: What is the proper greatest height and depression, estimated from a mean spheroid, which will bring out the above averages estimated from present sea-level, and what is the position of the mean spheroid with reference to the sea-level.

From the solution of the problem considered in the note below,† it appears that, if the continents and sea-beds have sections which are harmonic curves, then if we take,—

* In a previous paper, "Geological Changes, etc.," Phil. Trans., vol. 167, Part I, p. 295, I have endeavored to discuss this subject, and references to a few authorities will be found there.

† Conceive a series of straight harmonic undulations corrugating a mean horizontal surface, and suppose them to be flooded with water. This will represent fairly well the undulations on the dried earth, and the water-level will represent the sea-level.

Suppose that the average heights and depths of the parts above and below water are known, and that it is required to find the position of the mean horizontal surface with reference to the water level, and the height of the undulations measured from that mean surface.

Take an origin of co-ordinates in the water-level, the axis of x in the water-level and perpendicular to the undulations, and the axis of y measured upward. Let

$$y=h(\cos x-\cos a)$$

be the equation to the undulations.

The average height of the dry parts is clearly $\frac{1}{2a}\int_{-a}^{+a} y\,dx$ or $\frac{h}{a}(\sin a-a\cos a)$.

Similarly the average depth below water is

$$\frac{h}{\pi-a}[\sin(\pi-a)-(\pi-a)\cos(\pi-a)] \text{ or } \frac{h}{\pi-a}[\sin a+(\pi-a)\cos a]$$

The mean level bisecting elevations and depressions as 2,480 meters (8,150 feet) below the sea-level, and the greatest elevation and depression from that mean level as 3,009 meters (9,840 feet), it results that the *average* height of the land above sea-level is 350 meters, and the *average* depression of dried sea-bed is 3,150 meters.

It thus appears that 3,000 meters would be a proper greatest elevation and depression to assume for the harmonic analysis of this paper, if the earth were homogeneous. But as the density of superficial rocks is only a half of the mean density of the earth, I shall take 1500 meters as the greatest elevation and depression from the mean equilibrium spheroid of revolution.

It is proper here to note that the height of the undulations of elevation and depression in the zonal harmonic inequalities is considerably greater toward the poles than it is about the equator; it might, therefore, be maintained that by making 1500 meters the equatorial height we are taking too high an estimate. But the state of stress caused in the sphere at any point depends very much more on the height of the inequality in the neighborhood of a superficial point immediately over the point considered, than it does on the inequalities in remote parts of the sphere.

Now in all the inequalities, except the second harmonic, I have considered the state of stress in the equatorial region, and

If the latter average be p times as great as the former

$$ph\cos a\left(\frac{1}{a}\tan a-1\right)=h\cos a\left(\frac{1}{\pi-a}\tan a+1\right)$$

This is an equation for determining a.

Now I find that $a=34°\ 30'$ gives $p=8{\cdot}983$, which corresponds very nearly with $p=9$ of the text above.

This value of a corresponds with an average equal to $\cdot1165h$ for the height above water, and $1{\cdot}0469h$ for the depth below water. Now, if we put

$$1{\cdot}0469h=3150 \text{ meters}$$
$$\text{which gives } \cdot1165h=350 \text{ meters, very nearly,}$$

we have $h=3009$ meters.

The depth below water-level of the mean level is $h\cos 34°\ 30'$, or 2480 meters.

The greatest height of the dry part above the water-level is 3009—2480, or 429 meters, and the greatest depth of the submerged part below water-level is 3009 + 2480, or 5489 meters.

[After the proof-sheets of this paper had been corrected, Professor Stokes pointed out to me that, according to Rigaud (Cam. Phil. Soc., vol. vi), the area of the land is about four-fifteenths of the whole area of the earth's surface. Now, in the ideal undulations we are here considering the area above water is about one-tenth of the whole area; hence in this respect the analogy is not satisfactory between these undulations and the terrestrial continents. If I have not considerably over-estimated the average depth of the sea (and I do not think that I have done so), the discrepancy must arise from the fact that actual continents and sea-beds do not present in section curves which conform to the harmonic type; there must also be a difference between corrugated spherical and plane surfaces.

The geological denudation of the land must, to some extent, render our continents flat-topped.—Added May 4, 1882.]

it will therefore, I think, be proper to adhere to the 1500 meters for the greatest height and depression.

We have next to consider what order of harmonic inequalities is most nearly analogous to the great terrestrial continents and oceans. The most obvious case to take is that of the two Americas and Africa with Europe. The average longitude of the Americas is between 60° and 80° W., and the average longitude of Africa is about 25° E., hence there is a difference of longitude of about a right-angle between the two masses. These two great continents would be more nearly represented by an harmonic of the sectorial class,* rather than by a zonal harmonic, nevertheless I think the solution for the zonal harmonic will be adequate for the present purpose.

Now it has been explained above that the harmonic of the fourth order represents an equatorial continent and a pair of polar continents. In the case of the fourth harmonic therefore there is a right angle of a great circle between contiguous continents. We may conclude from this that the large terrestrial inequalities are about equivalent to the harmonic of the fourth order.

Table V (*b*), § 7, gives the maximum stress-differences under the center of the equatorial elevation of the several zonal harmonics, the height of each being 1500 meters.† The point at which this maximum is reached is given in each case, and Plate xx, fig. 4, illustrates graphically the law of variation of stress-difference.

The second harmonic cannot be said to represent a continent, and the table shows that in each of the other cases the maximum stress-difference is very nearly four tons per square inch. The depths of the maximum point are of course very different in each case.

* The sectorial harmonic of the fourth order $\sin^4 \theta \cos 4\phi$ would well represent these two great continents. It would fairly represent Chiná and Australia, but would annihilate the Himalayan plateau, and place another great continent in mid-Pacific. It is not at all difficult to find the stress-difference under the center of a sectorial inequality, but to find it generally involves the solution of a cubic equation.

† The following is the table:

TABLE V (*b*).—*Maximum stress-differences due to harmonic continents and seas.*

Order of harmonic.	2	4	6	8	10	12
Max. stress-difference, in metric tonnes per sq. c.m. due to contin'ts 1500 meters high	·858	·633	·626	·625	·625	·625
Ditto in British tons per sq. inch, for same continents	5·43	4·01	3·97	3·96	3·96	3·96
Depth in British miles at which this stress is attained	Center of earth	1146	725	532	420	347

N. B.—The continents referred to are supposed to be of the earth's mean density and are equivalent to actual continents of double the height.

We have concluded above that Africa and America are about equivalent to an harmonic of the fourth order, hence it may be concluded that the stress-difference under those continents is a maximum at more than 1100 miles from the earth's surface, and there amounts to about four tons per square inch. A comparison with Table VII shows that marble would break under this stress, but that *strong* granite would stand.

The case of the isolated continent investigated in section eight appeared likely to prove the most interesting one, for the purpose of application to the case of the earth. But unfortunately I have found it difficult to arrive at a satisfactory conclusion as to the proper height to attribute to the continent.

The average height of the American continent is about 1100 feet above the sea, and the average depth of the Pacific Ocean about 15,000 feet. If the water of the Pacific be congealed into rock it will have an effective depth of 10,000 feet. The greatest height of the American continent above the bed of the dried Pacific when smoothed down must be fully 12,000 feet, or 3700 meters. The height of the great central Asian plateau above the average bed of the southern ocean (after drying) must be considerably more than this.

Now, in the application to the homogeneous planet the heights are to be halved to allow for the smaller density of surface rock. I therefore take 2,000 meters as the height of the top of the equatorial table-land above the remaining approximately spherical portion of the sphere.

The investigation of § 8 then shows that the equatorial table-land will give rise to a stress-difference of 4·1 tons per square inch at a depth of 660 miles; and that the equatorial table-land counterbalanced by the pair of polar continents (the second harmonic constituent being absent), gives a stress-difference of about 3·8 tons per square inch at a depth of 590 miles.

This estimate of stress-difference agrees in amount, with singular exactness, with that just found from the case of the fourth zonal harmonic, but the maximum is reached 400 or 500 miles nearer to the earth's surface.

I think there can be no doubt but that there *are* terrestrial inequalities of much greater breadth than that of my isolated continent; thus this investigation for the isolated continent will give a position for the maximum stress-difference too near the surface to correspond with the largest continents. On the other hand, I do not feel at all sure that I have not considerably under-estimated the height of such a comparatively narrow plateau.

In the present paper it has been impossible to take any notice of the stresses produced by the most fundamental inequality on the earth's surface, because it depends essentially on heterogeneity of density.

It is well known that the earth may be divided into two hemispheres, one of which consists almost entirely of land, and the other of sea. If the south of England be taken as the pole of a hemisphere, it will be found that almost the whole of the land, excepting Australia, lies in that hemisphere, whilst the antipodal hemisphere consists almost entirely of sea. This proves that the center of gravity of the earth's mass is more remote from England than the center of figure of the solid globe.

A deformation of this kind is expressed by a surface harmonic of the first order, for such an harmonic is equivalent to a small displacement of the sphere as a whole, without true deformation.

Now if we consider the surface forces produced by such a deformation in a homogeneous sphere, we find, of course, that there is an unbalanced resultant force acting on the whole sphere in the direction diametrically opposed to that of the equivalent displacement of the whole sphere.

The fact that in the homogeneous sphere such an unbalanced force exists shows that in this case the problem is meaningless; it is, in fact, merely equivalent to a mischoice in the origin for the coördinates. But in the case of the earth such an inequality does exist, and the force referred to must of course be counterbalanced somehow. The balance can only be maintained by inequalities of density, which are necessarily unknown. The problem therefore apparently eludes mathematical treatment.

It is certain that so wide-spreading an inequality, even if not great in amount, must produce great stress within the globe. And just as the second harmonic produces a more even distribution of stress than the fourth, so it is likely that the first would produce a more even distribution than the second.

It is difficult to avoid the conclusion that the whole of the solid portion of the earth is in a sensible state of stress.

I would not, however, lay very much emphasis on this point because we are in such complete ignorance as to the manner in which the equilibrium of the solid part of the earth is maintained.

From this discussion it appears that if the earth be solid throughout, then at a thousand miles from the surface the material must be as strong as granite. If it be fluid or gaseous inside, and the crust a thousand miles thick, that crust must be stronger than granite, and if only two or three hundred miles in thickness much stronger than granite. This conclusion is obviously strongly confirmatory of Sir William Thomson's view that the earth is solid throughout.

ART. XXX.—*The Deerfield Dike and its Minerals;* by BEN. K. EMERSON, Professor of Geology in Amherst College.

PREHNITE.—*a. In fissures at Cheapside, south of the river.*—Prehnite occurs here most abundantly and always as the oldest mineral in the veins in which it appears. That the veins where it is absent have been filled at a later period and at a lower temperature is evident from the fact that in these the vein-walls are quite as fresh as the body of the rock, while in the prehnite veins the walls are deeply decomposed, often to a depth of several centimeters into a rusty vesicular mass, which has been filled with massive prehnite, forming a rock nearly as compact as the trap itself. Similarly many detached fragments of the trap have been thoroughly decomposed and in the same way filled with massive prehnite. Under the microscope the mineral is here seen to be made up of fibers variously matted and interlaced and intermingled with the remains of the trap, and much of it exactly resembles chlorastrolite. In other specimens the oldest layer of the mineral is jet-black to deep oil-green, polished and often slickensided and gashed, the color being due to the thorough impregnation of the prehnite with diabantite. The motion of the rock walls has also at times broken up the prehnite into sheets which are slipped over each other variously and re-cemented by prehnite. Wherever the mineral is hindered in its growth it shows a strong tendency to take on these fibrous forms which seems to me to depend upon a greater energy of the crystallizing force in the direction of the long horizontal axis; upon which depends also the curvature of the faces so common in the species. Generally these fibers are quite large, peculiarly rigid and in large numbers parallel to each other. In one slickensided piece the fibers of black prehnite, all straight and parallel and placed at a slight angle to the surface of the trap, seem as if combed into this position by the movement of the walls and being jet-black from enclosed diabantite, resemble in appearance seams of fibrous hornblende or chrysotile.

The fibers are, however, generally colorless, transparent and of a high satiny luster on the face *O*. They are apparently always elongated in the direction of the long horizontal axis and bounded by the planes *O*, $i\text{-}\bar{\imath}$, $i\text{-}\breve{\imath}$. At times the satiny luster is reflected from a large group of the needles at once, and they are seen when magnified to be in juxtaposition, and forming each group for itself an aggregrate crystal, the lines of junction being represented in the larger crystals by the striation parallel to the long axis. At times the little groups ran under and over each other, or joined at their ends under angles of 80°

and 100°, as if there were some trace of twinning on *I*, as in the spindle-shaped crystals described later. It seemed like a model of the complex striation seen in the latter.

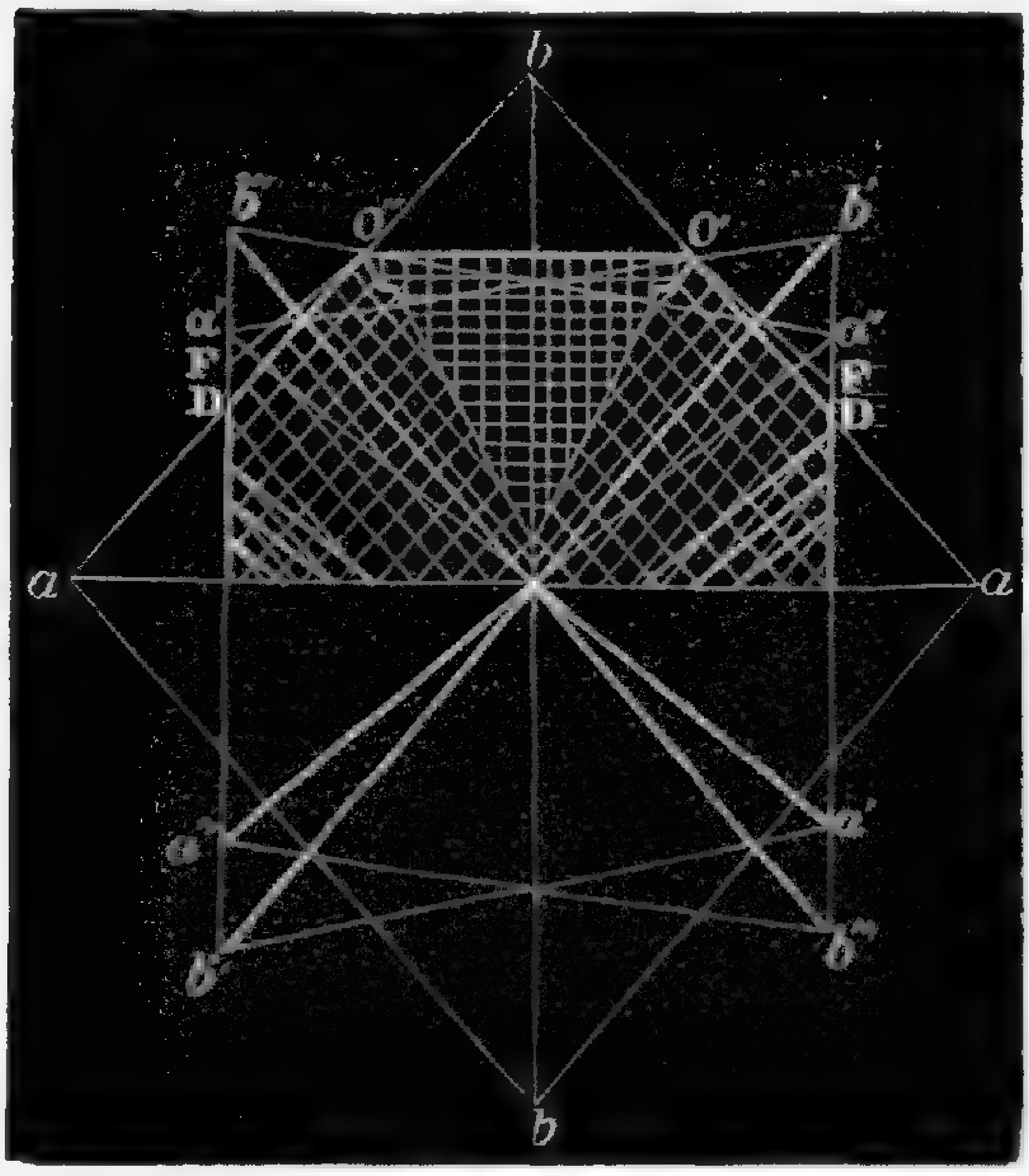
The prehnite also occurs in many drusy cavities covered with small distinct crystals, pale green, emerald-green to yellow, and in delicate emerald-green "roses" produced by the multiple twinning of the same form *O*, *i-ī*, *i-ĭ*, and in stout, square prisms with base and two sides convex, the two remaining sides concave. The more common botryoidal forms are scarcely represented.

By far the most abundant, finely-crystallized and peculiar form, is a stout double cone or spindle, the two cones joining directly base to base with an angle of 80°, or separated by a plane cylindrical, which may become as wide as the conical faces by which it is bounded; rarely this face is replaced by a reëntrant angle of 41°. These three faces are physically unlike, the two sloping ones being sometimes smooth and polished, at others mosaic-like, the equatorial plane being oftentimes milled as regularly as a coin, by the oscillatory repetition of *I* and *i-ĭ;* and finally the conical faces become rarely convex in the direction from the apex to the base, producing small globular forms. These cones are laid usually with their axes parallel to the surface on which they rest—the axes pointing in all directions in this plane—and fused together so that only a fraction of each one is distinct, though they often stand out so that half or three-quarters of the circumference is visible, and in this way completely cover broad surfaces with a splendid crystallization. In color, they range from white and nearly pellucid to pale celandine-green, and rarely to pale rose color in the smaller spindles with polished sides; to deep clear apple-green in the largest cones; and in other forms with very broad cylindrical faces, deep mountain-green. Several pieces a foot square were obtained covered with the finest crystals. In a single instance the crystals of this form have spread over calcite, and this having been removed, they presented a group of scarcely adhering individuals,—the segments of cones bounded below by a single, saddle-shaped face.

The internal structure of these crystals is quite peculiar. The pearly basal cleavage passes inward in the direction of a vertical section of the cone, and plates cut in this direction and continued down into the trap show the fibrous prehnite at the base felted together with much decomposed trap, above growing purer and forming distinct crystals, with doubly striated cleavage faces, which are twinned along a distinct suture and bounded outwardly by irregular planes of contact. After each crystal has risen above the general level to form the segment of a double cone, the suture forks with an angle of about 41°

and the two lines run to meet the angles formed by the meeting of the two conical faces, with the central zone. Each of the spindles is thus made up of three crystals, one on either side of, and one within, the angle of the Y-shaped suture.

1.



The shaded portion of figure 1 represents such a vertical section, in which *D o″* and *D o* (=*i-ĭ*) are the sections of the two conical faces and *o″ o′* (=*i-ĭ*) that of the central cylindrical face.

The relations of the three crystals are made clear by fig. 1. Three superimposed prisms (*I*) having the base (*O*) in common are revolved on the common vertical axis *c* to right and left until a prism face of each becomes parallel to the long horizontal axis of the third. Thus the two lateral crystals form an arrow-headed twin with a face of *I* in common, and are twinned against the middle one so that the same face (*I*) in each is parallel with *i-ĭ* of the latter. If now, the sharp angle of the two lateral forms be truncated by *i-ĭ*, and that of the central one by *i-ĭ*, down to their point of contact *o′* and *o*, a plane, marked with a heavier line in the figure, results, by whose revolution on the short axis *a-a*, the spindle-shaped twin would be formed. The central crystal has the form of a triangular belt fitted into a similar groove upon the circumference of a wheel. An inspection of the figure will show that the arrow-headed twin, if formed by the union of two crystals having only the faces *I* and *i-ĭ*, would leave for the third crystal only an extremely shallow reëntrant angle of 160°, whereas the latter penetrates between the two in an angle of about 41°. This is because the obtuse angles of the lateral crystals are each replaced by the form *i*-2¼, giving a reëntrant angle at *x* of 40° 57′ 6″. The approximated faces of this form are alone strongly developed and make a trumpet-shaped cavity for the reception of the wedge. The curved basal face in the free crystals mentioned above were formed by the blunt point of the arrow-head and by the corresponding faces of *i*-2¼ on the outer obtuse angles below at *a″* and *a′*. The tendency of the mineral to form these strange triplets seems to depend upon the greater intensity of the crystallizing force in the direction of the long horizontal axis, so that of the many crystals which start in the fibrous base, only a few survive and grow up into the free space by preponderating additions to the face *i-ī* at right angles to the long axis, and are soon twinned so as to allow a third crystal to wedge in between them and grow by the development of the same face. All three grow thus predominantly in the same direction and expose and add to only the single crystalline face, and the crystal expands in growing like the top of a growing tree. The common vertical axis of the three crystals is bent thus into a circle.

When examined under the polarizing microscope, the central crystal, though showing a strong vertical and a faint horizontal striation, acts as a single crystal. The two flanking crystals present through a whole revolution under the Nicols a complex lattice-work of brilliant colors with two predominant positions of maximum extinction, or rather of extinction of the greatest number of the narrow bands and wedges of color in the field, at angles of 40° and 50° on either side of the suture; that is, when parallel to the two sets of axes a', b', and a'' b'' of the two lateral crystals. The narrow wedges of color often repeated many times, placed parallel to each other, extinguishing the light together and bounded by lines making an angle of 10° with each other, are especially peculiar.

Of course the extinction of the light on the right hand of the suture parallel to the axis a'' can alone be referred to the right hand crystal, and the extinction at an angle of 10° with this and on the same side of the suture, that is parallel to the axis of the left-hand crystal, must be referred to this latter. So that the twin is not formed simply by the approximation of the two parts along the common suture plane, but by the interpenetration also of each by the other in narrow, and, as it were, interwoven bands, as is represented schematically in the figure —much more regularly, of course, than in nature.

The two principal striations in the lateral prisms make an angle of 40° with the central suture—that is, an angle of 80° with each other.

It follows, taking the prism on the right (fig. 2) for example, that while one of these striations is parallel to the long axis b' of this prism, the other is parallel to the long axis b'' of the opposite, and in fact both striations seem in the plainest manner to be continuous as right lines across the suture.

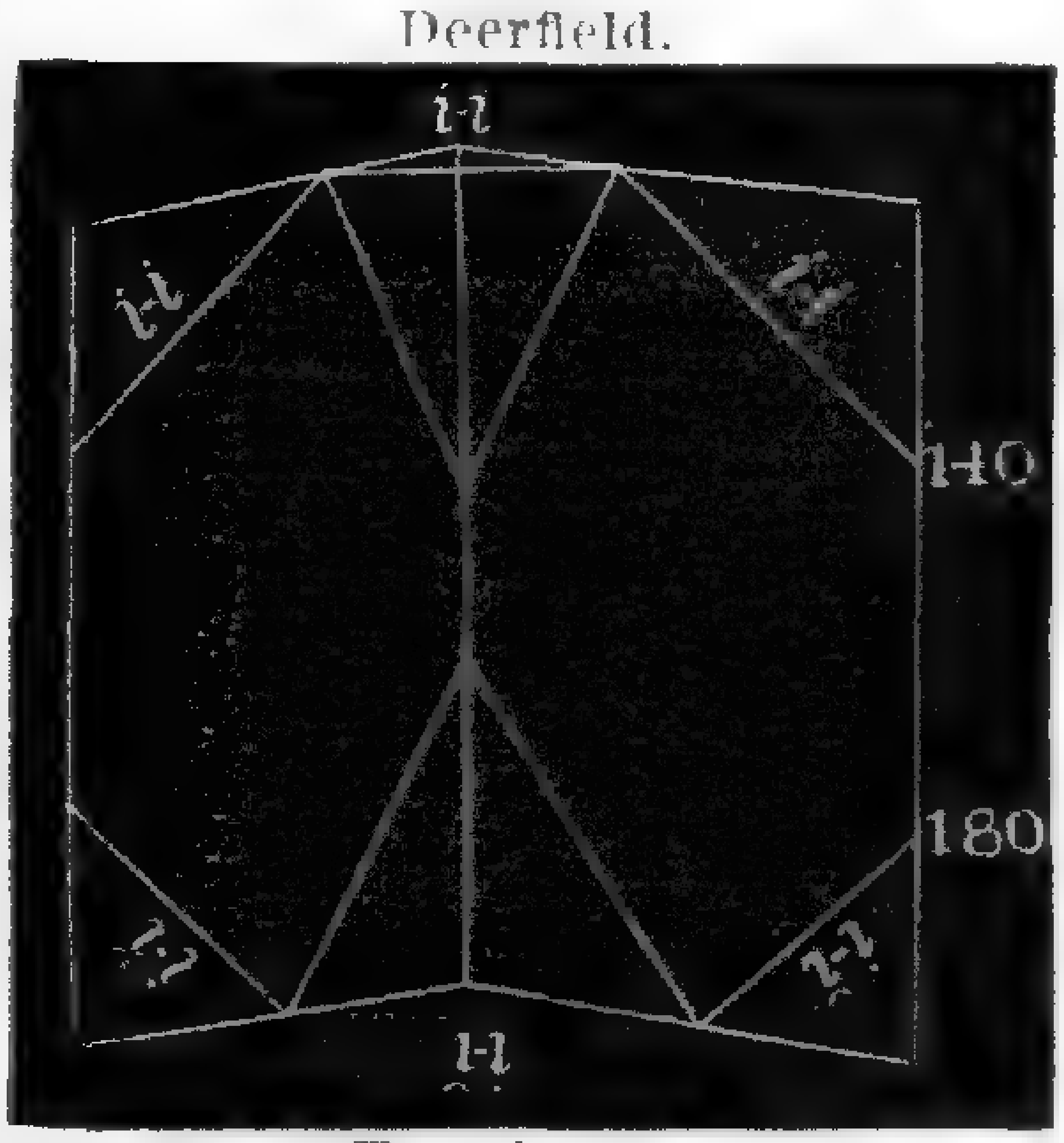
Traces exist also, very faint indeed, of two other sets of striations at right angles respectively to those already described, which are identical with the delicate horizontal lining of the central crystal, and which combined with those first described produce the long wedge-shaped blades with angle of 10° described above. This second striation is indicated in the lower portion of the shading in fig. 1. The phenomena here detailed would seem also to find their explanation in the interpenetration of the lateral prisms.

The similar twins of prehnite from Farmington, Conn., which occur in the same triassic trap as the Deerfield crystals, were described by M. DesCloizeaux,* and have been recently the subject of discussion by the same author † and by M. Mallard ‡ because of their optical peculiarities. They do not seem from the descriptions to present the spindle shape described above, and in cross-section they differ from the Deerfield crystals in one important particular.

In the Farmington crystals the sloping faces (*F* in fig. 1) make an angle of 100° with each other, and the termination of the crystal is thus bounded by a threefold repetition of the face *i-ĭ*, while in the Deerfield forms the corresponding angle of the two sloping faces measured over the single exposed face of the central crystal is 80° (*DbD*, fig. 1), and the three faces have the formulæ *i-i*, *i-ĭ*, *i-i*.

2.

Deerfield.



Farmington.

One may express the relation of the two very simply by saying that in the Farmington crystals the end of the arrow-headed twin having the re-entrant angle has its acute angles truncated by *i-ĭ* to form the sloping sides, while in the Deerfield forms the other end is developed, and the outer obtuse angles truncated by *i-i*, as in the annexed figure.

It seems to me simpler to say that the interpenetration of the two is so complex and at the same time so varying that in one case on the right of the suture the crystal which is turned to the right predominates and is truncated by *i-ĭ* (*F* in fig. 1), and in the other that which at right angles to *b′* is turned to the left predominates on the same (the right) side, and determines the truncation by *i-i* (*D* in fig. 1), at right angles to axis *a″*; while in the forms curved in the direction *o′ a*, and in those with facetted faces there is a gradual or interrupted transition from the one to the other.

This would also harmonize very well with the complex optical results detailed in the above papers, and especially with the *dispersion tournante* signalized by M. DesCloizeaux for the Farmington crystals.

If the sloping faces in the Deerfield crystals like those of the

* Min., p. 451, Atlas XXIX, 167 bis, 1862.

† Bul. Soc. Min., vol. v, No. 2 and No. 5, 1882. ‡ Ibid., No. 3.

Farmington be referred to the acute angles of the arrow-head, to recur to the first explanation given above, they would have the more complex formula $i\text{–}\breve{6}\frac{8}{4}$. Furthermore, the two well-marked striations described above form by their intersections diamonds with the acute angles (80°) at top and bottom, while the larger angle is at the sides, while the drawing of M. Des-Cloizeaux * shows the reverse to be the case in the crystals from Farmington.

That is, in the first they are parallel to b' and b'' (fig. 1), while in the second case, if they were exactly the reverse, they would be parallel to the short axes a' and a''; but they are stated in the later article of M. DesCloizeaux to make an angle not of 80° but of 82° with each other, so that while one is parallel to a short axis, the other is parallel to a hypothetical face, i-6. If they made an angle of exactly 80° with each other, they would represent the horizontal striation of the central crystal and the faint second striation described in the Deerfield crystals as slightly indicated at the bottom of figure 1. As it is they are difficult of explanation.

b. In amygdaloidal cavities.—The amygdules of the trap quite closely repeat in miniature the occurrences of the large fissures, but the peculiar changes the prehnite undergoes in the former case makes it needful to discuss separately its modes of appearance there.

In the coarse diabase it occurs compact, of a bright green, as if colored by copper. The paragenesis is (1) diabantite, (2) chalcopyrite, pyrite, galena, prehnite, one or all, (3) calcite.

In the red diabase, so abundant in the upper part of the dyke through Greenfield and Gill it appears in spherical and spheroidal balls 12–15^{mm} in diameter, very fine-fibrous and satiny, and very pale green to colorless; coated, and for a distance in impregnated with diabantite. It is radiated fine-fibrous, the fibers not easily separated, and diverging from several centers and meeting along sharp suture lines, so that only parts of spheres result, and if water-worn the grains would form perfect chlorastrolites.

In the dark gray diabase from the north side of the Deerfield and on through Greenfield and Gill, cavities 10–35^{mm} across are sometimes filled with fibrous prehnite, the whole blackened as if it had been held in the flame of a candle. Under the microscope the fibers are, for the most part, perfectly fresh, and up through the spaces between them has penetrated a black amorphous powder looking like the beard of iron filings on a magnet, or like a network of soot-covered cobwebs. The whole seems to be dendritic in character.

* Min., loc. cit.

PRODUCTS OF THE DECOMPOSITION OF PREHNITE. *Chlorophæite* (of Hitchcock.)—The mineral, chlorophæite, described by Macculloch in 1825, but not analyzed, proves now, from the analysis of Heddle,* to be of very different composition from the highly hydrated protoxide of iron silicate analyzed by Forchhammer, with which it has been associated. It is a magnesian peroxide of iron silicate with about 25 per cent of water, sometimes aluminous, and it approaches thus much more nearly to diabantite, from which it differs mainly in the peroxidation of the iron and in containing double the quantity of water.

In 1825 Pres. Hitchcock discovered a mineral "in the trap rocks about Turner's Falls, in Gill, Mass.,† which Professor J. W. Webster, of Harvard University, pronounced to be the chlorophæite of Macculloch," and the description given by Pres. Hitchcock agrees so exactly with that of Macculloch and Heddle, and the rapid blackening of the mineral is so peculiar, that the reference was very natural, and, I think, correct.

On examining slides of the "smoked" prehnite last described, its radiated needles were in the center colorless and perfectly fresh, and contained in abundance scales of diabantite with remarkably strong dichroism, brown-green to black. Although the smoky-black mass resembled closely an amygdule of the chlorophæite its great hardness and the crystalline surface proved it to be prehnite, and the peculiar striation dependent upon the arrow-head twinning was quite as characteristic. Toward the outer surface, however, the mass softened rapidly and could be readily impressed by the finger-nail, and under the microscope the fibers were seen to change quite rapidly into an amorphous or finely scaly material of red-brown color, showing faint aggregate polarization, but no dichroism. Farther in among the clear needles portions of the mass have all the needles likewise stained brown superficially. On examining the original specimens of President Hitchcock, No. 91, of the last catalogue of the Massachusetts State collection,‡ it was found to be distinctly radiated from several centers, the fibers of the same size and arrangement as those of the fine fibrous prehnite described *ante* p. (275), and a fragment broken from the specimen gave a pale-green powder and scratched apatite without difficulty. The cavity in which it is found is lined first with the foliated diabantite, then follows inwardly chalcopyrite, chlorophæite, the latter occupying thus the same place as the prehnite in the unaltered nodules. Under the microscope traces of the bright quartz-like polar-

* Trans. Roy. Soc. Edin., xxix, 84.

† This Journ., x, 393.

‡ State Board of Agricult. Report, vi, Appendix, p. lvi, where the mineral is misprinted chlorophocite.

ization and the peculiar striation of prehnite could be clearly seen. The latter mineral was, however, for the most part changed into a red-brown indistinctly scaly mass, with very faint polarization. The fibers of the original prehnite had not been at all fused together or changed in their relation to each other, and nothing was interposed among them. Other nodules completely changed showed also the network of black material between the needles. In specimen No. 92 of the same collection with H. 1·5, the fibrous structure is much less distinct than in the former one, both are of the same dull black color, but under the microscope it is seen to be made up of the same faintly scaly red-brown material arranged in radiated needles exactly as before, but now showing no trace of the further presence of unchanged prehnite. The brown material is not to be distinguished under the microscope from that which results from the change of diabantite, except that in each case the structure of the original mineral is retained.

In other cases the change of the prehnite has taken another course. In the variety from the new cutting at Cheapside described on page (270), where the lustrous bars of the mineral are interwoven with minute green fluor, the bars change toward the side where the fissure in which they were formed opened into the main vein, gradually into a pale green scaly mass which retains for a distance the shape of the bars and their relation to the fluor, but farther on is blended into a pale green mass with satiny luster, which looks as if it had been worked up into a paste and dried in a thin layer upon the surface. Similar masses are found abundantly, especially in the datolite, and under the microscope contain still fragments of fresh, unchanged prehnite. The mineral itself is under the microscope seen to be made up of loosely aggregated scales and to show a bright green color and a dichroism, both like that of diabantite. It is apparently hexagonal, many scales remaining black during a complete revolution between Nicols. Its lighter color seems to be the result of its different aggregation, and the powder of both is of the same light green. Prehnite can thus change into a mineral very similar to if not identical with diabantite (enough pure material for an analysis could not be obtained), and both the prehnite and the common scaly-radiated diabantite change into red-brown almost amorphous materials which cannot be distinguished microscopically.

I have assumed on what seems good grounds that the diabantite which fills the fibrous prehnite so often was formed at the same time with the latter, and it often shows a zonal arrangement in the prehnite which goes far to show that this was so, and in the specimens the two cases* can be easily dis-

* That of the diabantite originally enclosed in the fresh prehnite and the similar scaly mineral formed by the decomposition of the latter.

tinguished. On the other hand I think the change of the prehnite is primarily into the green diabantite-like mineral and through this into the brown peroxidized substance, and that the instability of the first or protoxide stadium of the substance is the condition of its rapid change from green to brown or black when exposed to the air. Indeed, this is also a striking characteristic of the common diabantite itself, and fresh trap specimens lose their green tint and soon turn brownish-black if exposed to the weather, though the change does not occur with such remarkable rapidity as is the case with the prehnite-diabantite or chlorophæite. Professor Heddle explains the sudden change of color by shrinkage-cracking due to partial dehydration.*

[To be continued.]

ART. XXXI.—*Note on the Occurrence of Siphonotreta Scotica,* Davidson, *in the Utica Formation near Ottawa, Ontario;* by J. F. WHITEAVES.

IN the spring of 1881, three specimens of a remarkable spinose brachiopod were collected by Mr. J. W. H. Watts, R.C.A., from a band of impure limestone in the Utica Slate at Cumming's Bridge, near Ottawa. These specimens, which Mr. Watts has since presented to the Museum of the Geological Survey of Canada, consist of two perfect examples of the beaked and perforated valve, which is probably the ventral, and of one detached dorsal valve in which the beak is obsolete. Over most of the central area of the sides of the valves the spines are broken off, and where this is the case the surface is marked with pitted imbricating concentric lamellæ, the pits representing the fractured bases of the spines. In each case the margins of the valves are densely fringed with a single and continuous row of fine hair-like spines, except immediately upon the beaks.

Upon examination with an ordinary simple lens it was at once apparent that these specimens are referable to DeVerneuil's genus *Siphonotreta*, and that in most respects they bear a very close resemblance to an English species, the *S. Anglica* of Professor Morris. But the spines of *S. Anglica* are distinctly stated to be annulated, whereas those of the Canadian specimens appeared perfectly smooth when viewed under an achromatic microscope with an inch and a half objective.

A few months ago the writer had occasion to send some Canadian fossil Brachiopoda to Mr. Thomas Davidson, F.R.S.,

* Loc. cit.

for examination and comparison with British species. In the parcel forwarded the three examples of the *Siphonotreta* from Cumming's Bridge were included, and in a letter received from Mr. Davidson in May last they are reported upon as follows:

"The *Siphonotreta* from near Ottawa interests me much. It is identical in shape and characters with the Upper Llandeilo species which I named *Siphonotreta Scotica.* I am very uncertain whether the Wenlock Shale species named *S. Anglica* by Morris is the same or not. Only one crushed specimen of the *S. Anglica* has been found, and its spines are annulated as described by Morris. I could see no annulations in the spines of the many specimens of *S. Scotica* found by Mrs. Gray in the Upper Llandeilo of Craighead, nor do I see any in your specimens. As there is uncertainty as to the specific identity of the highest Upper Silurian form with the Lower Silurian one, and as none have been found in all that mass of intervening strata, I prefer provisionally to retain the two names, or until other Upper Silurian species shall have been found."

S. Scotica was originally described and figured in the Geological Magazine for January, 1877, and if the Canadian specimens are specifically identical with those from Scotland, the species must have had a considerable range in time, for the Upper Llandeilo rocks are generally regarded as of about the same age as the Chazy Limestone of the State of New York, and the Utica Slate as corresponding to beds on a comparatively high horizon in the Caradoc or Bala Group. To the paleontologist, Mr. Watts' discovery will be of special interest, as this is the first time that the occurrence of a species of *Siphonotreta* in North America has been placed upon record.

Art. XXXII.—*On a recent species of Heteropora from the Strait of Juan de Fuca;* by J. F. Whiteaves.

The genus *Heteropora* was constituted by DeBlainville in 1830 for the reception of a number of fossil species of Polyzoa of the order Cyclostomata, whose characters are thus defined by Busk: "Polyzoarium erect, cylindrical, undivided or branched; surface even, furnished with openings of two kinds; the larger representing the *orifices* of the cells, and the smaller the *ostioles* of the interstitial canals or tubes." "The essential character of the genus," writes Dr. H. A. Nicholson, "is thus the possession of a skeleton made up of two kinds of tubes, larger and smaller, the latter being the most numerous." Further, it has been ascertained that the tubes of *Heteropora* are provided with cross partitions and radiating spines, and that their walls are perforated by numerous openings. These structures have been held to be the homologues of the tabulæ and septa of the tabulate corals, and of the mural pores of the Favositidæ. Lindström, in 1876, maintained that the Paleozoic fossils known to geologists as *Chætetes*, *Stenopora* and *Monticulipora* have almost exactly the same kind of internal structure as *Heteropora*, and consequently that the former genera should be removed from the class Anthozoa, to which the true corals are supposed to belong, and placed with the Polyzoa,—a conclusion which had been arrived at ten years before by Dr. Rominger.

Many species of *Heteropora* have been described from the Mesozoic and Tertiary rocks of Europe and the United States, but no living representative of the genus had been discovered until 1879. In that year Mr. Waters described and figured a recent species from Japan under the name *H. pelliculata*, in the Journal of the Royal Microscopical Society; and a little later in the same year, in the Journal of the Linnæan Society, Mr. Busk published a diagnosis, accompanied by illustrations, of a living polyzoon from New Zealand, which he called *H. Neozelanica.* Mr. Waters and Dr. H. A. Nicholson, however, have both expressed the opinion that the *H. Neozelanica* of Busk is identical with the previously described *H. pelliculata.*

On the coast west of Sooke, Vancouver Island, in the Strait of Juan de Fuca, Mr. James Richardson, late of the Geological Survey of Canada, found a single specimen of a recent polyzoon, in 1874, which, in the writer's judgment, cannot be distinguished by any tangible character from the Japanese and New Zealand species of *Heteropora* described by Messrs. Waters and Busk. No thin sections of this specimen have been made to show the minute structures of the interior, but the whole of the outer surface has been carefully examined under the microscope, and camera drawings of some of the most striking appearances thus presented have been made. The punctured, calcareous pellicle which Mr. Waters represents as closing the mouths of the interstitial canals in *H. pelliculata*, the character which suggested that specific name, can be well seen in part of the Canadian specimen. The general shape of the polyzoary of the latter and the microscopical characters of other portions of the surface agree perfectly with Busk's figures of the corresponding parts of *H. Neozelanica.* In one portion of the surface of the Fuca polyzoon it was noticed that the apertures of some of the larger tubes project distinctly beyond the general level, a feature not specially indicated in any of Messrs. Waters' or Busk's illustrations, but this slight variation from their types can scarcely be held as indicative of a specific difference from them.

ART. XXXIII.—*Communications from the U. S. Geological Survey, Rocky Mountain Division.* II. *Notes on some interesting Minerals occurring near Pike's Peak, Colorado;* by WHITMAN CROSS and W. F. HILLEBRAND.

THE region about Pike's Peak, in El Paso County, Colorado, has, within the past few years, become well known to mineralogists the world over through the large and perfect crystals of Amazon stone (microcline), which have found their way into almost every collection of importance, in Europe as well as in America. Other minerals, for the most part associated with the Amazon stone in occurrence, have also come into circulation to a less extent. The following minerals have been announced from this region, and are all authentic, viz: microcline, albite, biotite, quartz (smoky and clear), fluorite, columbite, göthite, hematite and limonite (pseudomorph after siderite), arfvedsonite, astrophyllite and zircon.

With but one or two exceptions the minerals named occur in "cavities" or "pockets" in granite, and although large quantities of some of the species have been found there is scarcely a mineral locality which at first sight seems more unpromising than this. The coarse reddish granite of the district disintegrates rapidly through the action of the weather into a coarse, gravel-like mass, and many of the mountain slopes are made of such material, lying at a very steep angle, with solid rock projecting through it here and there. On finding fragments of crystals in the debris, the prospector for minerals, with pick and shovel in hand, endeavors to find the original cavity from which the fragments came. The "cavities" are very irregular in shape and size, and yield varying quantities of crystals. A single cavity has been known to yield more than a ton of crystallized specimens. All so far discovered have been on the surface. That a direct connection exists between the tendency of the granite to disintegrate so readily, the formation of the cavities, and the deposition of these various minerals in them, can hardly be doubted.

Quite recently several occurrences of minerals, new to this region, have come to our notice, and are thought worthy of description. We can add to the above list of minerals, topaz, phenacite, cryolite, thomsenolite, and others not yet fully determined.

The phenacite and topaz were found about two years ago by Mr. Thebaut, a prospector of Colorado Springs, associated with feldspar, smoky quartz and zircon, in one of the "pockets" described. A crystal of phenacite came into the hands of Rev. R. T. Cross, of West Denver, to whom we are indebted for calling our attention to it, and for aid in procuring other of the specimens here to be described.

Topaz.

Three crystals of topaz have been examined, all of them remarkable for size and clearness.

The most perfect one measures $2{\cdot}5^{cm}$ parallel to the vertical axis, $3{\cdot}3^{cm}$ parallel to the brachy-axis, and $2{\cdot}8^{cm}$ parallel to the macro-axis. It is colorless, and some parts of the crystal are very clear. The prisms I (∞P) and i-2 ($\infty P2$) are well developed. The terminations are drusy, although many of the prominences are large enough to admit of the determination of some of the faces which bound them. The pyramid 2 ($2P$) has been recognized with certainty, while a form between $\frac{2}{3}$ ($\frac{2}{3}P$) and 1 (P), which is probably $\frac{4}{5}$ ($\frac{4}{5}P$), and another pyramid near 2–4 ($2P4$) are also present. Measurements of sufficient accuracy for the calculation of these latter forms could not be obtained. The lateral edges of these pyramidal prominences lie in a plane corresponding to the brachydome 2-i ($2P\infty$), and although that form does not actually appear, the crystal has a domatic habitus. A rough face of 4-i ($4P\infty$) is present quite distinctly. While one termination is more perfect than the other, both are alike.

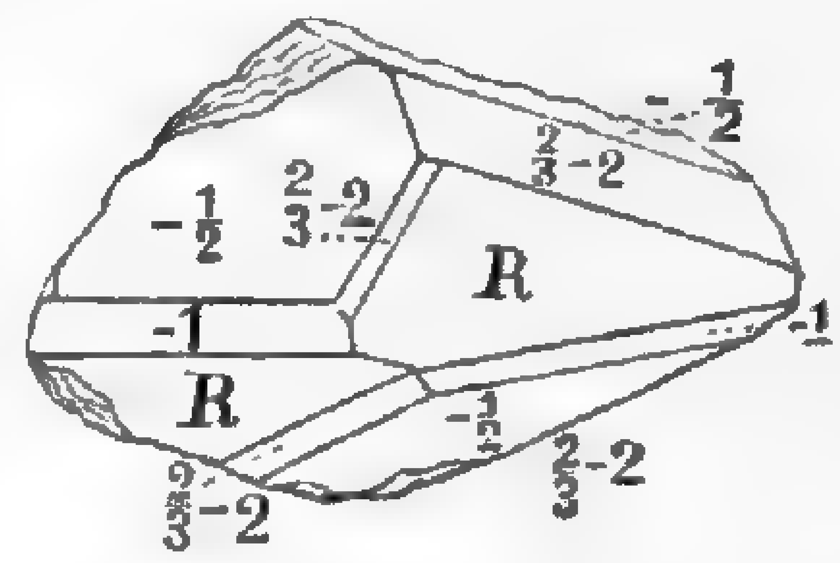
The second crystal is less perfect. The prism i-2 ($\infty P2$) predominates, and the terminations are low and indistinctly drusy. The crystal measures 5^{cm} parallel to the macro-diagonal, and has a slight greenish tinge.

The third crystal, or rather fragment, was found recently near Florissant, northwest from Pike's Peak, with Amazon stone, etc. It is mainly noteworthy on account of the enormous size of the original crystal from which it came. This specimen is but a corner of a large crystal, the forms appearing being two faces of i-2 ($\infty P2$), one of I (∞P), and one each of 2-i and 4-i. The fragment is about 9^{cm} ($3\frac{1}{2}$ in.), in its longest diameter, and if the other faces were developed to correspond to those here seen, the complete crystal must have been nearly or quite one foot in diameter parallel to the brachy-diagonal. It is clear in parts and has a decided greenish tinge. It was supposed to be fluor spar, by the original collectors, and the other pieces of the crystal are undoubtedly lost.

The specific gravity of this fragment is 3·578 at 22° C., and its chemical composition is entirely normal.

Phenacite.

The two crystals of phenacite examined were found together, and are, so far as we can learn, the only ones as yet obtained. They are but fragments, representing in each case somewhat less than half of the complete crystal. The accompanying figure represents the smaller crystal in about the natural size; the other one measures nearly 7[cm] in longest diameter, and has the same faces developed in a similar manner. In neither crystal do any faces of the vertical zone appear, thus producing a flat lenticular habitus. The forms appearing have been identified as R, $-\frac{1}{2}$ ($-\frac{1}{2}R$), -1 ($-R$), and $\frac{2}{3}$–2 ($\frac{2}{3}P2$), and although all faces are too rough to admit of exact measurements with the reflection-goniometer, the size of the faces and their simple development renders sufficient accurate results with the hand instrument possible. The angles obtained, as means of several measurements, are—



	Crystal *a*, (fig.)	Crystal *b*.	Authorities.
$R \wedge R$ (terminal) ------	-------	116° 20′	116° 36′ (D)
$R \wedge R$ (lateral) ---------	-------	63° 00′	63° 24′ (S)
$R \wedge -\frac{1}{2}$ (over $\frac{2}{3}$-2) ------	148° 30′	148° 50′	148° 18′ (D)
$R \wedge \frac{2}{3}$-2 --------------	159° 45′	159° 58′	159° 56′ (D&S)
$R \wedge -1$ --------------	74° 30′	74° 40′	74° 42′ 45″ (S)
$-\frac{1}{2} \wedge -\frac{1}{2}$ --------------	143–144° 00′	-------	144° 1′ 26″
$-\frac{1}{2} \wedge -1$ --------------	-------	163° 43′	163° 32′ 2″
$\frac{2}{3}$-2 $\wedge -\frac{1}{2}$ --------------	168° 11′	168° 50′	168° 22′ (S)
$\frac{2}{3}$-2 $\wedge \frac{2}{3}$-2 --------------	156° 40′	156° 00′	156° 44′ (D&S)

The figures of the third column are the calculated angles given for phenacite by Dana* or Seligmann†, or else our own calculations based on the theoretical values given by them. The agreement between the angles measured on these crystals and the theoretical ones is sufficiently close to justify the signs given to the faces of the figure. In the development of the different forms, R and $-\frac{1}{2}$ are always prominent, while the faces of $\frac{2}{3}$-2 are variable. One face of $\frac{2}{3}$-2 on crystal *b* is 2·5[cm] broad, although usually each face of $-\frac{1}{2}$ is broader than both adjoining faces of $\frac{2}{3}$-2; -1 is subordinate, and the faces are quite rough; $\frac{2}{3}$-2 appears with its full complement of faces. The roughness of the faces is in part caused by striæ which on $-\frac{1}{2}$ and $\frac{2}{3}$-2 run parallel to the terminal edge of R replaced by those faces. On R the markings are less distinct. These striæ and partially regular depressions seem like natural etch-figures, and bring out the rhombohedral symmetry of the mineral very plainly.

The crystallographic determination of these crystals as phenacite is confirmed by all the physical characteristics, as far as observed, and by the chemical composition. There is an imperfect cleavage parallel to i-2 ($\infty P2$). Both crystals are clear and colorless, resembling quartz, and the hardness is nearly or quite 8. The specific gravity of the crystal figured, though containing some impurities, is 2·967 at 23° C.

* Dana, System of Mineralogy, Fifth Ed., p. 263.

† G. Seligmann, in "Neues Jahrbuch für Mineralogie," etc. 1880, I, 129.

According to the latest edition of Naumann–Zirkel's "Elemente der Mineralogie" (Leipzig, 1881), phenacite has been described from but four localities—two in the Ural Mountains, one in Lothringen, and one in Mexico. Dana* gives a second locality in Mexico. The crystals described recently by Websky† being from an unknown source, the locality near Pike's Peak seems to be the *sixth* authentic occurrence of this rare mineral, and the first in the United States.

A partly historical description of phenacite and its known forms was given by G. Seligmann in the "Neues Jahrbuch für Mineralogie" etc., 1880, I, 129.

Zircon.

G. A. König has described and analyzed zircon from two occurrences of the Pike's Peak district, in one case the mineral being associated with astrophyllite,‡ and in the other with Amazon-stone.§ In one of the instances we have to describe, the zircon is intergrown with large crystals of flesh-colored microline, in one of the localities above-mentioned, and is thus analogous to the latter occurrence noticed by König. There were many loose crystals in this cavity, but a few were found penetrating or imbedded in the microline. The crystals described by König showed both pyramid and prism, but the prism is entirely lacking on all of our specimens. Some crystals are more than an inch in diameter, and these large ones especially are often mere aggregates of numerous small pyramids grown together with a common crystallographic orientation. The lateral edges of such crystals are often continuous, but the terminations are made up of many small pyramids. Although the pyramid 1 is the only prominent form, one can notice, on looking at the terminations in the right position, a minute reflecting surface on each perfect apex. A closer examination with the loupe shows it to correspond to the basis *O*, but all observed surfaces are too small to admit of certain determination.

Near the Pike's Peak toll-road, about due west from Cheyenne Mountain, a prospect tunnel, in following a vein-like mass of white quartz in granite, has disclosed a number of interesting minerals. The main body of the quartz is pure white in color and contains only traces of galena and chalcopyrite. Within this body, however, is a second smaller vein consisting likewise chiefly of white quartz, but carrying in it a number of other minerals, the most abundant of them being zircon. The

* System of Mineralogy, p. 263.
† Websky, "Neues Jahrbuch für Mineralogie," etc. 1882, I, 207.
‡ G. A. König, Zeitschrift für Krystallographie, I, p. 423.
§ G. A. König, Proc. Acad. Nat. Sci. Philad.

boundary between the two masses of quartz is sharply drawn, but the development of the tunnel is not extensive enough to show clearly the relation of the two bodies.

Throughout the greater part of the vein the zircon is imbedded directly in the quartz and is so abundant that a cubic inch of the latter mineral contains from 25 to 100 crystals and particles of zircon, varying in size from 1^{cm} downward. In parts of the vein, however, are small, irregular spaces filled with a soft, yellow foliate mineral in which are imbedded very perfect crystals of zircon. Fluorite and a white foliate mineral are sometimes associated with the others. The two foliate minerals are as yet undetermined.

This occurrence is worthy of special notice on account of the perfection of the crystals and their transparency. Some of the crystals lying in the quartz are perfectly developed, but usually their growth has been more or less hemmed by the quartz, and many are fissured. The crystals imbedded in the soft, yellow material, however, are often absolutely perfect in form, and beautifully clear. The ruling color is a deep reddish-brown with variations toward pink or a pale honey-yellow. A few crystals are of a deep emerald-green, and spots of the same were noticed in some of the pink crystals.

The common habitus of all crystals is pyramidal, the prisms being always subordinate when they appear. The forms determined with certainty are, $1\,(P)$, $3\,(3P)$, $O\,(0P)$, $3\text{-}3\,(3P3)$, $I(\infty P)$ and $i\text{-}i\,(\infty P\infty)$. The rare face O is much less frequently developed than any of the others but it was observed distinctly on at least twenty-five crystals. Repeated measurements on different crystals of the angle $O \wedge 1$ give results varying less than 3′ from the calculated value (137° 50′). Between O and 1 is a low pyramid appearing quite constantly with O, which forms an angle of 164° 46′ with 1. This corresponds very nearly to $\frac{14}{25}\,(\frac{14}{25}P)$. The angle between this form and 1 is a curved surface giving an almost continuous reflection, but the angle with O is distinct. The crystals showing O occur in the soft, yellow substance, and the face in question could not have been formed by pressure of the surrounding material. The face O was noticed by König (l. c.) on the zircon occurring with astrophyllite, but his statement has been either overlooked or discredited, as Zirkel, in the recent edition of Naumann's "Elemente der Mineralogie," says that O has not yet been observed, though he cites an analysis by König of the same zircon which showed the basis O. On all but one of our crystals O and the pyramid $\frac{14}{25}$ are developed on one end only, the other showing simply 1, thus giving a hemimorphic appearance to the crystal.

The chemical investigation of this zircon shows it to be exceedingly pure, and the specific gravity of the transparent crystals is 4·709 at 21° C.

The perfection of the crystals, with their transparency and color, make this occurrence of zircon one of the most beautiful known.

In a paper which we hope may appear in this Journal within a short time, we shall describe several minerals of the cryolite group which occur in connection with a quartz vein in the neighborhood of the zircon locality. Most of these fluorides are identical with those associated with cryolite in Greenland. The body of mineral found is of small extent, but yields a large number of species.

There are also several interesting species more or less closely associated with the zircon, in the study of which we are now engaged. The results we hope to communicate in a future number of this Journal.

Denver, Colorado, August 3, 1882.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *The production of electricity regarded as the equivalence of a chemical process.*—W. Thomson and Joule have shown that in the case of the Daniell cell all the chemical heat of the cell has its equivalence in the electrical current which is produced. J. Thomson has lately shown by careful measurements that the above-mentioned investigators were right as far as the Daniell cell is concerned. W. Thomson, among others, inclines to the belief that chemical heat in the case of all galvanic cells has its equivalence in the electric currents produced. F. Braun in this paper reiterates his objection to the above conclusion as far as it becomes a general one, and shows that in certain galvanic combinations all the chemical heat is not changed into electricity, but only a portion, which he terms useful electro-motive effect. The other portions of the heat are probably employed in internal work among the molecules of the metals and liquids used in the cell. Braun does not believe that polarization can account for the amount of heat that does not have its equivalence in an electrical current. He shows that the theory that in a combination of sulphate and acetate of zinc, copper and cadmium, the whole chemical energy manifested between and at the electrodes of the cells is transformed into the work of the electrical currents produced by these cells, leads to irreconcilable contradictions. He maintains that there are a number of *polarization free* galvanic combinations in which the processes taking place within the cells are fully known, yet which afford more electrical energy than is the equivalent of the heat of these in-

ternal processes. He calls attention to the fact that there are a large number of endothermic reactions—that is, chemical processes in which heat is absorbed—and promises a continuation of his investigation.—*Annalen der Physik und Chemie*, No. 8, 1882, pp. 562–593. J. T.

2. *Absorption of the Electric Light by the Atmosphere.*—Professors AYRTON and PERRY in using their Dispersion Photometer have been struck with the large percentage of absorption of the rays of the electric light by the atmosphere. The green rays on certain days are absorbed by an atmosphere which appears perfectly clear to the eye. The photometer employed by them has become simplified and they now use Rumford's method in preference to other screen methods.—*Phil. Mag.*, July, 1882, pp. 45–51. J. T.

3. *Tension of Mercury Vapor at low temperatures.*—The observations of various observers have differed. Those of Regnault have been generally accepted. Herr E. B. Hagen has made a careful investigation to reconcile the differences of various observers and is led to the conclusion that Regnault's results, which are given in most text-books, are too great. Hagen gives a table of comparison between his results and those of Regnault extending from 0° to 100° (for differences of 10°). At 0° Hagen obtains $0·015^{mm}$ and Regnault $0·0200^{mm}$. At 100° Hagen gives $0·21^{mm}$ while Regnault gives 0·7455.—*Ann. der Physik und Chemie*, No. 8, 1882, pp. 610–618. J. T.

4. *Influence of the quantity of gas dissolved in a liquid upon its surface tension.*—WROBLEWSKI states that in all the liquids studied by him the surface tension in contact with air is a little greater than in contact with carbonic acid. Under pressures of 1 to 30 atmospheres there exists a remarkable relation between the laws of the solubility of carbonic acid in water and the surface tension of that liquid; this relation is given in mathematical form. The phenomena are completely independent of the pressure and depend only on the state of saturation of the surface of the liquid.—*C. R.*, Aug. 7. *Phil. Mag.*, September.

5. *On the state of Carbon in Iron and Steel: a New Hypothesis of the Hardening of Steel;* by R. SYDNEY MARSDEN, D.Sc., F.R.S.E., etc. (Abstract from Proc. Edinb. Roy. Sci., 1881–1882, p. 368.)—This paper first treats of the composition and properties of the different kinds of iron, known as wrought iron, steel and cast iron, and especially of the changes which steel undergoes on being heated to redness and then suddenly cooled by plunging it into water, mercury, or oil, and known as *hardening;* also of the peculiar property known as *tempering*, by which the hardness and brittleness can be removed.

After having passed in review the chief properties of the different kinds of iron, the paper goes on to discuss the different theories that have been proposed to account for these properties.

An objection is raised against the different theories which consider the iron and carbon as chemically united together, on the grounds that if these hypotheses be true, we are then presented with an anomaly unknown in any other instance, viz., that of two elements uniting together in all proportions up to a certain point, and then suddenly losing this power, and it is very difficult to believe that such can be the case; whilst another difficulty is the fact of the carbon being capable of changing its condition and passing in and out of combination under the action of heat or different methods of cooling, in a manner at once extraordinary and totally different from anything else with which we are acquainted in the whole range of chemistry.

A new hypothesis is then given with regard to the nature of the different kinds of iron.

The carbon is considered to be in a state of solution in the iron, and it is shown (by analogy of what takes place in the case of a solution of carbon in silver) how if the metal be cooled slowly the carbon by preference crystallizes in the graphitic form, which accounts for the carbon in slowly cooled steel and cast iron being chiefly in that condition; but how if the cooling be rapidly effected by plunging the metal in water or running it into a cold mould (as in chill casting) then the carbon is not as it were given the option as to which form of crystallization it will take, but is caused to crystallize in the diamond form, and in this way the hardness of steel and chilled cast iron is accounted for by the presence of an innumerable quantity of excessively minute diamond points disseminated over the whole surface of the hardened metal. It is then shown how (supposing this hypothesis to be correct) such points of difficulty as the following can be explained, namely:

1. What constitutes the difference between steel and white cast iron, and between white and gray cast irons?
2. Why steel requires some time after fusion of the metal to become good steel?
3. How the hardening of steel takes place?
4. Why hardened steel has a less sp. gr. than unhardened steel, and why it is so brittle?
5. How tempering is effected?
6. How the passage of carbon from one condition to another can be accounted for?
7. How re-hardening takes place?
8. How the brittleness of steel is removed by tempering?
9. Why hardened steel instruments when used gradually lose their hardness?
10. Why iron containing from 0·4 to 1·7 per cent. of carbon only presents these properties of hardening and more particularly of tempering that are peculiar to steel?
11. How damascened steel is produced?

Steel is regarded as a normal solution of carbon in iron, and cast iron as a supersaturated solution, and it is shown how the difference between a normal and a supersaturated solution is sufficient to account for differences as great as those between steel and cast iron. Objections to this hypothesis are then discussed, particularly the two strongest, viz., (1) the production of hydrocarbons when hardened steel or white cast iron is dissolved in acids; and (2) the reversed analogy of the copper and tin alloys in favor of the physical theory.

6. *The Limit of the Liquid State of Matter;* by J. B. Hannay.—The conditions under which an investigation is carried out often predetermine the conclusions to be drawn from the observations made. That this has been the case with the observations made upon the upper confines of the liquid state, there is now ample evidence to show. When Cagniard de Latour, on heating liquids in sealed tubes, noticed the disappearance of the liquid surface, he came to the conclusion that the liquid state had ceased to be possible, and that the substance had passed into the gaseous state. But Latour had no means of varying the volume of his liquid to observe whether or not increase of pressure might again induce liquefaction. This defect was removed by Dr. Andrews, who constructed the well-known apparatus for varying the volume by means of a screw; and it is to the work performed with this apparatus that the above remark is applied. By two modes of observation Dr. Andrews arrived at the conclusion that the liquid and gaseous states of matter were continuous. The experiments being conducted in transparent glass tubes, the appearance of the contained fluid constituted one mode, and the registration of the pressure constituted the other. *Neither of these methods could by the necessities of the case give any aid in determining the state of matter.* Dr. Andrews's method of demonstrating the continuity, by passing from a lower to a higher temperature under a pressure which prevented the formation of vapor, ensured the homogeneity of the fluid under examination, and precluded the existence of a visible liquid surface; and as liquid and gas are equally transparent, no tidings of the state of the fluid under examination could come to him by observations of its appearance. How did Dr. Andrews tell when his tubes contained liquid? By lowering the pressure till a meniscus was seen. *Then the formation of a meniscus is the only test of the liquid state.* Dr. Andrews then obliterated the only ocular test of the fluid's condition by increasing the pressure, and raised the temperature till on again reducing the pressure no meniscus was formed, showing the fluid to be gaseous, and he then declared that no sudden change of state had occurred—that is to say, that it was impossible to say that the fluid was either liquid or gaseous, but that it had probably passed through an intermediate state. Of course a change of state had taken place, and if we only reflect that the change from cohesion to repulsion is caused by the thermal velocity of the molecules, and not by the number of them in a space, the change should depend upon temperature and not upon pressure.

The characteristic property of the liquid state is then the possession of cohesion sufficient to form a surface, or simply surface tension; and could this property be retained in a visible form at all pressures, the existence of the continuity enunciated by Andrews could be put to a crucial test. By compressing hydrogen over various liquids in which it is insoluble, I was enabled to carry the above proposition into effect, and after several hundreds of experiments, detailed in a paper read before the Royal Society, the conclusion was arrived at that the two states are not more continuous than are the solid and liquid states, but are separated by an isothermal passing through the critical point. In fact by Latour's or Andrews's method, where the liquid was in contact with its own vapor, the critical point is the only place where the direct passage from liquid to gas is visible, but the employment of hydrogen for retaining a free surface enables us to observe the passage at any pressure, and it takes place as suddenly at 200 atmospheres pressure as at the critical pressure. Thus the critical point is the termination of an isothermal line, which is the limit of the liquid state.

As to the other mode employed by Andrews—namely, pressure—continuity of pressure does not prove continuity of state. If it did the continuity of solid and liquid states could easily be proven. In fact, the irregularities observed by Andrews in the vicinity of the critical point rather lend support to the views that a change of state takes place there.

We may state the change thus:—The cohesion of the liquid state is weakened as the thermal motion increases, till the repulsion is in excess of the attraction, and the gaseous state ensues. The evidence I have collected from capillary phenomenon in the paper above referred to proves this to be the case, and shows that pressure has no effect in altering the occurrence of the phenomenon. Thus we are led to the conclusion, that so far from the liquid and gaseous states of matter being continuous and indistinguishable, the liquid limit or "absolute boiling point" *is the only fixed point among the properties of matter.* The freezing point can be altered by pressure, and besides, many bodies like ethyl alcohol may have no freezing point, probably becoming more and more viscous till absolute zero is reached. But all substances may be made to pass into the gaseous state, and even delicate compounds may be rendered gaseous without decomposition when under sufficient pressure. We see then that this important change of state, for which I propose the name Cohesion Limit, and which till lately was supposed to have no existence, is in reality the only fixed point in the relations of the states of matter, being determined by temperature alone.—*Nature*, August, 1882.

7. *Crystallization of silica from fused metals.*—Dr. R. S. Marsden, on an examination of microscopic sections of some Berlin porcelain crucibles which had been used in experiments with fused silver and amorphous carbon at a temperature considerably above the melting-point of the former, found that, while the alumina part of the crucible had undergone little change, the glaze had become a "mass of little crystals of a hexagonal form." Similar prisms were separated from the silver. The crystals quietly

dissolved in hydrofluoric acid, while not acted on by nitric or hydrochloric acid. There were also leaf-like forms, apparently silica, which are not yet fully explained.—*Proc. Roy. Soc. Edinb., Session of* 1880–1881.

II. Geology and Mineralogy.

1. *Geological age of the Taconic System;* by J. D. Dana. Quart. J. Geol. Soc., xxxviii, 397, 1882; read April 5, 1882.—This paper opens with the following paragraphs:

"A paragraph in the "Proceedings of the Geological Society" for the 16th of November last, making part of an abstract of an address by Dr. T. Sterry Hunt sustaining the pre-Cambrian age of the Taconic schists, throws more doubt than is right on the stratigraphical observations that have been made in the region by different geologists. It does not present, as a reason for doubt, any facts from the author's personal investigation convicting these geologists of errors in their statements or conclusions, but simply mentions what the author regards as a possible source of error in any study of folded metamorphic strata, and urges this as a probable source in the present case.

The paragraph says: "The speaker insisted upon the fact that where newer strata are in unconformable contact with older ones, the effect of lateral movements of compression, involving the two series, is generally to cause the newer and more yielding strata to dip towards, and even beneath the edges of the older rock, a result due to folds, often with inversion, sometimes passing into faults. This phenomenon throws much light on the supposed recency of many crystalline schists."

The supposed recency of the Taconic schists, and the observations which have led to the inference that these schists *overlie* certain Lower Silurian strata, are among the points to which the paragraph is meant especially to apply. It implies that in any overlying, apparent or actual, it is *an overlying of newer strata, unconformably.*

The Taconic system, first propounded by Professor E. Emmons about forty years since, in his New York Geological Report, published in 1842, has found a place, right or wrong, in European as well as American geological science. Whether right or wrong is therefore a question of the highest importance. I have hence thought that a brief review of the facts bearing on the two points of *unconformability to the associated rocks* and *geological age*, by one of the workers in the field, would be acceptable to the Geological Society.

The true original Taconic schists are those of the Taconic mountain range, at the base of one portion of which Professor Emmons for many years lived and labored. The range stands along the boundary region between the States of Massachusetts and New York, extends thence northward through western Vermont to its center, and southward across northwestern Connecticut into and through Dutchess County, New York. The general course of the range is nearly north and south (about N. 10° E., and S. 10° W.), and the length about 150 miles. The schists make the center of the belt. Against nearly all the eastern side of these schists there lies a stratum of crystalline limestone called the *Stockbridge Limestone* by Professor Emmons; and against the greater part of the western, another range of limestone, less perfectly crystalline, the *Sparry Limestone* of Professor Emmons. These three ranges of rocks (the central of schists, the two other of limestone) are all that need be considered: for the question is only this—are these strata conformable, or, as the cited paragraph implies, is the eastern of these limestones a newer rock than the Taconic schist, and unconformable to it?

It is plain, from these statements as to the position of the range, that the opportunities for ascertaining the relation in stratification of the Taconic schists and the adjoining limestones are not confined to a single disturbed area. They occur all along the 150 miles; and observations have been made from the northern end of the range to the southern."

It is next explained that the Taconic rocks here referred to are those of the Taconic range itself; those on which Professor Emmons founded his Taconic system; those which should be called "Taconian" if any are; and that the so-called Taconic slates of Northern Vermont and Canada and of other States or countries are not under consideration.

The paper then shows that all observers who have studied the Taconic range have described the schists and limestones as conformable; that Professors W. B. and H. D. Rogers announced this conclusion in 1841; that Dr. Emmons has published this as a fact in all his writings on the Taconic system; that the conformability and general eastward dip taught by Rogers and Emmons are explained and illustrated in the New York Geological Report of Professor W. W. Mather; (1842) in the Massachusetts Report of Professor Edward Hitchcock; in the Vermont Geological Report, by means of sections and descriptions, by Professor E. Hitchcock and Mr. (now Professor) Charles H. Hitchcock, who make the rocks not older than Lower Silurian; and this result is reiterated by Professor C. H. Hitchcock in a note published in volume xix, of this Journal (1880); that the same conclusion was sustained, after investigations of the Berkshire region, by Sir William Logan, who referred the series of slates or schists and limestones to the Quebec system; that it was still more fully proved by the investigations of Mr. A. Wing, reported at length in this Journal for 1877, who, after new discoveries of fossils, reached the conclusion that the eastern and western limestones and the slates with the accompanying quartzite, represent the whole Lower Silurian.

The paper states further that the writer's study of the rocks, over the country from Central Vermont to Western Connecticut and Dutchess County, New York, was undertaken to ascertain the fact as to conformability, and resulted in confirming the observations of previous investigators; that it also had in view the age of the rocks, and on this point proved that the western of the two limestones in Dutchess County contained Trenton fossils. To this it adds a mention of the later discoveries of numerous fossils, both Trenton and Calciferous, in the same Dutchess County limestone, by Professor Wm. B. Dwight, and of the earlier detection of Hudson River brachiopods by Mr. Nelson T. Dale, in the adjoining Poughkeepsie slates—part of the Taconic slates of Emmons, the former slates being the direct southwestward continuation of the latter.

On the closing page it is added:

"A word further with regard to the paragraph cited in the early part of this paper from the Proceedings of the Geological Society.

"This paragraph makes the stratigraphical evidence doubtful, because it says, "where newer strata are in unconformable contact with older ones, the effects of lateral movements of compression, involving the two series, is *generally* to cause the newer and more yielding strata to dip towards and even beneath the edges of the older rock."

"The fact here alleged may be questioned. But letting it stand that, under the conditions stated, the newer and more yielding strata are generally made to dip toward the older rock, it has no bearing here; for there is no such general dip along the Taconic range. The limestone of its eastern side, here claimed to be the newer, *does not generally dip toward the older rock*, that is, toward the Taconic schists, which are claimed to be the older. Through nine tenths of the length of the belt, the dip, as all observers have found, and as recognized above, is eastward for both the eastern limestone, the schists, and the western limestone, the westward dip of the eastern limestone occurring, as has been stated, in the region of the higher peaks. Hence the point *insisted* upon by the propounder of the doubt, if true in fact, has no application to the region of the Taconic schists.

2. *Geological Report on Indiana for the year* 1881; John Collett, State Geologist. 414 pp. 8vo. Indianapolis, 1882.—In the early pages of this Report, Prof. Collett gives facts respecting the architectural use of the gray Oölitic limestone, Sub-carboniferous in age (St. Louis group), which occurs in the counties of Owen, Monroe, Lawrence, Washington, Harrison and Crawford. Analyses of it were published in the Report for 1878. In an investigation, by Mr. T. H. Johnson, of its strength and elasticity, the modulus of rupture—or the load that would break a beam one inch square, resting on supports one inch apart—was found to be 2,338 lbs. for the sawed material, and 1,477 for the tool-dressed, showing the great weakening that comes from the hammering in tool-dressing. The same for compression was 12,675 and 7,857 lbs.

The following pages treat of the topographical features, geology and economical mineral products of Shelby, Fountain, Delaware and Bartholomew Counties. The volume is very full in its paleontological portion, which includes a memoir by Prof. JAMES HALL, on the Fauna of the Niagara Group of Central Indiana, covering 130 pages of the volume, with 30 plates; and another by Dr. C. A. WHITE on other fossils of the Indiana rocks, occupying the remaining 55 pages, with 19 plates. Prof. Hall's memoir is chiefly from his paper published in a documentary edition of the New York State Museum Report in 1876, and in 1879 in the Museum edition of the Report, and a later paper in the Transactions of the Albany Institute for 1879. The pages by Dr. White contain descriptions of various Illinois fossils, four of which are new species, and some of the others were never before figured. The last twelve of the plates are made up of figures of corals, engraved many years since by J. W. Van Cleve, and in the text are contained the descriptions of them by the authors on American corals who have identified the species. The new species described by Dr. White are *Gyroceras Elrodi*, from the Niagara group, *Patella Levettei*, from the St. Louis group at Spergen Hill, *Lepidesthes Colletti*, from the Keokuk division of the Subcarboniferous, and *Agaricocrinus Springeri*, probably from the Keokuk or lower Burlington division of the Subcarboniferous. These memoirs on fossils make the Report especially convenient and valuable for the student of Illinois geology. Copies of the original plates of Van Cleve it is now almost impossible to obtain.

3. *Nummulitic deposits in Florida.*—Specimens of a white or yellowish-white friable limestone from the vicinity of the Cheeshowiska River, Hernando County, four miles from the coast, consist chiefly, according to Mr. ANGELO HEILPRIN (Proc. Acad. Sci. Philad., 1882, p. 189), of Nummulites of the genus *Nummulina*. They are of one species, which he names *N. Willcoxi*, from its discoverer Mr. Joseph Willcox. It is remarkable, as stated by the author, that the accompanying fossil mollusks are of species more recent than Eocene, even *living species of fresh-water genera*, viz., *Glandina parallela*, *Paludina Waltonii*, *Ampullaria depressa*. But the genus *Orbitoides*, which had its largest development in the Upper Eocene, is also present, indicating with "little or no doubt" that the rock fragments "derived their faunal character from deposits of a more ancient formation," either Eocene or Oligocene; and the original beds may possibly be now submerged.

4. *Mastodons in New Jersey.*—Prof. LOCKWOOD, in a paper read before the American Association at Montreal, described his discovery and uncovering of mastodon remains in a peat meadow about two miles west of Freehold, New Jersey. The skeleton rested on the hard-pan, beneath the peat, with the right side below and the tusks beneath the neck. It was inferred, from the conditions observed, that the mastodon died on the right bank of the stream which there existed; and, since there lay over the neck many fragments of sticks that had been cut by beavers, it is concluded that the stream was afterward dammed by the beavers so that the pond they made covered the skeleton; subsequently, on

the disappearance of the dam, the pond ultimately was drained, and the area became a peat swamp and afterward a meadow.

The author reported the finding of teeth of a mastodon in two instances at distant intervals, out at sea off Long Branch; and the taking of a tusk and other bones from an ancient buried swamp about fifteen miles south of Long Branch, the swamp having been recently uncovered during a severe storm from the sea. He presented these facts as new evidence of a recent subsidence of the New Jersey coast, and as proof that the mastodon was living in the region after the appearance of the modern beaver. The teeth and tusks were in a bad state of preservation, and crumbled to pieces on reaching the air.

5. *New Fossil Marsupials.*—Prof. E. D. Cope, in the American Naturalist for August, adds three to the two species of kangaroo-like marsupials which he has described from the Eocene of Puerco, New Mexico, and for one of them the new genus, *Polymastodon*, is instituted. The species are *P. Taöensis*, *Catopsalis pollux*, *Ptilodus Troverssartianus* (after Dr. E. L. Trouessart of Angers). He also describes from the same beds *Haploconus entoconus* and *H. Gillianus*.

6. *Fossil Corals of the Niagara and Upper Helderberg Groups*, by James Hall. 60 pp. 8vo. Published in advance of the Annual Report of the State Museum of Natural History. August, 1882.—This paper contains brief descriptions of a large number of new species from the groups above mentioned, fuller descriptions of which, with detailed illustrations, to constitute volumes of the Reports on the Paleontology of the State, have been long ready for publication.

7. *G. Lindström on Silurian Corals from Northern Russia and Siberia* (Svenska v. Akad. Handl., vi, No. 18, January, 1882).—Mr. Lindström describes and figures both Lower and Upper Silurian species of coral, and among them new species of the genera *Cyrtophyllum*, *Rhaphidophyllum*, *Zaphrentis*, *Acervularia* and *Palæaræa*.

8. *Supposed subterranean drainage of the interior of Australia.*—In a paper, in the Journal of the Royal Society of N. S. Wales, vol. xv, 1882, entitled "Notes of a Journey on the Darling," by Mr. W. E. Abbott, the author refers to the observations of Mr. Russell, which seem to prove that the amount of water received by precipitation over the watershed of the Darling much exceeds that which is carried off by the Darling and by evaporation; and he inclines to the opinion expressed by Mr. Russell, that there is an underground drainage system wholly distinct and different in direction from the surface drainage. The underground water would probably take a course to the southwest; and he suggests that this may have been the course of a more ancient river-system. Some evidence with regard to such subterranean waters is presented from wells which have been sunk in the vicinity of the Darling, and whose flow seems to be independent of variations in that river.

III. Botany and Zoology.

1. G. Briosi. *Sopra un Organo finora non avertito di alcuni Embrioni Vegetali.* Abstract of a Memoir presented in 1881 to the *Accademia dei Lincei*, now published in the Proceedings of the *Stazione Chimico-Agraria Sperimentale* of Rome, by its Director Briosi. Illustrated by eighteen figures on three lithographic plates.—The discovery here announced was made in the first instance upon the germinating seeds of *Eucalyptus globulus.* The caulicle (radicle of systematic writers) is slightly club-shaped, and with broad extremity as it were truncate. Close examination and longitudinal section show an opening at the extremity into a shallow cavity, partly filled by a conical projection from above. This is the incipient root, which develops in the usual way. The hollowed extremity of the caulicle surrounding it grows into an annulus or frill of considerable size, and the whole surface of this promptly developes long "root-hairs," or their equivalents, forming a conspicuous ruff, not unlike that in the portraits of Velasquez and other painters of that period. This ruff of root-hairs is fully developed before these appear on the young root: the whole withers away after the latter has attained a certain development. A great number of species of *Eucalyptus* were examined, some in seed only, others in germination, and all show the same structure. Traces of the same were observed in *Callistemon. Fabricia lævigata* produces the ruff of long root-hairs at the junction of caulicle and root, but without any evident development of the annulus. Species of *Leptospermum* and *Melaleuca* show the annulus more or less. *Myrtus Tarentina* and *M. Romana* accord with *Fabricia.* Extending his observations somewhat into orders allied to the *Myrtaceæ*, Briosi found a beautiful ring of very long hairs at the junction of caulicle and root of germinating *Lythrum Salicaria* and *Heimia salicifolia*, and somewhat the same in three species of *Epilobium;* but found no trace of it in *Godetia* and *Œnothera.*

Briosi naturally takes the function of this collar of hairs on the base of the caulicle to be the same as that of the ordinary root-hairs: it is a provision for the absorption of moisture from the soil, which comes into action at a very early period in germination, before the root and its root-hairs are produced.

An appendix to this interesting paper rehearses some objections made by Professor Caruel to its title, "About an organ of some vegetable embryos hitherto unnoticed,"—first, because he takes the "organ" to be the *coleorhiza* of Richard, and secondly, because Irmisch had, in 1876, mentioned and roughly figured an "annular inflation" at the junction of caulicle and root-radicle in a germinating *Eucalyptus globulus,* and compared it with what is found in many *Cucurbitaceæ*, etc. To which Briosi well rejoins, that this open *calotte* of *Eucalyptus* cannot well be the homologue of the closed *coleorhiza* of Richard, through which the incipient root breaks its way, and which has no function, the term *coleorhiza* being only an inapt expression of the fact that the root originates within: whereas this is a structure with evident function. Also that Irmisch, as his figure and remarks prove, saw the structure too late to discover its origin and meaning. A. G.

2. *Latent Vitality of Seeds.*—This is the heading of a short article in a recent number of the Gardeners' Chronicle, mentioning "some preliminary experiments to ascertain the effects of different conditions on the latent vitality of seeds," by Van Tieghem and G. Bonnier. Several packets of seeds, supplied by Vilmorin, were, in January, 1880, divided into three equal parts; one portion exposed to the free air but screened from dust; another in closed air, being tightly corked up in a tube; the third placed in pure carbonic acid. At the end of two years the seeds were taken out, weighed and sown. All those which had been exposed to free air had gained in weight; for instance, beans had gained $\frac{1}{50}$ and peas about $\frac{1}{72}$ of their original weight. The seeds confined in closed air had gained a little, peas $\frac{1}{790}$ and beans $\frac{1}{1190}$. The seeds confined in carbonic acid gas hardly at all varied from their original weight. As to comparative germination; of

Peas kept in the free air, 90 per cent germinated.
" " " closed air, 45 " "
" " " carbonic acid, none.
Beans (*Phaseoli*) kept in free air, 98 per cent germinated.
" " closed air, 2 " "
" " carbonic acid, none.

If the full course of experiments gives such results, it will (we should say) be made clear, 1st, that the vegetable embryo in the seed is not strictly speaking latent, but is doing some work, however little, is keeping up a respiration, which is essential to its continued life. 2, That the life of seeds cannot be indefinitely prolonged. *Very old* seeds exposed to the air must be dead by exhaustion, and those deeply buried, by suffocation; and the numerous recorded cases of the germination of ancient seeds are more and more to be distrusted. A. G.

3. *Contributions to American Botany, X.* By SERENO WATSON. From the Proceedings of the American Academy of Arts and Sciences, vol. xvii. pp. 316–382. Issued August 10, 1882, with an Index, pp. 1–5.—This is the tenth of the series of contributions which the author has made since the publication of the Botany of King's Exploration upon the 40th parallel, ten or twelve years ago; which shows unparalleled activity. The leading paper in the present publication is a *List of Plants from Southwestern Texas and Northern Mexico, collected chiefly by Dr. E. Palmer in* 1879–80; Part I, *Polypetalæ.* This collection has been distributed in sets among botanists; and the determination is opportune and important. The Texan portion of the collection is of comparatively small account, having been made at an unpropitious season. That of the adjacent parts of Mexico

(in Coahuila and Nuevo Leon), is most interesting, as few herbaria possess the plants collected in this region by Gregg, Wislicenus and Berlandier. It supplements the earlier collection made by Dr. Palmer in conjunction with Dr. Parry, in the province of San Luis Potosi, which was also distributed, and it contains a good many new plants. Some plants received from Dr. Dugès of Guanajuato, and more from a recent collection of Dr. Schaffner are added. The second paper consists of *Descriptions of New Species of Plants, chiefly of our Western Territories.* Seventy-six species are here characterized, of which 47 are Polypetalæ; two are Gamopetalæ; namely, *Douglasia dentata* of the author's own discovery, in the interior of Washington Territory (very near *D. lævigata*) and *Pedicularis Furbishiæ*, an interesting discovery, "on wet banks of the St. John's River, at Van Buren, Aroostook Co., Maine, and extending along the river for sixty miles. Dedicated to its discoverer Miss Kate Furbish, whose careful study of the flora of her State, and perseverance and success in illustrating it by colored drawings of all the species, richly deserve an appropriate recognition." The remainder are Apetalæ (four more species of *Atriplex* and as many of *Eriogonum*) and Monocotyledones (three of *Allium*, two of *Brodiæa*). One of them is the remarkable *Cypripedium fasciculatum* of Kellogg, now first published, which, in addition to three or four Californian localities, has been detected by Mr. Suksdorf in Washington Territory. The following notice contains the title and contents of another separate issue from the same volume.

4. *Contributions to North American Botany*, by ASA GRAY. From Proc. of Am. Academy of Arts and Sciences, vol. xvii. Issued June 26, 1882, pp. 163–230.—It contains: 1. *Studies of Aster and Solidago in the older Herbaria;* to which is added a conspectus of *Solidago* as the species are now understood and received by the writer. 2. *Novitiæ Arizonicæ*, etc., being characters of new species, and critical notes on some old ones, in recent collections, for the most part made in Arizona and adjacent parts of Mexico, California, etc. This publication appears to add 85 new species; some of them were distinguished and named by other botanists. Naturally they run very much to *Compositæ*, three new genera of which are here proposed, viz: *Plummera* (*floribunda*), dedicated to the discoverer, the wife of Mr. Lemmon; *Dugesia* (*Mexicana*), dedicated to Professor Alfred Dugès of Guanajuato, Mexico, a little plant which was formerly named *Lindheimera Mexicana;* and *Hecastocleis Shockleyi*, a very curious Mutisiaceous shrubby Composita, discovered by Mr. W. S. Shockley in Southwestern Nevada. The principal contributors of these *novitiæ* are Mr. and Mrs. Lemmon, Messrs. Pringle, Palmer (Northern Mexican collection), and the Messrs. Parish. From notes and from seeds contributed by the latter is derived the illustration of the embryo and germination of *Bursera microphylla*, at the close of the paper. The plant is remarkable for its biternately divided cotyledons. A. G.

5. *Journal of the Linnean Society; Botany.*—The two most recent numbers, 120 and 121, issued last summer, besides numerous other papers, have the special interest of containing the last writings, and an account of the last investigations, of Charles Darwin, viz: his paper on "*The Action of Carbonate of Ammonia on the Roots of certain Plants,*" and "*The Action of Carbonate of Ammonia on Chlorophyll-bodies;* which were read on the 6th and the 16th of March, little more than a month before his death. The two papers are characteristic specimens of the acute and painstaking researches, suggested by seemingly casual observations in former years, the following up of which became the chosen occupation of his later days. As they fill nearly fifty pages of the Journal, we cannot here undertake an analysis of them. One of these numbers likewise contains Francis Darwin's paper *On the connection between Geotropism and Growth,* a convincing reply to some criticisms by Weisner, made by means of new experiments.

In the last number B. Daydon Jackson, the Secretary of the Society, has an article *On the Occurrence of Single Florets on the Rootstock of Catananche lutea* (a Cichoraceous *Composita*), a discovery of M. Battandier in Algeria. A note at the close states that he had just accidentally ascertained that Salisbury knew of these radical solitary flowers, and gives a reference to his Prodromus (1796). Mr. Jackson adverts also to an analogous case, that of the American and much of the Asiatic (but not the European) *Scirpus supinus,* the solitary radical flowers of which were discovered here by Mr. Morong, and announced in this Journal. South African specimens in Kew herbarium also show these peculiar flowers.

Sir Joseph Hooker also characterizes *Dyera, a new Genus of Rubber-producing Plants,* Malayan *Apocynaceæ,* which is appropriately dedicated to the accomplished and efficient Assistant Director of Kew Gardens, T. Thiselton Dyer. H. Marshall Ward, who went to Ceylon for the purpose, here publishes *Researches on the Life-history of Hemileia vastatrix, the Fungus of the Coffee-leaf disease,* an elaborate paper, of 36 pages.

A. G.

6. *Analyses of the ash of Epiphytic Plants,* by A. Dixon. (Journ. Roy. Soc. New South Wales, 1881).—The special object in view in these analyses was to ascertain (1) the amount and kind of ash as compared with plants that grow in ordinary soil, and (2) the relations of the constituents to those afforded by the ash of the tree on which the epiphytes grew. The species examined were ferns of the genus Platycerium and one of an Asplenium.

The *Platycerium grande,* or stag's horn fern, "grows single, and throws out, at intervals of about six months, large barren fronds or plates alternately to the right and left, which cling closely to the fronds which preceded them and to the tree to which it has attached itself at the bottom and sides; whilst the upper part spreads out into a crown, surmounted by antler-like processes, from which it derives its common name of stag's-horn fern. As the fern grows outward from the tree stem by the addition of plate upon plate, a basket-like space is left behind the crown, or perhaps it should be rather called coronet, to distinguish it from the growing crown of the plant; and this space forms a receptacle for rain, leaves and dust, while the dead plates form a humus-like mass interspersed with small rootlets, which often weighs several hundred weight. In this peaty matter an abundant fauna finds shelter, the specimen which was obtained for examination containing earthworms, centipedes, two species of ant, and several beetles. Some of these probably bring nutriment to the plant from without."

The ash from the live fronds amounted to 8·62 per cent; that from the humus and roots, 3·21 and 2·02 per cent; that from the wood and bark of the tree on which it grew, 1·27 per cent. The analyses of the ash afforded:

	From live fronds.	From humus.	From roots.	From wood and bark of tree.
Potash	33·88	7·05	11·25	14·93
Soda	11·33	2·26	3·61 KCl	8·09
Sodium chloride	1·77	2·26	3·61	trace
Lime	21·99	26·63	42·52	39·91
Magnesia	5·58	2·26	3·61	23·84
Alumina	8·16	12·88	20·55	----
Iron sesquioxide	2·47	1·83	2·90	1·46
Manganese oxide, Mn_3O_4	0·45	----	----	trace
Phosphorus pentoxide	9·18	1·16	1·85	7·94
Sulphur trioxide	1·47	6·33	10·10	trace.
Soluble silica	3·54	----	----	3·89
Silica and undecomp. silicates	----	37·31	----	----
	99·82	99·97	100·00	100·06

The species *Platycerium alcicorne*, similar to the last, but growing not singly but numerous individuals together and forming a common humus mass, and either on projecting rocks or attached to the stems of Casuarinas and other trees, afforded 4·51 per cent of ash from live fronds of a plant grown on a rock, and 4·74 of a plant grown on a Casuarina. The ash contained:

	A. grown on a rock.	B. grown on a Casuarina.	Dead frond of B.	Humus of B.	Casuarina bark & wood.
Potash	20·51	40·48	2·95	7·51	9·59
Soda	17·90	21·68	13·71	----	9·87
Sodium chloride	12·07	10·16 KCl	5·64	9·64	4·01
Lime	13·73	5·03	28·54	39·89	50·57
Magnesia	14·57	4·77	7·07	8·29	11·54
Alumina	10·51	7·28	21·72	13·41	----
Iron sesquioxide	1·26	0·68	4·74	4·63	1·34
Mn_3O_4	1·74	----	----	----	1·85
Phosphorus pentoxide	3·13	4·75	5·38	4·41	8·38
Sulphur trioxide	2·58	3·95	10·25	12·22	trace
Soluble silica	1·73	0·93	----	----	3·24
Sand and silica	----	----	----	----	----
	99·73	99·71	100·00	100·00	100·39

The amount of ash from the withered fronds of B, after separating sand and a trace of copper, was 1·21 per cent; and from the humus, 1·91 per cent, from the Casuarina wood and bark, 2·03 per cent. In an analysis of the ash (12·55 per cent) of *Asplenium nidus*, the author found no alumina, 28·26 potash, 23·10 potassium chloride, 13·26 sodium chloride, 18·56 lime, 0·87 iron sesquioxide, 5·53 phosphorus pentoxide, 1·11 sulphur trioxide and 2·15 soluble silica =99·56. The ash (1·31 per cent) from the tree on which the Asplenium grew afforded 22·12 potash and 3·93 potassium with no soda and traces only of sodium chloride, with 38·07 lime and 17·07 soluble silica.

The author remarks in conclusion that the epiphytes do not get their inorganic matters from the plants on which they grow; and that the sand often present in the humus indicates that they obtain much in the form of dust.

IV. Astronomy.

1. *Elements of the great Comet of September*, 1882, from observations on Sept. 19·1, 19·9 and 20·9, made at the U. S. Naval Observatory. Communicated by the Superintendent of the U. S. Naval Observatory, Washington, D. C.

T	= Sept. 16·9836 Wash. M. T.			
π	= 57°	23′	8″	[Obs.—Comp.]
Ω	= 346	26	41	Agreement of middle place { $\lambda = -11''$
i	= 142	11	40	$\beta = -11''$
ω	= 70	56	26	
log q =	7·9395			

Observations.

	h	m	s		h	m	s	°	′	″
Sept. 19·1	2	45	42·7	W. M. T.	11	19	39·8	+ 0	7	34
19·9	on meridian.				11	14	18·94	− 0	34	28·5
20·6	on meridian.				11	9	10·97	− 1	19	21·1
23·7	18	19	35	W. M. T.	10	58	12	− 3	9	54

The elements were computed by Messrs. Frisby and Skinner.

Ephemeris computed by Prof. Frisby.

	α h	m	s	δ °	′	log Δ	log r	$\frac{1}{r^2\Delta^2}$
Sept. 10·5	9	56	10	− 0	48·1	0·0330	9·5827	0·221
12·5	10	20	13	− 0	27·8	0·0138	9·4771	0·393
22·5	11	3	20	− 2	14·9	0·0745	9·6144	0·250
26·5	10	50	44	4	40·0	0·0982	9·6794	0·105
30·5	10	41	37	6	48·0	0·1144	9·7847	0·060
Oct. 4·5	10	34	25	8	41·4	0·1275	9·8611	0·040
8·5	10	28	3	10	31·0	0·1383	9·9226	0·028
12·5	10	22	22	12	15·6	0·1467	9·9729	0·022
16·5	10	16	53	13	52·6	0·1532	0·0158	0·017
20·5	10	11	23	15	32·8	0·1584	0·0531	0·014
24·5	10	8	16	− 17	3·2	0·1612	0·0788	0·013

$$x = r\,[9{\cdot}99558]\sin(171^\circ\ 43'\ 32'' + v)$$
$$y = r\,[9{\cdot}98796]\sin(263^\circ\ 42'\ 42'' + v)$$
$$z = r\,[9{\cdot}43629]\sin(\ 50^\circ\ 58'\ \ 0'' + v)$$

2. *Anales de la Officina Meteorológica Argentina, por su director* B. A. Gould. Vol. II, 4°, Buenos Aires, 1881.—This volume (for notice of vol. i, see this Journal, xvii, p. 83) contains the results of observations during a period of twenty years, at Bahia Blanca by Senor Caronti, and during seven years at Corrientes

by Senor Fitz-Simon. The observations are discussed in full by Dr. Gould, and the results expressed by trigonometrical formulas and by plates.

3. *Monograph of the Central parts of the Nebula of Orion;* by E. S. HOLDEN. Appendix to the Washington Astron. Observations for 1878. 4°, pp. 230. Government Printing Office, 1882. —This is an elaborate résumé and discussion of all the observations hitherto made on the central parts of this nebula. The accessible published and unpublished drawings are in general reproduced. The author's observations made with the Washington 26-inch telescope from 1874 to 1880 are added, and the monograph very appropriately closes with the photograph taken by Professor Henry Draper, March 14, 1882.

4. *Report of the Superintendent of the U. S. Coast and Geodetic Survey, for the year ending June,* 1878. Washington, Gov. Printing Office, 1881.—Besides the full account of the work on the coasts and in the interior done by the survey during the year, this report has with other subjects in the appendices: Observations on the Transit of Mercury; Adjustment of the primary triangulation between the Kent Island and Atlantic base-lines; Physical Survey of the Delaware river in front of Philadelphia, by Henry Mitchell; Meteorological researches, by Wm. Ferrel; and Discussion of Tides in Penobscot Bay, by Wm. Ferrel.

The triangulation between Kent Island and the Atlantic consisting of sixty-two triangles and stretching over 602 miles, gave for a central line of the chain 29·5 miles long only a difference in length of half an inch, according as the length was computed from the one or from the other base line. The treatment of the triangles is given in full by Mr. Schott and Mr. Doolittle.

The first of Mr. Ferrel's papers is an extended one on cyclones, tornadoes, and waterspouts. An abstract is given on p. 33, vol. xxii.

5. *Report of the Superintendent of the U. S. Coast and Geodetic Survey for the year ending June,* 1879. Washington, 1881.—The Appendices to this report of the late superintendent, Mr. Patterson, include the following among other papers: Comparison of local deflections of the plumb-line, by C. A. Schott; Secular change of magnetic declination in the U. S. and at some foreign stations, by C. A. Schott (fourth edition); Physical Geography of the Gulf of Maine, by Henry Mitchell; The internal constitution of the earth, by B. Peirce; Instruments and methods used for precise leveling, by O. H. Pittmann; Refraction on lines passing near a surface of water in geodetic leveling, by Andrew Braid.

The decided superiority of Clarke's spheroid over Bessel's for the figure of the earth is shown by Mr. Schott.

6. *Resultados del Observatorio Nacional Argentino en Córdoba,* BENJ. A. GOULD, director. Vol. ii. Buenos Aires, 1881.—The first volume of this series was the Uranometria Argentina (see this Journal, xix, p. 376). The present volume contains the zone observations of 1872, being 128 zones with an average of over 100

stars each. Dr. Gould has nearly ready for printing all the observations made at the Observatory up to 1880 inclusive, which reach the enormous number of over 250,000. These will require for proper publication twelve more volumes; and they will constitute one of the most important contributions made to astronomy in this generation.

V. Miscellaneous Scientific Intelligence.

1. *Meeting of the American Association for the Advancement of Science at Montreal.*—The thirty-first meeting of the American Association was held at Montreal, under the presidency of Dr. J. W. Dawson, of McGill College. The meeting opened on Wednesday, August 23, with a General Session in Molson Hall, McGill College. This was called to order by the retiring president, Professor George J. Brush, and the chair was then resigned by him to the president elect, Dr. J. W. Dawson. Introductory remarks were made by Dr. T. Sterry Hunt, chairman of the Local Committee, and a welcome to the Association on behalf of the citizens of Montreal was pronounced by the Hon. J. L. Beaudry, mayor of the city; a reply to these addresses was made by President Dawson. After the transaction of some special business the Session adjourned, and the work of organizing the Sections was proceeded with. In the evening of Wednesday, the address of the retiring president, Professor Brush, was delivered before a large audience in the Queen's Hall, upon the early History of American Mineralogy. Following this address there was a reception of the members of the Association by the Local Committee in the Assembly Room of the same building.

On Thursday the special work of the various Sections was opened by addresses from the several vice-presidents. These officers were as follows: in Section A, Mathematics and Astronomy, William Harkness, (in his absence his address was read by Professor Eastman), W. A. Rogers was later elected to preside over the Section; in Section B, Physics, T. C. Mendenhall; in Section C, Chemistry, H. Carrington Bolton; in Section D, Mechanical Science, W. P. Trowbridge; in Section E, Geology and Geography, E. T. Cox; in Section F, Biology, W. H. Dall; in Section G, Histology and Microscopy, A. H. Tuttle; in Section H, Anthropology, Alex. Winchell, in the absence of Daniel Wilson; in Section I, Economic Science and Statistics, E. B. Elliott. The remainder of Thursday and also Friday, Monday, Tuesday and in case of some of the Sections a portion of Wednesday, August 30, were devoted to the reading of papers, a list of which is given beyond. Thursday evening a reception was given to the members of the Association by the President, Dr. J. W. Dawson, in the new Peter Redpath Museum; and at this time the Museum was formally opened. During a portion of the evening an address was delivered in the Lecture room of the Museum by Rev. H. C. Hovey on Caves and Cave Scenery, illustrated by numerous lantern views. Saturday, August 26, was devoted to excursions to Quebec and Ottawa, in one or the other of which nearly all the members present took part. Tuesday evening, August 29, a lecture was delivered by Dr. William B. Carpenter, of London, in Queen's Hall, upon the Temperatures of the Deep Sea. Most of the Sections adjourned on Tuesday, and on Wednesday, the 30th, after the election of the officers for the following meeting, as noted beyond, the Association adjourned. On Thursday a concluding excursion to Lake Memphremagog was enjoyed by many of those who remained to the end.

The meeting was with one exception the largest which has ever been held, between 950 and 1,000 names being enrolled. The arrangements made by the Local Committee were in all respects admirable, and the liberal hospitality shown to the members by the citizens of Montreal, as also those of Quebec and Ottawa, was worthy of the highest praise. Nothing was left undone which could contribute in any way to the comfort or entertainment of the visitors. Numerous receptions were given by prominent citizens of Montreal in the afternoons and evenings, and besides the longer excursions mentioned, various shorter excursions to the Lachine Rapids, to the Victoria Bridge and so on, were provided for the unoccupied hours.

The next meeting of the Association, in August, 1883, was appointed to be held at Minneapolis, Minn. The officers elected are as follows:—

President, C. A. Young of Princeton; *Permanent Secretary*, F. W. Putnam (continued); *General Secretary*, J. R. Eastman of Washington; *Assistant General Secretary*, Alfred Springer of Cincinnati; *Treasurer*, Wm. Lilly of Mauch Chunk, Penn.

Vice-Presidents—Section A, W. A. Rogers, Cambridge, Mass.; Section B, H. A. Rowland, Baltimore, Md.; Section C, Edward W. Morley, Cleveland, O.; Section D, DeVolson Wood, Hoboken, N. J.; Section E, C. H. Hitchcock, Hanover, N. H.; Section F, W. J. Beale, Lansing, Mich.; Section G, J. D. Cox, Cincinnati, O.; Section H, O. T. Mason, Washington, D. C.; Section I, F. B. Hough, Lowville, Ky.

Secretaries of the Sections.—Section A, W. W. Johnson, Annapolis; Section B, C. K. Wead, Ann Arbor; Section C, J. W. Langley, Ann Arbor; Section D, A. J. Dubois, New Haven; Section E, Alex. A. Julien, New York; Section F, S. A. Forbes, Normal; Section G, Carl Seiler, Philadelphia; Section H, G. H. Perkin, Burlington; Section I, Joseph Cummings, Evanston.

List of Papers accepted for Reading.

Section A, Mathematics and Astronomy.

A. Hall: Parallax of *a* Lyræ and 61 Cygni.

C. A. Young: Description of the new 23-inch equatorial recently erected in the Halstead Observatory, at Princeton, N. J.

W. W. Johnson: Inverse elliptic functions and the imaginary period; Circular coördinates, and complex anharmonic ratios.

W. E. Hamilton: A mode of representing any cyclical fact in meteorology.

T. C. Mendenhall: Note on an experimental solution of a problem in the doctrine of chances.

PLINY EARLE CHASE: Conservatism of solar energy.

C. P. HART: On the arithmetic of chords.

WM. A. ROGERS: On the performance of a new form of astronomical level; On a method of reducing different catalogues of stars to a homogeneous system.

P. H. VAN DER WEYDE: Some suggestions on the nature of comets, in connection with recent astronomical and electrical discoveries.

JAMES E. OLIVER: A method of finding the law of linear elasticity in a metal; On the law of distribution for certain plant numbers.

SAMUEL HAUGHTON: New views of Mr. George H. Darwin's theory of the evolution of the Earth Moon system, considered as to its bearings on the question of the duration of geological time.

J. BURKITT WEBB: A method of eliminating the personal equation in transit observations.

CHARLES H. ROCKWELL: Scheme for observing the great Eclipse of May, 1883.

HENRY M. PARKHURST: Bell attachment for telescope circles (with illustration).

Section B, Physics.

S. P. LANGLEY: The color of the Sun.

STEPHEN S. HAIGHT: Danger from lightning increased by telegraph wires.

WM. H. BREWER: On the apparent size of magnified objects.

W. LECONTE STEVENS: On vision by the light of the electric spark; The binocular union of spectral images.

PLINY EARLE CHASE: Atomic phyllotaxy.

GEORGE F. BARKER: On secondary batteries.

DEVOLSON WOOD: The tension of the luminiferous ether.

ALEX. GRAHAM BELL: Upon the electrical experiments to determine the location of the bullet in the body of the late President Garfield; and upon a successful form of inductive balance for the painless detection of metallic masses embedded in the human body; Upon a proposed method of producing artificial respiration by means of a vacuum jacket.

GEORGE ILES: The force of diffusion of the gases forming the atmosphere.

S. W. ROBINSON: Electric induction by stress.

D. P. PENHALLOW: A new soil thermometer.

T. C. MENDENHALL: On the reduction of the electrical resistance of the carbon button by the passage of an electrical current.

H. A. ROWLAND: Concave gratings for use in spectroscopic work.

H. T. EDDY: Radiant heat an exception to the second law of thermodynamics.

A. E. DOLBEAR: On the constitution of magnets; On electrical conduction *vs.* induction; On the telephone as an explorer in an electric field; On vortex ring phenomena; On telegraphing without wires.

W. A. ROGERS: Exhibition of a simple and inexpensive comparator for measuring distances between the limits 1 min. and 1 dm.; Experimental determination of the limits of accuracy in measurements by the sense of feeling; Determination of the relation: Metre des Archives = Imperial yard + 3·37015 inches.

E. S. NICHOLS: On the duration of color impressions upon the retina.

P. H. VAN DER WEYDE: On the diatonic scales obtained in the chromatic scales of equal temperament of 12, 19 and 31 tones in the octave, with exhibition of novel scale indicators and correcting keyboard.

J. R. BARTLETT: Experiments with Siemens' electrical deep-sea sounding apparatus.

CHARLES K. WEAD: On a mean direction integration anemometer.

C. S. HASTINGS: On certain complex flame spectra of sodium.

JAS. D. WARNER: Note on the appearance of a halo on the evening of Aug. 4th, 1882.

RUDOLPH KŒNIG: The influence of harmonics on the timbre of sound.

HENRY CARMICHAEL: An instrument for readily producing low temperatures.

BROWN AYRES: On some phenomena of diffraction due to the shape of the source of light.

EDWIN H. HALL: On the "rotational coefficient" in gold, iron, etc.

Section C, Chemistry.

THOMAS W. TOBIN: On the causes which render flour and organic dust explosive, with suggestions for the prevention of such explosions.

LEONARD P. KENNICUTT: Action of water at 100° C. on the B-phenyltribrompropionic acid.

ALBERT R. LEEDS: Preliminary notice of a new organic base.

H. CARRINGTON BOLTON: Application of organic acids to the examination of minerals: Note on the absorption spectrum of humic acid.

C. F. MABERY and RALPH WILSON: The action of basic hydrate on chlortribrompropionic acids: On certain substituted acrylic and propionic acids.

CHAS. W. DABNEY, Jr.: Notes on effects of different soils upon soluble phosphates; Some derivatives of isopicraminic acid; A benzoyl anhydro acid from B-metamidosalicylic.

C. F. MABERY: On the products of the distillation of wood at low temperatures.

C. C. CALDWELL: Pemberton's method for the volumetric determination of phosphoric acid.

HARVEY W. WILEY and C. A. CROMPTON: Estimation of dextrine in solid commercial starch sugar by loss of rotatory power on solution.

ARTHUR H. ELLIOTT and FRED SANDS: Notes on Bone Oil.

R. B. WARDER: Observations on the contamination of City Wells.

ERNEST H. COOK: Carbon dioxide in the Atmosphere; A simple laboratory appliance.

ARTHUR H. ELLIOTT: On Nitro-saccharose.

Paper from several Agricultural Chemists on the estimation of reverted phosphoric acid.

HARVEY W. WILEY: Direct estimation of dextrose, dextrine and maltose in commercial amylose (sugar starch).

J. B. LAWES and J. H. GILBERT: Determinations of nitrogen in the soils of some of the experimental fields at Rothamsted, and the bearing of the results on the question of the sources of the nitrogen of our crops.

J. SZABÓ: On a new micro-chemical method of determining the feldspars in rocks.

J. KITSEE: Fire-damp indicator.

C. G. WHEELER and F. MENZEL: Transmission of gases through liquids of different densities.

HENRY CARMICHAEL: The solution and late crystallization of gold heated with chlorohydric acid in a sealed tube.

WILLIAM DUDLEY: Remarks on the application of the Iridium knife-edge to analytical balances.

WM. H. ELLIS: Some Tea analyses.

L. W. ANDREWS: On the constitution of Benzole.

Section D, Mechanical Science.

R. H. THURSTON: Newly discovered absolute limit to economic expansion in the Steam Engine.

GÆTANO LANZA: Transverse strength of large Spruce beams.

JOSEPH L'ETOILE: A review of the subjects of atmospheric currents, electricity and gases, with a view to practical aërial navigation by means of balloons.

F. FOSTER BATEMAN: St. Lawrence Bridge and Manufacturing Scheme.

J. BURKITT WEBB: A method of cutting screws of increasing pitch; Indicator attachment for high speeds.

T. R. BAKER: The Permeability of the linings of house walls to air.

W. H. LYNCH: The future of the balloon as a practical means of aërial travel.

SAMUEL MARSDEN: Experiments to determine the strength of cylinders with dome attached, with specimens.

Section E, Geology and Geography.

JAMES HALL: On the relations of Dictyophyton, Phragmodictyum and similar forms with Uphantænia; Note upon the genus Plumulites.

Edward Orton: A Source of the bituminous matter in the Ohio Black Shale (Huron Shale of Newberry); Suggestions as to the History of the Lower Coal-measures of Ohio.

Richard Owen: Contribution to Seismology.

William Bross: The Topography and Geology of the Great Salt Lake valley.

Charles Whittlesey: Pre-glacial channel of Eagle River, Lake Superior.

J. F. Whiteaves: Recent Discoveries of Fossil Fishes in the Devonian Rocks of Canada; Note on the occurrence of Siphonotreta Scotica in the Utica formation near Ottawa, Ont.

T. Sterry Hunt: The Eozoic Rocks of Central and Southern Europe; The Serpentines of Italy.

John Rae: Arctic Explorations in North America.

Wm. B. Dwight: Recent investigations and paleontological discoveries in the Wappinger limestone of Dutchess and neighboring counties, New York.

Samuel Lockwood: A Mastodon Americanus in a Beaver dam near Freehold, N. J.

Robert B. Warder: Silicified stumps of South Park, Col.

J. W. Dawson: Palæozoic Floras of Eastern North America and more especially of Canada.

J. R. Bartlett: Deep-sea soundings and temperatures in the Gulf Stream off the Atlantic Coast, taken under the direction of the U. S. Coast Survey.

Jos. W. Spencer: Terraces and Beaches about Lake Ontario; Occurrence of Graptolites in the Niagara Formation of Canada.

Geo. H. Cook: On the Change of relative level of the ocean and uplands on the Eastern coast of North America.

M. L. Britton: On a Post-Tertiary Deposit containing impressions of leaves in Cumberland County, N. J.

W. O. Crosby: On the classification and origin of Joint structure.

G. H. Perkins: On the Winooski Marble of Vermont, with exhibition of specimens.

Alexis A. Julien: The Comparative stratigraphy of the crystalline rocks of North Carolina and Canada; The Genesis of the crystalline iron ores of North Carolina and Northern Michigan; The Dunyte beds of North Carolina; The Felsyte-tufa of Colorado.

H. F. Walling: The origin of joint cracks.

H. Carvill Lewis: The great terminal moraine across Pennsylvania.

E. W. Claypole: Note on the exterior markings of bark of Lepidodendron Chemungense; On Amphicœlia Cedarvillensis from the Niagara group of Cedarville, Ohio; Note on the Fauna of the Catskill Red Sandstone.

Chas. H. Graham: A Rocking Stone in New York city.

W. Hamilton Merritt: Occurrence of Magnetic ore deposits in Victoria County, Ontario.

Henry S. Williams: The Undulations of the rock-masses across Central New York State.

D. W. Kowalevsky: Freshwater lignitic series of the beds in the Cretaceous formation of France.

John C. Smock: On the surface limit of the thickness of the Continental glacier in New Jersey and adjacent States, with notes on glacial phenomena in the Catskills.

C. H. Hitchcock: The Glacial flood of the Connecticut River Valley.

J. S. Newberry: Some mooted points in American Geology; Genesis of North American Flora.

J. Beaufort Hurlbert: Currents of air and ocean in connection with climate; Regions of summer rains and summer droughts.

Horace C. Hovey: Subterranean Map-making, with new maps of Mammoth and Luray Caves.

Richard Owen: Law of fracture or fissuring, applied to Inorganic and Organic matter.

F. Cope Whitehouse: The Caves of Staffa and their relation to the ancient civilization of Iona.

R. B. Hare: On the association of crystals of Quartz and Calcite in parallel position.

Section F, Biology.

THOMAS MEEHAN: The Fertilization of Yucca.

WILLIAM OSLER: Demonstration of a series of Brains prepared by Giacomin's method.

ROBT. E. C. STEARNS: Description of a new species of Alcyonoid Polyp.

W. H. EDWARDS: On the Polymorphism of Lycæna pseudargiolus.

E. W. CLAYPOLE: Note on the Sterility of the Canada Thistle at Yellow Springs, Ohio; Insects *versus* Flowers in the matter of fertilization; Note on the occurrence of traces of a Northern Flora in Southwestern Ohio.

WM. SAUNDERS: On the Mouth of the larva of Chrysopa.

MRS. A. B. BLACKWELL: Cross heredity from sex to sex.

ASA GRAY: Some remarks on the Flora of North America.

HENRY F. OSBORN: Achænodon from the Bridger Eocene beds.

HENRY O. MARCY: The Placental development in Mammals.

W. S. BEAL: The motion of roots and radicles of Indian Corn and Beans.

C. V. RILEY: Observations on the fertilization of Yucca, and on structural and anatomical peculiarities in Pronuba and Prodoxus; The Hibernation of Aletia xylina in the U. S., a settled fact; Emulsions of petroleum and their value as insecticides.

W. K. BROOKS: A sketch of the history of our knowledge of the budding of Salpa; Fritz Miller and the Nauplius of Decapods.

T. WESLEY MILLS: Examination of some controverted points of the physiology of voice.

G. MACLOSKIE: Achenial hairs and fibers of Compositæ; Observations on the Elm-leaf Beetle (Galeruca xanthomelana).

WM. H. SEAMAN: Blastesis tridens; a pear-tree fungus.

J. F. WHITEAVES: On a recent species of Heteropora from the Strait of Juan de Fuca.

W. A. BUCKHOUT: On the Gall Mites.

J. A. LINTNER: A new Sexual character in the pupæ of some Lepidoptera; On an Egg parasite of the currant saw-fly, Nematus ventricosus.

CLARENCE J. BLAKE: On the position of the Gamopetalæ; Progressive growth of Dermoid coat of the Membrana tympani.

FRANK BAKER: The Morphology of arteries.

ALBERT S. BICKMORE: The Jessup collection to illustrate American Forestry in the Museum of Natural History, Central Park, New York.

LESTER F. WARD: The Organic Compounds in their relations to life; Classification of organisms.

BURT G. WILDER: On the habits of Cryptobranchus.

C. E. BESSEY: Some observations on the action of frost upon leaf-cells.

EDWARD D. COPE: The Fauna of the Puerco Eocene; The primary divisions of the Ungulata.

WYLLIS A. SILLIMAN: Remarks on the Turbellaria.

JOSEPH F. JAMES: Monograph of the Clematidæ of the United States.

SERENO WATSON: Notes on the Flora of the Rocky Mountains.

Section G, Histology and Microscopy.

WM. B. CARPENTER: On angular aperture in relation to biological investigation.

W. OSLER: Demonstration of the Bacillus of Tuberculosis; The third Corpuscular element in the Blood; The development of Blood Corpuscles in the bone-marrow; Note on the Microcytes of the blood, and their probable origin.

LOUIS ELSBERG: Plant-"cells" and living matter.

HENRY O. MARCY: Histology of uterine fibroid tumors. Illustrated by microphotographs.

T. J. BURRILL: Some vegetable poisons.

W. A. ROGERS: A study of the problem of fine rulings with reference to the limit of naked eye visibility and microscopic resolution; On a new form of dry mounting.

THOMAS TAYLOR: The House Fly considered in connection with the distribution of infectious and contagious poisons; A new economic freezing Microtome for section-cutting, with new mechanical devices.

A. H. TUTTLE: On the epidermis of Marsipobranchs.

D. P. PENHALLOW: Notes on some of the peculiarities incident to the diseases of fruits.

ROMEYN HITCHCOCK: Notes on the present status of sanitary inspection, with special reference to the examination of water and air.

C. E. HANAMAN: A filtering wash-bottle adapted to the use of the Histologist.

J. H. PILLSBURY: Development of Cilia in the planula of Clara leptostyla.

Section H, Anthropology.

OTIS T. MASON: A Scheme of Anthropology.

CHARLES WHITTLESEY: The Cross and the Crucifix.

G. H. PERKINS: Notice of a collection of Sioux weapons and articles of dress; Recent Archæological discoveries in Vermont.

J. MCNAB CURRIER: Stone implements from Bomoseen and Castleton Valleys.

CHARLES RAU: A Stone Grave in Illinois.

ALBERT S. GATSCHET: Chief deities in American religions.

MRS. ERMINNIE A. SMITH: Beliefs and superstitions of the Iroquois Indians; A few deductions from a dictionary of the Tuscarora dialect.

J. OWEN DORSEY: On the comparative phonology of four Siouan languages; The kinship system and marriage laws of the Dhegiha.

P. R. HOY: Who made the native copper implements? Who built the mounds?

F. W. PUTNAM: On Copper implements and ornaments from North America; Discovery of the remains of a log-building belonging to the stone-grave period in Tennessee; Account of three mounds explored in Ohio and Tennessee; The contents of eighty-four stone graves at Brentwood, Tenn.

HORATIO HALE: Indian migrations, as evidenced by language.

J. W. PHENE: On some hitherto unnoted affinities between ancient customs in America and on the other continents.

R. G. HALIBURTON: Atlas and the Atlantes.

H. N. RUST: A "find" of chipped stone articles on the Pacific coast and exhibition of the specimens; Remarks upon the Davenport tablet.

WILLS DEHASS: Monumental and art remains in the Lake regions of Ohio, Pennsylvania and New York; Mountain antiquities; Geological testimony to the antiquity of man in America; Archæological exploration, progress of discovery.

A. E. DOUGLAS: A find of ceremonial weapons in Florida.

MISS ALICE C. FLETCHER: Home life among some of the Indian tribes; Religious ceremonials of some of the Dakotan family of Indians.

MISS VIRGINIA K. BOWERS: The bleaching of the Aryans.

WM. H. HINGSTON: Influence of climate of Canada on Europeans.

Section I, Economic Science and Statistics.

CHAS. W. SMILEY: Exhibition of some statistics of College men; Notes upon some methods and results of collecting statistical matter by mail.

E. B. ELLIOTT: On international standard time; on certain Government securities; Suggestions on electrical units.

FRANKLIN B. HOUGH: Upon the investment of labor and capital in forest culture as compared with other productive industries; Experimental plantation of Eucalyptus near Rome.

J. OWEN DORSEY: On methods of obtaining registration of vital and other statistics of the Omahas and cognate tribes of Indians.

J. R. DODGE: Statistics in agriculture.

JAMES HYATT: References to some of the economic and scientific principles in tree-growth and tree-destruction.

WINSLOW UPTON: Standard time for North America.

Three of the papers are published in the preceding pages, and others will appear in the following number of this Journal.

2. *British Association; fifty-first meeting, at Southampton.*—The fifty-first meeting of the British Association opened on the 23d of August. The address of the president of the year, C. W. SIEMENS, related especially to recent practical applications of science, to which some of the profoundest workers in pure science have contributed—scientific progress having "rendered theory and practice so interdependent that an intimate union of them is a matter of absolute necessity for our future progress." Mr. Siemens first speaks of the importance of adopting generally in his country the metric system, which is now legalized there and used in science; and passing from this subject of "accurate measures of length, weight and time," discusses the subject of unit measures in electricity. He proposed four new units: (1) a unit of power to be called a "Watt" = the rate of doing work when a current of one ampère passes through a resistance of one ohm, or, $\frac{1}{746}$ of a horse-power, thus eliminating a factor which comes into calculations; (2) a unit of magnetic pole, to be called a "Weber;" (3) a unit of magnetic field, to be called a "Gauss;" (4) a unit of heat, to be called a "Joule" = the amount of work done, or its equivalent, the quantity of heat generated, by the ampère flowing through an ohm for one second. The *watt* and *joule* were unanimously approved by the Association at one of the sessions of the Physical section. Another topic of the presidential address was the electric current as a means of transmitting power, which was discussed in its application to telegraphy, to the telephone, "that marvel of the present day," in connection with which "the names of Reiss, Graham Bell, Edison and Hughes, will ever be remembered;" and to the transformation of electricity into mechanical energy and its application for the transmission of power; stating, on this last point, that "the small space occupied by the electro-motor, its high working speed, and the absence of waste products, render it specially available for the general distribution of power to cranes and light machinery of every description. A loss of effect of 50 per cent does not stand in the way of such applications, for it must be remembered that a powerful central engine of best construction produces motive power with a consumption of two pounds of coal per horse-power per hour, whereas small engines distributed over a district would consume not less than five; we thus see that there is an advantage in favor of electric transmission as regards fuel, independently of the saving of labor and other collateral benefits."

He remarked further that "the electric railway posseses great advantages over horse- or steam-power for towns, in tunnels, and in all cases where natural sources of energy, such as waterfalls, are available; but it would not be reasonable to suppose that it will in its present condition compete with steam propulsion upon ordinary railways. The transmission of power by means of electric conductors possesses the further advantage over other means of transmission that, provided the resistance of the rails be not very great, the power communicated to the locomotive reaches its maximum when the motion is at its minimum—that is, in commencing to work, or when encountering an exceptional resistance —whereas the utmost economy is produced in the normal condition of working when the velocity of the power-absorbing nearly equals that of the current-producing machine."

He next touched on the deposition of metals by the electric currents; heating and lighting by electricity; the relative values of gas and steam as motive powers, under which the gas or caloric engine is stated "to combine the condition most favorable to the attainment of maximum results," and that "it may reasonably be supposed that the difficulties still in the way of their application on a large scale will gradually be removed;" the ways of improving steam ships and their equipment; the deep-sea sounding machines of Sir William Thomson; and some of the recent engineering projects and accomplishments.

Mr. Siemens closed with remarks on the progress now making toward a clearer conception of the condition of matter when particles are left some liberty to obey individually the forces brought to bear on them, as in vacuum and in interstellar space. He quotes the result of the last eclipse expedition as follows: "Different temperature levels have been discovered in the solar atmosphere; the constitution of the corona has now the possibility of being determined, and it is proved to shine with its own light. A suspicion has been aroused once more as to the existence of a lunar atmosphere, and the position of an important line has been discovered. Hydro-carbons do not exist close to the sun, but may in space between us and it;" and then alludes to a speculation of his own, in a paper read March last before the Royal Society, concerning the conservation of solar energy, which was based on the three following postulates:

"1. That aqueous vapor and carbon compounds are present in stellar or interplanetary space.

2. That these gaseous compounds are capable of being dissociated by radiant solar energy while in a state of extreme attenuation.

3. That the effect of solar rotation is to draw in dissociated vapors upon the polar surfaces, and to eject them after combustion has taken place back into space equatorially.

"It is therefore a matter of peculiar gratification to me that the results of observation here recorded give considerable support to that speculation. The luminous equatorial extensions of the sun which the American observations revealed in such a striking manner (with which I was not acquainted when writing my paper) were absent in Egypt; but the outflowing equatorial streams I suppose to exist could only be rendered visible by reflected sunlight, when mixed with dust produced by exceptional solar disturbances or by electric discharge; and the occasional appearance of such luminous extensions would serve only to disprove the hypothesis entertained by some, that they are divided planetary matter, in which case their appearance should be permanent. Prof. Langley, of Pittsburg, has shown, by means of his bolometer, that the solar actinic rays are absorbed chiefly in the solar instead of in the terrestrial atmosphere, and Capt. Abney has found, by his new photometric method, that absorption due to hydrocarbons takes place somewhere between the solar and terrestrial atmosphere; in order to test this interesting result still further, he has lately taken his apparatus to the top of the Riffel with a view of diminishing the amount of terrestrial atmospheric air between it and the sun, and intends to bring a paper on this subject before Section A. Stellar space filled with such matter as hydrocarbon and aqueous vapor would establish a material continuity between the sun and his planets, and between the innumerable solar systems of which the universe is composed."

The address of Lord Rayleigh, before the Mathematical and Physical section, related to the recent progress in physics and the methods necessary for the best progress. With regard to the two schools of physicists, the mathematical and experimental, he well observes: "The tendency of the purely experimental school is to rely almost exclusively upon direct evidence, even when it is obviously imperfect, and to disregard arguments which they stigmatise as theoretical. The tendency of the mathematician is to overrate the solidity of his theoretical structures, and to forget the narrowness of the experimental foundation upon which many of them rest."

Professor G. D. Liveing, President of the Chemical section, observed that the most important progress recently made in chemistry had been in the "attempt to place the dynamics of chemistry on a satisfactory basis, to render an account of the various phenomena of chemical action on the same mechanical principles as are acknowledged to be true in other branches of physics." In his introduction of the subject he said:

"But how far can we say that mechanical principles are actually recognized as the true basis of rational chemistry? So far as I know no chemist denies that it is so, and yet how little do our text-books, even the most recent and the most highly reputed, show the predominance of this idea! How very small a portion of such books is taken up with it; how much seems utterly to ignore it, or to be couched in language which is antagonistic to it! We still find chemical combinations described as if they were statical phenomena, and expressions used which imply that two perfectly elastic bodies can by their mutual action alone bring each other into fixed relative positions. We still find change of valency described as a suppression of "bonds of affinity," as if a suppression of forces were the usual course of nature, or as if it were possible that the same two forces, acting at the same place and in the same direction, should at one time neutralize one another, and at another time not neutralize one another. We still find saturated compounds spoken of, as if the stability of a compound were independent of circumstances, and chemical combination no function of temperature and pressure. Beginners are sometimes helped by the invention of intermediate reactions in explanation of final results, without any reference to the dynamical conditions of the problem, without any consideration whether the fancied intermediate reactions imply a winding up or running down of energy. In fact our long familiar chemical equations represent only the conservation of matter, and to keep always in mind the mechanical conditions of a reaction is as difficult to some of us as it is to think in a foreign language. Moreover we still find in many of our text-books the old statical notion of chemical combination stereotyped in pictures of molecules. I do not, of course, mean to accuse the distinguished inventors of graphic formulæ of meaning to depict molecules, for I believe they would agree with me in thinking that these diagrams do not any more nearly represent actual molecules than they represent the solar system; but unfortunately we cannot prevent beginners from regarding them as pictures, and moulding their ideas upon them."

Professor Liveing observes that "the vortex theory, whether we think it probable or not, at least gives us a standing ground for the assertion that the supposed impenetrability of matter, and the curious compound of nucleus and atmosphere which has been invented to account for elasticity, are not necessary assumptions. The kinetic theory of gases has analyzed for us the different motions of the molecules in a mass of matter, and has facilitated the conception of the part which heat plays in chemical action. Hence we have had of late several attempts to reduce to a form susceptible of mathematical calculation the problems of chemistry. Most of these attempts have proceeded on the well-known mechanical principle that the change of *vis viva* of a system in passing from an intial to a final configuration is independent of the intermediate stages through which it may have passed so long as the external conditions are unaltered; and on the principle of the dissipation of energy, that is to say, on the condition that the state of the system, if it be a stable one, must be such that the energy run down in reaching it is a maximum. These principles have been applied successfully to the solution of some particular cases of the equilibrium between a mixture of chemicals by Willard Gibbs, Berthelot, and others. By the first-mentioned principle, all consideration of the intermediate stages by which the final result is reached is avoided. Quite recently Lemoine has attacked the same problem on another principle. His principle is that of an equilibrium of antagonistic reactions in a mixture of materials, a mobile equilibrium such as we are now familiar with, dependent on compensating effects; but he does not seem able to solve the problem in any great number of cases. In fact, the difficulty does not now lie so much in expressing mathematically the conditions of the problem as in the defect of knowledge which depends upon experiment. And it is just in this that I think the outlook most hopeful. In some cases the patient work of weighing and measuring and comparing, which is necessary to make our theoretic speculations of any substantial value, has been already done for us. The publication, three years since, of Berthelot's essay on chemical mechanics has given us in a collected form a large quantity of data of the first importance; and now I am glad to say that the long labors of another worker in the same field, Thomsen of Copenhagen, are in course of publication in a handy form. I think these two investigators have done more than any one else of late years toward making it possible to give to chemistry the rank of an exact science. But besides the data which they have supplied to us, there are others which are still wanting. For instance, almost every equation of chemical equilibrium involves an expression depending on the specific heats of the materials. At present we do not know enough of the law of specific heats to be able to give in most cases a probable value to those expressions; but these and other data of the kind do not seem out of our reach, and we may hope that the same ingenuity and patience which has gained for us so much firm ground in thermal chemistry will extend it to the uncertain spots where we have yet no solid foundation.

Further, the laws of dissociation so ably investigated by Deville have taught us that the force called chemical affinity, by which we suppose the atoms of unlike matters are held together in a compound molecule, follows precisely the same laws as the force of cohesion, by which particles of a similar kind are united in molecules."

Dr. Arthur Gamgee, president of the section of Biology, ably discussed "the growth of our knowledge of the function of secretion."

The president of the Geological section, Robert Etheridge, took for his subject one of local as well as general interest, a review of what had been hitherto done in the study of the Tertiary rocks of the Hampshire basin.

Sir Richard Temple, President of the Geographical section, discoursed instructively on the Central Plateau of Asia—its mountains, river-sources, plateaus, lacustrine systems, and the importance of the further investigation of the great region to the sciences of terrestrial physics, geology and meteorology, as well as to that of general history and sociology.

In the section of Biology, the vice-president, in the department of Anthropology, Professor Dawkins, spoke on "the present phase of the Antiquity of Man." Professor Dawkins remarked upon the great improbability of the discovery of remains of man in the Eocene or Miocene from the fact that the known placental mammals of the first of these periods are all of extinct genera, and from the second of extinct species; for the most specialized of all animals cannot be looked for until the higher mammalia by which he is now surrounded were alive. He adds, "nor in the succeeding Pliocene can we expect to find man upon the earth, because of the very few living species of placental mammals then alive. The evidence brought forward by Professor Capellini, in favor of Pliocene man in Italy, seems both to me and to Dr. Evans unsatisfactory, and that advanced by Professor Whitney in support of the existence of Pliocene man in North America, cannot in my opinion be maintained. It is not until we arrive at the succeeding stage, or Pleistocene, when living species of Mammalia begin to abound, that we meet with undisputable traces of the presence of man on the earth."

He next gives a general review of the mammalian life of the Pleistocene or Quaternary era, with reference to the associates of the earliest remains of man, called by him "River-drift Man," speaks of English, European and American discoveries, and gives the following as his general conclusions:

"It remains now for us to sum up the results of this inquiry, in which we have been led very far afield. The identity of the implements of the River-drift hunter proves that he was in the same rude state of civilization, if it can be called civilization, in the Old and New Worlds, when the hands of the geological clock pointed to the same hour. It is not a little strange that his mode of life should have been the same in the forests to the north and south of the Mediterranean, in Palestine, in the tropical forests of India, and on the western shores of the Atlantic. The hunter of the reindeer in the valley of the Delaware was to all intents and purposes the same sort of savage as the hunter of the reindeer on the banks of the Wiley or of the Solent. It does not, however, follow that this identity of implements implies that the same race of men were spread over this vast tract. It points rather to a primeval condition of savagery from which mankind has emerged in the long ages which separate it from our own time.

It may further be inferred, from his wide-spread range, that the River-drift man (assuming that mankind sprang from one center) must have inhabited the earth for a long time, and that his dispersal took place before the glacial submergence and the lowering of the temperature in Northern Europe, Asia and America. It is not reasonable to suppose that the Straits of Behring would have offered a free passage, either to the River-drift man from Asia to America, or to American animals from America to Europe, or *vice versa*, while there was a vast barrier of ice or of sea, or of both, in the high northern latitudes.

I therefore feel inclined to view the River-drift hunter as having invaded Europe in pre-glacial times along with other living species which then appeared. The evidence, as I have already pointed out, is conclusive that he was also glacial and post-glacial.

In all probability the birthplace of man was in a warm if not a tropical region of Asia, in 'a garden of Eden,' and from this the River-drift man found his way into those regions where his implements occur. In India he was a member of a tropical fauna, and his distribution in Europe and along the shores of the Mediterranean prove him to have belonged either to the temperate or the southern fauna in those regions.

It will naturally be asked, to what race can the River-drift man be referred? The question, in my opinion, cannot be answered in the present stage of the inquiry, because the few fragments of human bones discovered along with the implements are too imperfect to afford any clue. Nor can we measure the interval in terms of years which separate the River-drift man from the present day, either by assuming that the glacial period was due to astronomical causes, and then proceeding to calculate the time necessary for them to produce their result, or by an appeal to the erosion of valleys or the retrocession of waterfalls. The interval must, however, have been very great to allow of the changes in geography and climate, and the distribution of animals which has taken place—the succession of races, and the development of civilization before history began. Standing before the rock-hewn tombs of the kings at Luxor, we may realize the impossibility of fixing the time when the River-drift hunter lived on the site of ancient Thebes, or of measuring the lapse of time between his days and the splendor of the civilization of Egypt.

In this inquiry, which is all too long, I fear, for my audience, and all too short, I know, for my subject, I have purposely omitted all reference to the successor of the River-drift man in Europe—the Cave man, who was in a higher stage of the hunter civilization."

The first of the evening lectures was that of Sir WILLIAM THOMSON, *on the Tides.* The Athenæum of September 2d, reports: "It was delivered with but few notes and without much regard to exact logical consecution of topics; but the intense energy of the lecturer and the startling points he made sustained the attention of the audience. The subject is one which, as chairman of the Tidal Committee of the Association, he has worked at for many years, and one result of his labors has been the publication of very complete tide tables for the principal Indian ports. Another result, of great importance to the geologist, is a determination of the amount by which the solid earth yields to the same distorting forces which produce tides in the sea. If it were of India rubber, or, what amounts to much the same thing, if it had a crust only twenty or thirty miles thick, with fluid within, its yielding would be so great as practically to prevent any tidal currents from being formed in the water, for the formation of these depends upon the water yielding more than the land. Sir William's calculations show that the actual amount of yielding on the part of the land is less than it would be in a solid globe of glass of the same size. The latest forms of his tide guage and tide-predicting machine were exhibited, and his harmonic analyzer was explained by the aid of a diagram."

The report of the committee appointed for the purpose of obtaining photographs of the typical races of the British Isles, gives the following definitions of the main types:

"*The First or Dolichocephalic Dark Type, A.*—The definition of the short, narrow-headed race shown by Dr. Thurnam and Professor B. Dawkins to have preceded the so-called Celts, and termed by them Iberian (=the Silurian of Professor Rolleston), is at present incomplete. The forehead, however, appears to have been fairly vertical, the brows prominent, the nasal bones long and straight, the lower jaw weak (Rolleston), and the hair and eyes dark. Statistics of the color of the hair and eyes, collected by Dr. Beddoe, show that the race exerted a much wider influence on the population than is usually supposed.

The Second or Brachicephalic Fair Type, B.—The principal characteristics of this race consist in the prominence of brow and supra-nasal ridges; a slightly receding forehead; sharply projecting nasal bones, causing a high-bridged or arched nose, without undulation; a long, oval face; high cheek-bones; and a prominent fine chin. From Mr. Park Harrison's observations the lips of this type appear to be thin, and the ear pear-shaped, with no proper lobe, the fossa being continuous.

These features are found associated with light hair and eyes, and a stature above the average. This type includes Belgic, Cymric, and Danish varieties, which, further observation, the Committee believe, will by-and-bye enable them to differentiate; as also the Anglian, Jutish and Frisian types. They have selected several portraits, which present common characteristics.

The definition of Type B agrees in all the main points with descriptions given some years ago by Dr. Beddoe, Mr. David Mackintosh, and Mr. Hector Maclean, as well as with Dr. Rolleston's deductions in the appendix to 'British Barrows.'

The Third or Sub-Dolichocephalic Fair Type, C.—The Committee believe that the following is a correct definition of true Saxon features. Brows smooth; forehead rounded and vertical; nasal bones short and straight; nose not arched, ending in more or less of a bulb; face elliptical, rounded; cheek-bones broad; chin rounded; lower part of face wide; eyes prominent, in color blue or bluish grey; lips moulded; ears flat, with formed lobes; face and frame well covered. Height about the average.

The definition accords with Schadow's pure German (Teutonic) type, and with the Saxon type of Beddoe and Mackintosh."

The preceding notes on the meeting of the British Association have been taken almost wholly from Nature, whose numbers, commencing with No. 669, for August 24, contain full reports of the presidential addresses, and copious abstracts of the reports, papers read, and other proceedings.

The British Association, after much discussion, decided, by a vote of fifty-three to thirty-nine, to hold its meeting in 1884 at Montreal. The Athenæum of September 2d says:

"Great inducements were offered in the shape of facilities for traveling; and the rare chance thus afforded of seeing America was doubtless a powerful attraction, especially to the younger portion of the members. At the worst, no very great harm can come of it. The regular work of the Association is not so vitally essential that a year's interruption for the sake of a holiday tour will produce any very grave inconvenience."—It can be safely promised that the scientific men of America will do what they can toward making the harm very small, and the profit of the occasion great in all respects.

3. *Report of the New York State Survey (Trigonometrical) for the year* 1880, JAMES T. GARDINER, Director. 80 pp. 8vo, with five maps. Albany, 1881.—This report announces the completion of a line of triangulation across the State of New York, from the Massachusetts line in the town of Canaan to the western boundary near Lake Erie. The width of the State between these points is found to be 326·46 miles, instead of 328·68, the result of former measurements. The exact location also of twenty-three cities and villages along the line has been determined. The position of the southern boundary of the State along by Pennsylvania and New Jersey is promised in the report as another practical result of the triangulation soon to be realized.

4. *On the Cause of the Infection of the Waters at Lille;* by M. ALF. GIARD.—The reddish color, bad taste, and unpleasant odor presented at times by the waters of the Emmerin springs which supply the town of Lille have long been noticed by the population of that town; but in the spring of this year the infection assumed alarming proportions. On the 22d of April the water was absolutely unusable; and from that time every somewhat copious rainfall was followed by a longer or shorter period of more or less intense infection. During these periods the water carries on its surface a ferruginous red scum which can easily be collected by stretching cloths across the stream. Ferruginous deposits also form in the reservoirs and in certain parts of the distributing channels. These on certain days were so abundant that the horses refused to drink the water which was offered to them. A microscopic examination showed that the cause of the infection was a Schizomycete, *Crenothrix Kühniana* Rabenh., the filaments of which become charged, in contact with the water exposed to the air, with a precipitate of sesquioxide of iron, then putrefy, and communicate a most disagreeable flavor to the water.

This *Crenothrix* has been noticed in several localities, especially Halle, Breslau and Berlin, and has been carefully studied by Professors F. Cohn, O. Brefeld and W. Zopf. To the observations of those eminent botanists we have only to add that the microgonidia, formed in the swollen extremities of the tubes of *Crenothrix* by transverse division of the bacillar joints constituting those extremities, are animated during some time with an active motion, due to the existence of a flagellum. The latter is visible only with the highest magnifying power (Hartnack immersion objective No. 12).

The gonidia afterward gave birth to an irregular form (*Merismopœdia*), which is soon transformed into a mass of *Zooglœæ*, similar to a *Palmella*, and finally into regularly cylindrical tubes of various lengths.

The causes which have brought about the exaggerated development of *Crenothrix* in the Emmerin waters are evidently manifold. The soil was prepared by industrial dejections, especially those from distilleries, which discharge nitrates in abundance into the water-bearing stratum, at certain places very near the surface. The sources are, moreover, in the vicinity of swamps and ponds, like those of Tegel in the environs of Berlin.

Last winter having been relatively dry, the water-level was lowered about 5 meters. The rains of the spring and the beginning of the summer suddenly raised it, and carried with them the vegetable productions or the animals which had been developed in the humid earth.

While at Lille the *Crenothrix* was thus brought in abundance into the Emmerin reservoirs and the water-pipes, several wells at Tourcoing furnished balls of a fine Oligochæte worm (*Phreoryctes Menkeanus*), till then unknown in France.

Lastly, a portion of the aqueduct is dug in the aquiferous chalk; and it was thought needless to arch over that part; moreover, inlets have been pierced in order to increase by drainage-water the supply furnished by the springs. Every time that the flow of the water is made more rapid, in that part of the aquiferous layer a veritable aspiration is produced, which carries into the aqueduct the spores and filaments of the *Crenothrix*, which a slower and more complete filtration would have retained in the soil.

To remedy this scourge, we at first advised to do away with the latter source of contamination, against which it is comparatively easy to guard. But we believe that this palliation would be insufficient while the channels are sown with the innumerable spores of the Schizomycete. We shall doubtless be obliged to have recourse to filters of sand, similar to those recommended at Berlin by Zopf and Brefeld.

Towns establishing new systems of canals of potable water will do well, in order to avoid the *Crenothrix*, to take the sources in the deep strata, to avoid waters containing salts of protoxide of iron (necessary to the vegetation of this Schizomycete), and to prefer to subterranean waters the more aerated waters of lakes remote from all industrial establishments.—*Comptes Rendus*, July 31, 1882, xcv, 247–249. *Ann. Mag. Nat. Hist.*, Sept. 1882.

5. *Transactions of the Academy of Sciences of St. Louis*, Vol. iv, No. 2. St. Louis, Missouri, 1882.—This number contains among its scientific papers memoirs by C. V. Riley on N. A. Microgasters with descriptions of new species, and on new Tortricidæ; by F. E. Nipher, on problems in refraction, and magnetic determinations in Missouri in 1880; by C. A. Todd, on reversion of type in the digastric muscle of man; H. S. Pritchett, an ephemeris of Mars for the opposition of 1881; G. Engelmann, on the genus Isoetes in North America; E. A. Engler, on auroral phenomena of Sept. 12, 1881.

6. *Journal and Proceedings of the Royal Society of New South Wales*, 1881. Vol. xv. Edited by A. Liversidge, Prof.

Chem. and Min. Univ. Sidney. 1882.—The papers in this volume discuss subjects connected with the climate, geography, and botany of Australia, and give the results of extended astronomical observations. The analyses of epiphytic plants by Mr. Dixon on page 299 are from one of its articles; and also the note on the supposed subterranean drainage of Central Australia, on page 295. The astronomical memoirs are: On the elements of Comet II of 1881, by Mr. JOHN TERBUT, F.R.A.S.; on the spectrum and appearance of the same comet, by Mr. H. C. RUSSEL, F.R.A.S.; a paper of sixty-six pages on "New double stars and measures of some of those found by Sir John Herschel," by Mr. RUSSELL; and on the Transit of Mercury of Nov. 8, 1881, by the same observer. Mr. Russell states that about 746 of Herschel's stars have been re-measured, and 350 new double stars have been found. Some of the latter have afforded evidence of motion. 46 of Herschel's list have not been found.

7. *U. S. Commission of Fish and Fisheries, Part VII*, being the Report of the Commissioner, Prof. S. F. BAIRD, for 1879. 846 pp. 7vo, with many plates.—This Report, after details as to the special work for the year in the propagation and distribution of food-fishes and the study of the facts bearing on their habits, food, and causes of increase and decrease, gives to the country a large amount of information on these and related subjects from outside sources. Some of the headings of its chapters from European writers are the following: the Iceland herring fisheries; the herring's mode of life; the fisheries of the west coast of South America; the temperature, saltness, currents, etc., of the German seas with reference to fish support and propagation, and the habits of food-fishes; the pollution of public waters by refuse from factories; sawdust as a source of injury; foreign piscicultural establishments; and the raising of sponges from cuttings. It also contains a treatise on the sea-weeds of New England, with fifteen plates, by Prof. W. G. FARLOW, the ablest writer on the subject in the country, and a report on the gigantic squids and other cephalopods of the northeastern coast of America, by Prof. A. E. VERRILL, illustrated by forty-six plates.

OBITUARY.

LIOUVILLE.—The announcement of the death of the veteran mathematician, J. Liouville, founder and, for nearly forty years, editor of the Journal de Mathematiques, has been announced.

PLANTAMOUR.—The late director of the Observatory at Geneva, M. E. Plantamour, died recently.

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

Art. XXXIV.—*Remarks concerning the Flora of North America*; by Asa Gray.

[Read to the Botanists at the meeting of the American Association for the Advancement of Science, at Montreal, August 25, 1882.]

In the remarks which I have to offer to this Section, you will understand the word *Flora* to be written with a capital initial. I am to speak of the attempts made in my own day, and still making, to provide our botanists with a compendious systematic account of the phænogamous vegetation of the whole country which the American Association calls its own.

I shall make no effort to avoid the personal turn which my narrative is likely to take. In fact, it will be seen that I have partly a personal object in drawing up this statement.

Only two Floras of North America have ever been published as completed works, that of Michaux and that of Pursh. A third was begun (by Dr. Torrey, assisted by a young man who is no longer young), by the publication in the summer of 1838 of a first fasciculus; the first volume of 700 pages was issued two years afterward; and 500 pages of the second volume appeared in 1841 and in the early part of 1843. The time for continuing it in the original form has long ago passed by. Its completion in the form in which I have undertaken it anew, is precarious. *Precarious* in the original sense of the word, for it is certainly to be prayed for: precarious, too, in the current sense of the word as being uncertain; yet not so, according to an accepted definition, viz: "uncertain, because depending upon the will of another;" for it is not our will but our power that is in question; and it is only by the combined powers and efforts of all of us interested in Botany that the desired end can possibly be attained.

It were well to consider for a moment how and why it is that a task which has twice been—it would seem—easily accomplished has now become so difficult.

The earliest North American Flora, that of the elder Michaux, appeared in the year 1803. It was based entirely upon Michaux's own collections and observations, does not contain any plants which he had not himself gathered or seen, is not, therefore, an exhaustive summary of the botany of the country as then known, and so was the more readily prepared. Michaux came to this country in 1785, returned to France in 1796, left it again in Baudin's expedition to Australia in 1800, and died of fever in Madagascar in 1802. The Flora purports to be edited by his son, F. A. Michaux, who signed the classical Latin preface. The finish of the specific characters, and especially the capital detailed characters of the new genera, reveal the hand of a master; and tradition has it that these were drawn up by Louis Claude Richard, who was probably the ablest botanist of his time. This tradition is confirmed by the fact that Richard's herbarium (bequeathed to his son, and now belonging to Count Franqueville), contains an almost complete set of the plants described, and I found that the specimens of Michaux supplied to Willdenow's herbarium at Berlin were ticketed and sent by Richard. Not only the younger Richard but Kunth also habitually cited the new genera of the work as of Richard, and some others have followed this example. Singularly enough, however, there is no reference whatever to Richard in any part of the Flora, nor in the elaborate preface. The most venerable botanist now living told me that there was a tradition at Paris that Richard performed a similar work for Persoon's *Synopsis Plantarum*, and that he declined all mention of his name in the Synopsis and in the Flora, because the two works—contrary to the French school—were arranged upon the Linnæan Artificial System. He had his way, and the tradition may be preserved in history; but his name cannot be cited for the genera *Elytraria*, *Micranthemum*, *Elodea*, *Stipulicida*, *Dichromena*, *Oryzopsis*, *Erianthus*, and the like. For, by the record these are of *Michaux, Flora Boreali-Americana*, and not of Richard.

Michaux's explorations extended from Hudson's Bay, which he reached by way of the Saguenay, to Florida, as far, at least, as St. Augustine and Pensacola; he was the first botanical explorer of the higher Alleghany Mountains, and, crossing these mountains in Tennessee, he reached the Mississippi in Illinois, and was as far south as Natchez. His original itinerary, which I once consulted, is preserved by the American Philosophical Society, at Philadelphia, to which it was presented by his son. It ought to be printed. That little journal shows that it was not Michaux's fault that the first Flora of North America was restricted to the district east of the Mississippi River. He had a scheme for crossing the continent to the Pacific. He warmly solicited the government at Washington to undertake such an exploration, and offered to accompany it as naturalist. This may have been the germ or the fertilizing idea of the expedition of Lewis and Clark, which was sent out a few years afterward by Jefferson, to whom, if I rightly remember, Michaux addressed his enterprising proposal.

Leaving out the Cryptogams of lower rank than the Ferns, we find that the Flora of Michaux, published at the beginning of this century, say eighty years ago, contains 1530 species, in 528 genera. No very formidable number; as to species (speaking without a count) little over half as many as are described in my Manual of the Botany of the Northern States, which covers less than half of Michaux's area.

Eleven years afterward, namely, in the year 1814 (the preface is dated December, 1813), appeared the second Flora of North America, namely the *Flora Americæ Septentrionalis*, by Frederick Pursh. This was not confined to the author's own collections, but aimed at completeness, or to give "a systematic arrangement and description of the plants of North America, containing, besides what have been described by preceding authors, many new and rare species, collected during twelve years' travels and residence in that country."

It appears that Pursh was born at Tobolsk, in Siberia, of what parentage we do not know. He himself tells us, in his preface, that he was educated in Dresden, and that he came to this country—to Baltimore and Philadelphia—at the close of the last century, when he must have been only twenty-five years old. He was able to make the acquaintance not only of Muhlenberg, who survived until 1815, and of Wm. Bartram, who died in 1823, but also of the veteran Humphrey Marshall, who died in 1805. His early and principal patron was Dr. Benjamin Smith Barton, who supplied the means for most of the travels which he was able to undertake, and who, as Pursh states, "for some time previous had been collecting materials for an American Flora." Pursh's personal explorations were not extensive. From 1802 till 1805 he was in charge of the gardens of Wm. Hamilton, near Philadelphia. In the spring of the latter year, as he says, he "set out for the mountains and western territories of the Southern States, beginning at Maryland and extending to the Carolinas (in which tract the interesting high mountains of Virginia and Carolina took my particular attention), returning late in the autumn through the lower countries along the sea-coast to Philadelphia." But, in tracing his steps by his collections* and by other indications, it appears that he did not reach the western borders of Virginia nor cross its southern boundary into the mountains of North Carolina. The Peaks of Otter and Salt-pond Mountain (now Mountain Lake), were the highest elevations which he attained. Pursh's preface continues: "The following season, 1806, I went in like manner over the Northern States, beginning with the mountains of Pennsylvania and extending to those of New Hampshire (in which tract I traversed the extensive and highly interesting country of the Lesser and Great Lakes), and returning as before by the sea-coast." The diary of this expedition, found among Dr. Barton's papers and collections in possession of the American Philosophical Society, has recently been printed by the late Mr. Thomas Potts James. It shows that the journey was not as extended or as thorough as would be supposed; that it was from Philadelphia directly north to the Pokono Mountains, thence to Onandaga, and to Oswego,—the only point on the Great Lakes reached,—thence back to Utica, down the Mohawk Valley to Saratoga, and north to the upper part of Lake Champlain and to the lesser Green Mountains in the vicinity of Rutland, but not beyond. Discouraged by the lateness of the season, and disheartened—as he had all along been—by the failure and insufficiency of remittances from his patron, Pursh turned back from Rutland on the 22d of September, reached New York on the 1st of October, and Philadelphia on the 5th. The next year (1807) Pursh took charge of the Botanic Garden which Dr. Hosack had formed at New York and afterward sold to the State, which soon made it over to Columbia College.† In 1810, he made a voyage to the West Indies for the recovery of his health. Returning in the autumn of 1811, he landed at Wiscasset, in Maine, "had an opportunity of visiting Professor Peck of Cambridge College, near Boston," and of seeing the alpine plants which Peck had collected on the White

* In herb. Barton and herb. Lambert.

† Expecting, no doubt, that it would be kept up. But "the Elgin Botanic Garden" was soon discontinued. It occupied the block of ground now covered by the buildings of the College, and the surrounding tract—now so valuable—from which the college derives an ample revenue. *Noblesse oblige*, and it may be expected that the College—so enriched—will, before long, provide itself with a botanical professorship, and see to the careful preservation and maintenance of the precious Torrey Herbarium, which it possesses along with other subsidiary herbaria.

Mountains.* At the end of the latter year or early in 1812 he went to England with his collections and notes; and at the close of 1813, under the auspices of Lambert, he produced his Flora, consulting, the while, the herbaria of Clayton, Pallas, Plukenet, Catesby, Morison, Sherard, Walter, and that of Banks. Evidently such consultations and the whole study must have been rapid. The despatch is wonderful. One can hardly understand the ground of the statement made by Lambert to my former colleague, Dr. Torrey, that he was obliged to shut Pursh up in his house in order to keep him at his work.

I know not how Pursh was occupied for the next four years, nor when he came to Canada. But he died here at Montreal, in 1820, at the early age of forty-six. More is probably known of him here. If I rightly remember, his grave has been identified, and a stone placed upon it inscribed to his memory.† A tradition has come down to us—and it is partly confirmed by a statement which Lambert used to make, in reference to the vast quantity of beer he had to furnish during the preparation of the Flora—that, in his latter days, our predecessor was given to drink, and that his days were thereby shortened.

In Pursh's Flora we begin to have plants from the Great Plains, the Rocky Mountains, and the Pacific Coast, although the collections were very scanty. The most important one which fell into Pursh's hands was that of about 150 specimens, gathered by Lewis and Clark on their homeward journey from the mouth of Columbia River. A larger collection, more leisurely made on the outward journey, was lost. Menzies in Vancouver's voyage had botanized on the Pacific coast, both in California and much farther north. Some of his plants were seen by Pursh in the Banksian Herbarium, and taken up. I may here say that in the winter of 1838–39 I had the pleasure of making the acquaintance of the venerable Menzies, then about ninety-five years old.

* It is at Wiscasset, therefore, that Pursh's "*Plantago cucullata* Lam. . . . . in wet rocky situations, Canada and Province of Maine," is to be sought. Mr. Pringle has recently found the related *P. Cornuti* (which may be the plant meant), in Lower Canada, not far from the other side of Maine.

It must have been in Professor Peck's herbarium (no longer extant), that Pursh saw what he took to be *Alchemilla alpina*, which he marks "*v. s.*" and refers to from memory only, probably mistakenly. For it has not since been detected either in Vermont or New Hampshire, or anywhere in North America; and Pursh's Journal makes it certain that he did not reach any alpine region in the Green Mountains.

† In the Canadian Naturalist, Principal Dawson gives a brief account of the transference of the remains of Pursh from a grave-yard below Montreal, in which they were interred, to the beautiful Mount Royal Cemetery, where they rest in a lot purchased for the purpose and under a neat and durable granite monument, provided by the naturalists of Montreal and their friends. A small company of botanists, led by Dr. Dawson, visited the spot shortly after the reading of this paper. We learned that Pursh had botanized largely in Canada, in view of a Canadian Flora, and that his collections were consumed by a fire at Quebec shortly before his death, to his extreme discouragement.

In the Supplement, Pursh was able to include a considerable number of species, collected by Bradbury on the Upper Missouri, in what was then called Upper Louisiana,—much to the discontent of Nuttall, who was in that region at the same time, and who, indeed, partly and imperfectly anticipated Pursh in certain cases, through the publication by the Fraser's of a catalogue of some of the plants collected by Nuttall.

To come now to the extent of Pursh's Flora, published nearly sixty-nine years ago. It contains 740 genera of Phænogamous and Filicoid plants, and 3076 species. Just about double the number of species contained in Michaux's Flora of eleven years before.

I must omit all mention of more restricted works, even such as Nuttall's Genera of North American Plants, which came only four years after Pursh's Flora; also the Flora Boreali-Americana of Sir Wm. Hooker, which began in 1829, but was restricted to British America. I cannot say how early it was that my revered master, Dr. Torrey, conceived the idea of the Flora which he at length undertook. But he once told me that he had invited Nuttall to join him in the production of such a work, and that Nuttall declined. This must have been as early as the year 1832, that is, half a century ago. My correspondence with Dr. Torrey began in the summer of 1830, when I was a young medical student, and three or four years afterward I joined him at New York and became, for a short time, his assistant, for all the rest of his life his botanical colleague. He was very much occupied with his duties as professor, chiefly of chemistry; he had not yet abandoned the idea of completing his Flora of the Northern and Middle States, the first volume of which was finished in 1824, while yet free from all professional cares. Although working in the direction of the larger undertaking, the *Flora of North America* did not assume definite shape before the year 1835. I believe that some of the first actually-prepared manuscript for it was written by myself in that or the following year. I was then and for a long time expecting to accompany the South Pacific Exploring Expedition, as originally organized under the command of Commodore Ap. Catesby Jones, but which was subject to long delay and many vicissitudes; during which, having plentiful leisure, I tried my 'prentice hand upon some of the earlier natural orders. Before the expedition, as modified, was ready to sail, under the command of Capt. Wilkes, I had accepted Dr. Torrey's proposal that I should be his associate in the work upon which I had made a small beginning as a volunteer. Two parts, or half of the first volume (360 pages), of this Flora, were printed and issued in July and October, 1838.

It was thought at first, in all simplicity, that the whole task could be done at something like this rate. But, apart from other considerations, it soon became clear that there had been no proper identification of the foundation-species of the earlier botanists, from Linnæus downward; and that our Flora could not go on satisfactorily without this. Dr. Torrey had, indeed, some years before, made a hasty visit to Hooker at Glasgow, to London, and to Paris; but the taking of a few notes upon some particular plants in the herbaria of Hooker, Lambert, and Michaux, and the acquisition, from Hooker, of a good set of the Arctic plants of the British explorers, was about all that had been done. I proposed to attempt something more; so, taking advantage of a favorable opportunity, I sailed for Liverpool in November, 1838, and devoted a good part of the ensuing year to the examination of the principal herbaria, which I need not here specify, in Scotland (where the important one of Sir Wm. Hooker still remained), England, France, Switzerland and Germany, namely those which contained the specimens upon which most of the then-published North American species had been directly or indirectly founded, especially those of Linnæus and Gronovius, of Walter, of Aiton's Hortus Kewensis, Michaux, Willdenow, Pursh, and the later ones of DeCandolle and Hooker.*

After my return the work made good progress; the remaining half of the first volume was brought out in the spring of the year 1840, and by the spring of 1843 the 500 pages of the second volume, mostly occupied by the vast order Compositæ, had been issued. But meanwhile I had in my turn to assume professorial duties and incident engagements,—with the result that, although the study of North American plants was at no time pretermitted, either by Dr. Torrey while he lived, or by myself, we were unable to continue the publication during my associate's life-time; and it was only recently, in the spring of 1878, that I succeeded in bringing out, in a changed form, another instalment of the work, completing the *Gamopetalæ*.

In the interval I had made two year-long visits to Europe for botanical investigation, the first partly relating to the botany of the South Pacific, the second wholly in view of the North American flora. And since this last publication still another visit—the fourth and we may suppose the last—of the same character and the same duration, has been successfully accomplished.

The serious question, in which we are all concerned, arises, whether this work can be carried through to a completion, and the older parts (wholly out of print and out of date), re-elabo-

* See, in this connection, "Notices of European Herbaria, particularly those most interesting to the North American Botanist," in this Journal, vol. xi, January, 1840.

rated—I will not say by my hands—but in my time, or soon enough to render the whole a reasonably full and homogeneous representation of the North American flora, as known in this latter part of the nineteenth century. And it brings us to consider why the undertaking to which so much time has been devoted, should be so slow of accomplishment.

If this slowness is a constant wonder and disappointment to most people interested in the matter, I can only add that it is hardly less so to myself. It is a constant surprise—if one may so say— that the work does not get on faster.

Of course the undertaking has become more and more formidable with the enlargment of geographical boundaries and of the number of species discovered. As to the increase in the number of species to be treated, we have by no means yet reached the end. The area, that of our continent down to the Mexican line, we trust is definitely fixed, at least for our day. And, since we cannot be rid of the peninsula and keys of Florida, which entails upon us a considerable number of tropical species, mostly belonging to the West Indies—the southern boundary is now as natural a one as we can have.

The area which Pursh's Flora covered was, we may say, the United States east of the Mississippi, with Canada to Labrador, to which was added a couple of hundred of species known to him outside these limits northwestward.

Torrey and Gray's Flora took the initiative in annexing Texas, ten years before its political incorporation into the Union; although the only plants we then possessed from it were certain portions of Drummond's collections. California was also annexed at the same time, on account of Douglas's collections, and those of Nuttall, who had just returned from his visit to the western coast, which he reached by a tedious journey across the continent over ground in good part new to the botanist. Douglas had already made remarkably full collections along a more northern line. The British arctic explorers, both by sea and land, had well developed the botany of the boreal regions, and Sir Wm. Hooker was bringing out the results in his Flora of British America. Of course our knowledge of the whole interior and western region was small indeed, compared with the present; and the botany of a vast region from the western part of Texas to the Californian coast was absolutely unknown, and so remained until after the publication of the Flora was suspended.

As to the number of species which Torrey and Gray had to deal with, I can only say that a rapid count gives us for the first volume about 2200 Polypetalæ; that there are 109 species in the small orders which in the second volume precede the *Compositæ;* and that there are of the *Compositæ* 1054. So one may fairly conclude that if the work had been pushed on to completion, say in the year 1850, the 3076 species of Pursh's Flora in the year 1814 might have been just about doubled. Probably more rather than less; for if we reckon from the number of the *Compositæ*, and on the estimate that they constitute one-eighth of the phænogamous plants of North America, instead of 6150, there would have been 8430 species known in the year specified.

It most concerns us to know the number of species which, after the lapse of thirty years more—years in which exploration has been active, and has left no considerable part of our great area wholly unvisited—the now revived Flora has to deal with. We can make an estimate which cannot be far wrong. In the year 1878, my colleague, Mr. Watson, finished and published his Bibliographical Index to the Polypetalæ of North America, covering, that is, the same ground as the first volume of Torrey and Gray's Flora, completed in 1840. In it the 2200 species of the latter date are increased to 3038. The "*Gamopetalæ* after *Compositæ*" in the Synoptical Flora, brought out in the same year, contains 1656 species. The two together must make up half of our phænogamous botany, that is, adding the increase of the last four years, about 5000 species. And so Mr. Watson adopts the estimate of 10,000 species for our known Phænogams and Ferns. My impression is that the species of *Compositæ* have increased at a rate which, unless they exceed the eighth part of our Phænogams, will warrant a still higher estimate. The number of introduced species of various orders, which will have to be enumerated and most of them described, is, unhappily, fast increasing;* and new indigenous species are almost daily coming to us from some part or other of our wide territory. So that the 10,000 species of this estimate may before long rise to eleven or twelve thousand. Only the experienced botanist can form a just idea of what is involved in the accurate discrimination and proper coördination of 10–12000 species, and in the putting of the results into the language and form which may make our knowledge available to learners or to succeeding botanists.

Moreover, there is of late an *embarras des richesses* which is becoming serious as respects labor and time. The continued and ever increasing influx of materials to Cambridge, beneficial as it ever is, is accountable for this retardation of progress in a greater degree than almost any one would suppose. The herbarium, upon whose materials this work is mainly done, and which has been, like the Temple, full forty and six years in building, has received the contributions of two generations of

* I say "unhappily," for they adulterate the natural character of our flora, and raise difficult questions as to how much of introduction and settlement should give to these denizens the rights of adopted citizens.

botanists, and the Torrey herbarium goes back one generation further. Still the number of American specimens annually coming to it is greater than in most former years. Apart from the mere selection and care of these, consider how in other ways it affects the rate of progress of the Flora. The incoming of additional specimens may at a glance settle doubts as to the validity of a species; but new specimens are as apt to raise questions as to settle them; more commonly they raise the question as to the limitation and right definition of the species concerned, not rarely, also, that of their validity. When one has only single specimens of related species, the case may seem clear and the definition easy. The acquisition of a few more, from a different region or other conditions, almost always calls for some re-consideration, not rarely for re-construction. People generally suppose that species, and even genera, are like coin from the mint, or bank notes from the printing press, each with its fixed marks and signature, which he that runs may read, or the practised eye infallibly determine. But in fact species are judgments—judgments of variable value, and often very fallible judgments, as we botanists well know. And genera are more obviously judgments, and more and more liable to be affected by new discoveries. Judgments formed to-day—perhaps with full confidence, perhaps with misgiving—may to-morrow, with the discovery of new materials or the detection of some before unobserved point of structure, have to be weighed and decided anew. You see how all this bears upon the question of time and labor in the preparation of the Flora of a great country. If even in old Europe the work has to be done over and over, how much more so in America, where new plants are almost daily coming to hand. It is true that these fall into their ranks, or are adjustable into their proper or probable places, but not without pains-taking and tedious examination.

Of our Flora, it may indeed be said, that "If 'twere done when 'twere done, then 'twere well it were done quickly." But I may have made it clear that, in the actual state of the case, it is likely to be done slowly. At least you will understand why thus far it has been done slowly. As to the future, if it depended wholly upon me, the completion would obviously be hopeless. I need not say that our dependence, for the actual elaboration, must largely be upon associates, upon the few who have the training and the vast patience, and the access to herbaria and libraries, requisite for this kind of work, but above all upon my associate in the herbarium at Cambridge, to whom, being present with us, I will not further allude.

Of course we rely, very much indeed, upon the continued coöperation of all the cultivators of botany in the country; and it is gratifying to know that their number is increasing, new ones not less zealous than the old, and better equipped, are taking the places of those that have passed away, and some of them extending their explorations over the remotest parts of the land, and into districts where there is most to be discovered. All can help on the work, and all are doing so, by the communication of specimens and of observations. Those within the range of the published manuals and floras get on—or should get on—with only occasional help from us. They should send us notes and specimens to any amount; but they should not ask us to stop to examine and name their plants, except in special cases, which we are always ready enough to take up. Those who collect in regions as yet destitute of such advantages may claim more aid, and we take great pains to render it; partly on our own account, that we may assort their contributions into their proper places, partly for the encouragement of such correspondents, who otherwise would not know what they have obtained, and who naturally like to know when they have made interesting discoveries.

But the scattered and piecemeal study of plants is neither very satisfactory nor safe. And it involves great loss of time, besides interrupting that continuity and concentration of attention which the proper study of any group of plants demands. As respects the orders of plants which are yet to be elaborated for the Flora, and as to plants which require critical study or minute examination, necessarily consuming much time, it is better to defer their complete determination until the groups to which they severally belong are regularly taken in hand.

The coöperation of all our botanical associates is solicited in this regard, as a matter of common interest and advantage. For we are all equally concerned in forwarding the progress of the Flora of North America; and we may confidently expect from our botanical associates their sympathy, their forbearance, and their continued aid.

Art. XXXV.—*Notes on Physiological Optics.* No. 6. *Binocular Union of Spectral Images;* by W. LeConte Stevens.

[Read before the Physical Section of the American Association for the Advancement of Science at Montreal, August, 1882.]

If a sharply defined object be momentarily illuminated by the intense light of the electric spark, a positive and then a negative after image is perceived, neither, however, lasting very long. A negative after-image lasting several minutes may be secured by gazing very steadily on one point of an object which contrasts sharply with the surrounding area, while the whole is illuminated by the direct beams of the sun, the eyes being at the same time protected from any glare proceeding from other directions. To secure these visual effects some ocular training is necessary, but the perception soon becomes almost as vivid as in ordinary vision. The after-image, being due to fatigue of the retina in certain parts while others remain unfatigued, appears in the direction of the visual line, changing in apparent position with every motion of the eye.

Professor W. B. Rogers* in 1860 published some experiments in the binocular union of after-images from illuminated lines so arranged as to produce the appearance of relief. Perspective after-images were likewise obtained by Wheatstone† and Wundt;‡ but the objection to conclusions drawn from such perceptions as these consists in the fact that the observer knows what effects *would* result in direct vision, under the conditions imposed; and it is difficult to determine how far the perception may be due to imagination rather than to retinal sensation. Professor Rogers succeeded in attaining perspective after-images, even when the luminous lines were regarded successively instead of together; but thus far no one else seems to have recorded the same results, and the experiment is still liable to the objection that the visual judgment is warped by anticipation and association. I have undertaken to test these results as rigidly as possible, and at the same time to ascertain whether any modification would be imposed by varying the muscular conditions under which the spectral images are seen.

1. Across the median plane of vision was held a card, with the upper edge more remote than the center, so that a white band from top to bottom on a dark background, was inclined about 40°. This was fixedly regarded with each eye in succession, while held in direct sunlight, until both retinas were fatigued. On going into a moderately dark room, the inclined spectral image was easily perceived, apparently in mid air. With visual lines parallel it became projected on the wall but without losing its obliquity. On strongly contracting the internal rectus muscles, it appeared still directly in front, but much smaller and nearer. The experiment was repeated many times, and varied, but with uniform results.

2. On separate cards a pair of diagrams were constructed in such manner as to produce an image in relief when binocularly viewed in the stereoscope or otherwise. These were separately and successively regarded in sunlight, each with the appropriate eye. In the dark room the resultant after-image was distinctly perceived in mid air, standing out in bold relief. On

* This Journal, II, xxx, Nov., 1860. † Phil. Transactions, 1838, ii, p. 392.
‡ Opt. Phys., p. 936.

shutting one eye, the component image that remained visible to the other was at once projected upon the wall as a flat picture. Strongly contracting the ciliary muscle of the eye remaining open, without sensibly contracting the rectus muscles, the picture was made to approach and grow apparently smaller, in almost as marked a degree as by the previous experiment.

3. A series of concentric black and white circular bands was constructed on a card, which was held in a vertical plane obliquely crossing the horizontal visual line of the left eye. After the retina became fatigued, the card was held across that of the right eye, but with opposite obliquity, so that the distortions of the elliptic images on the two retinas should be opposite in sense. The resultant spectral image was concave instead of plane, and presented the same variations with change of muscular conditions as in previous experiments.

4. To ascertain whether these perspective stereoscopic effects were due to imagination and association, or whether they were the immediate outcome of retinal sensation, from the existence of dissimilar images remaining through fatigue in the two eyes, it was necessary to test some person whose eyes were normal, but who was ignorant regarding the nature of the visual effects to be produced, and who therefore could not be influenced by anticipation. I enlisted the interest of a young friend, a youth of good general intelligence, but who was entirely unacquainted with even the elementary principles of binocular vision. He submitted to be trained until he could secure monocular after-images successfully with either eye at will. Without granting him the slightest clue by which results could be anticipated, I employed a pair of cards on which were diagrams, so arranged that the binocular resultant could be made either a raised cone, a flat picture, or a hollow cone, according to the mode of combination selected. These cards were viewed in sunlight, never binocularly but always in succession, the relation between the pictures being varied in successive experiments. As soon as the retinas were fatigued the observer was led into a perfectly dark room and requested to describe the resultant spectral images perceived. Without allowing him ever to know whether his visual judgments were right or wrong, I repeated these experiments day after day, until his own conclusions were formed by repeated interpretation of his retinal sensations. His judgments were in the majority of cases correct, and by spectral images alone he learned what was the proper arrangement of pictures to produce a binocular resultant that was concave or convex at will. I substituted then the cards with concentric circular bands; and in like manner he soon learned what kind of obliquity should be given the plane of each card

in order to produce a concave or convex spectral binocular image. His eyes did not have enough muscular power to test the effect of varying the tension in either ciliary or rectus muscles, nor was he able to perceive duplication in any part of any binocular spectral image.

5. A pair of diagrams were constructed in such manner as to show very plainly the binocular duplication of central parts in the background when the foreground was binocularly regarded, and the gaze was monocularly directed to the center of each in succession, with the usual precautions. The spectral image presented the appearance of relief. By an effort of special attention the duplication of the background became perceptible, but at the same moment the appearance of relief was lost.

These experiments, combined with those made under the light of the electric spark, show very conclusively that the *conscious* perception of double images, far from being conducive to clearness of binocular perception, tends rather to interfere with it. If it be said that we *unconsciously* perceive them and distinguish between the two kinds, this conclusion cannot be confirmed or disproven, except so far as experiments like those just detailed may be accepted as having some bearing upon the subject My own disposition is to discard intuition entirely, and, with Helmholtz, to regard the degree of attention bestowed upon objects pictured at the same moment on different parts of the two retinas as an element of more importance than either play of the eyes or the perception of double images. The point in the field of view to which most attention is habitually given is that pictured upon corresponding retinal parts; but the attention is at the same moment divided, being given in less degree to many other parts of the field of view, as simultaneously perceived with each eye. The mental suggestion due to the impression of non-corresponding parts is that of the third dimension in space. If this be called the perception of double images, their effect seems to be dependent upon their *not* emerging into consciousness. Add to this the fact that the gradation between single and double vision is wholly imperceptible, and hence that for infinitesimal departures from single vision, there can be no demonstrable distinction between the two kinds of double images. In the interpretation of our sensations we are certain that experience is our habitual guide, though by no means always a reliable one. Whether intuition can be accepted as an *additional* guide at all, it is not easy to pronounce. The debate between the advocates of the empiristic and nativistic theories is doubtless like the well known quarrel about a certain shield, and may be continued indefinitely. The domain of intuition is certainly more limited than was thought a few generations ago. Whether it can be reduced to zero may perhaps be decided a few generations hence. In all ordinary cases of binocular vision the judgment is cumulative, the conclusion quickly reached being a product not only of difference in the degree of attention given at the same moment to objects seen by direct and by indirect vision respectively, but also to variation in attention given to different points directly viewed in succession, to the muscular sense while free play is given to the eyes, and to all the elements available in monocular vision, which I have grouped together under the name of physical in contrast with physiological perspective.

ART. XXXVI.—*New views of Mr. George H. Darwin's Theory of the Evolution of the Earth-Moon System, considered as to its bearing on the question of the duration of Geological Time;* by the Rev. SAMUEL HAUGHTON, M.D., Fellow of Trinity College, Dublin.

[Read before the Mathematical Section of the American Association for the Advancement of Science, at Montreal, August, 1882.]

IT has been tacitly assumed, even so far back as the times of Newton and Clairaut, that the earth and planets have passed through a liquid condition (owing to former great heat) before assuming the solid condition, which some, at least, of them now possess.

Laplace, in his nebular hypothesis, also assumes the former existence of this liquid condition, and it is openly asserted by all geologists who believe that the earth consists of a solid crust (more or less thick), reposing upon a fluid or viscous nucleus.

It has been proved by Sir William Thomson, following out the views of the late Mr. Hopkins, that the present condition of the earth, taken as a whole, is such that it must be regarded as being more rigid than glass or steel, possibly more rigid than any terrestrial substance under the surface conditions of pressure.

The following considerations show that it may be fairly doubted whether the earth or any other planet ever existed in a fluid condition.

1. The possibility of the equilibrium of the rings of Saturn, on the supposition that they are either solid or liquid has been more than doubted, and the most probable hypothesis respecting them is, that they consist of swarms of discrete meteoric stones.

2. It is difficult to understand the low specific gravity of Jupiter and the other outer planets, on the supposition that they are either solid or liquid, for we know of no substance

light enough to form them.* If the outer planets consist of discrete meteoric stones moving around a solid or liquid nucleus, the difficulty respecting their specific gravity would disappear.

3. The recent researches connecting the November, the August, and other periodic swarms of shooting stars with comets tend in the direction of showing that comets in cooling, break up into discrete solid particles (each no doubt having passed through the liquid condition); and that probably the solar nebula cooled in like manner into separate fiery tears, which soon solidified by radiation into the cold of space.

4. Mr. Huggins's recent comparisons of the spectroscopic appearances of comets and incandescent portions of meteoric stones, showing the presence in both of hydrocarbon and nitrogen compounds, confirm the conclusions drawn from the identity of the paths of comets and meteoric periodic shooting stars.

5. Mr. H. A. Newton, in a remarkable paper read before the Sheffield Meeting of the British Association (1879), showed the possibility (if not probability) of the asteroids being extinct comets, captured and brought into the solar system by the attraction of some one or other of the outer large planets, and permanently confined in the space between Mars and Jupiter, which is the only prison cell in the solar system large enough to hold permanently such disorderly wanderers.

In the same paper, Professor Newton threw out the idea that some of the satellites of the large planets might also be of cometary origin.

From all these and other considerations it is therefore allowable to suppose that the earth and moon when they separated from the solar nebula, did so as a swarm of solid meteoric stones, each of them having the temperature of interstellar space; i. e. something not much warmer than 460° F. below the freezing point of water.

Mr. George H. Darwin has shown, admirably, how the earth-moon system may have been developed from the time when the earth-moon formed one planet revolving on its axis in a few hours, to the present time, when the earth and moon (in consequence of tidal friction) have pushed each other asunder to a distance of sixty times the radius of the earth.†

In his paper on the tidal friction of a planet‡ (supposed viscous and under the influence of bodily tides caused in it by an external body such as the moon), Mr. Darwin has found a remarkable equation of condition, which may be thus expressed:

* The force of this argument could not be felt before the revelations of the spectroscope, because at that time there was no proof that the whole universe was composed of the same simple substances, and those very limited in number.

† Proceedings of Royal Society, 19th June, 1879.

‡ Phil. Trans., 1881, Part ii, p. 494.

$$d(\sqrt{r}) \propto \frac{\Psi dt}{r^6} \qquad (1)$$

where γ = distance between centers of earth and moon.
t = time elapsed from a fixed epoch.

$$\Psi = \frac{p(n-\Omega)}{1+p^2(n-\Omega)^2} \qquad (2)$$

n = angular velocity of earth's rotation.
Ω = angular velocity of moon's orbital revolution.
p = quantity varying inversely as the viscosity of the planet.

The extreme interest of equation (1) consists in the appearance of the inverse sixth power of the distance.

As the function Ψ varies very slowly, we find by integration, for any portion of time during which Ψ may be regarded as constant

$$t = Ar^{\frac{13}{2}} + B, \qquad (3)$$

a most unexpected and remarkable result.

Upon reading Mr. Darwin's papers, my mind turned to a problem with which I was familiar, viz: the retardation of the earth's rotation produced by the lunisolar tide exerted upon the ocean supposed collected in an equatorial canal, the moon and sun having no declination, and I readily found an equation to express the evolution of the earth-moon system, on the foregoing hypothesis as to friction.

This equation is the following:

$$d(\sqrt{r}) \propto \frac{f\Phi dt}{r^6} \qquad (4)$$

where

$$\Phi = \frac{V_0(n-\Omega)}{\{4V_0^2(n-\Omega)^2-k^2\}\sqrt{4(n-\Omega)^2+f^2}} \qquad (5)$$

f = coefficient of friction supposed proportional to relative velocity.
k varies inversely as r^3.
V_0 = velocity at earth's equator.

This leads, as in Mr. Darwin's hypothesis of viscous earth, to the integral

$$t = A'r^{\frac{13}{2}} + B' \qquad (6)$$

The form of the functions Ψ and Φ is similar, as both ascend by odd powers of $(n-\Omega)$ and vanish when $n=\Omega$, that is to say, at the beginning and end of the evolution by friction of the earth-moon system.

It is quite clear, therefore, that the remarkable expression (1) found by Mr. Darwin, is not peculiar to his special hypothesis of a viscous earth, but can be deduced equally well from the totally distinct hypothesis of an absolutely rigid earth retarded by the tidal action of a liquid ocean.

I was led by this result to consider the case of the earth-moon separating (as I believe they did) from the central solar mass, in the form of a swarm of discrete masses of meteoric iron and stone, each one having the temperature of the cold of interstellar space, or not much above it. Translating this conception into mathematical language, I find that the equation of continuity belonging to the hydrodynamical theory applies equally well to the meteoric theory, viz:

$$vy = v'y' \qquad (7)$$

where v, v', are the velocities at any two points, and y, y' are the depths of the ocean or meteoric swarm at the same points.

The depth of the swarm or ocean, without jostling or friction will be least under the moon, and greatest at right angles to the moon, and the velocities will be inversely. Hence the chances of jostling among the meteorites, when disturbed by the moon's tidal action will be proportional to the velocity, being greatest where the velocity is greatest and the area of passage least, and *vice versa.*

This consideration reduces the meteoric problem to that of the hydrodynamical problem, with a friction proportional to the velocity, and gives equations, in all respects similar to those derived by Mr. Darwin, from the hypothesis of a viscous earth.

On the meteoric hypothesis, if the jostling of the stones be slow they may cool almost as fast as they are heated and the result will be a cool earth and almost indefinite time at the disposal of geologists.

Art. XXXVII.—*Recent discoveries in the Erian (Devonian) Flora of the United States;* by J. W. Dawson.

The following notes are extracted from a Report on Devonian Plants prepared for the Geological Survey of Canada, but not yet published. They relate to the recent discoveries made in the United States, and their bearing on points of interest with reference to the Erian Flora.

I. The Nature and Affinities of Ptilophyton.

(*Lycopodites Vanuxemii* of Report on Devonian and Upper Silurian Plants, Pt. I, p. 35.—*L. plumula* of Report on Lower Carboniferous Plants, p. 24, Pl. I, figs. 7, 8, 9.)

In previous publications these remarkable pinnate frond-like objects were referred to the genus *Lycopodites*, as had been done by Gœppert in his description of the European species *Lycopodites pennæformis*, which is very near to the American Erian form. Since 1871, however, there have been many new specimens obtained, and very various opinions expressed as to their affinities. While Hall has named some of them *Plumalina* and has regarded them as animal structures, allied to hydroids, Lesquereux has described some of the Carboniferous forms under the generic name *Trochophyllum*, which is however more appropriate to plants with verticillate leaves which are included in this genus. Before I had seen the publications of Hall and Lesquereux on the subject, I had in a paper on Scottish Devonian Plants,* separated this group from the genus *Lycopodites* and formed for it the genus *Ptilophyton*, in allusion to the feather-like aspect of several of the species. My reasons for this, and my present information as to their nature may be stated as follows:

Schimper, in his "Paléontologie Végétale," (possibly from inattention to the descriptions or want of access to the specimens) doubts the Lycopodiaceous character of species of *Lycopodites* described in my published papers on plants of the Devonian of America and in my Report of 1871. Of these *L. Richardsoni* and *L. Matthewi* are undoubtedly very near to the modern genus *Lycopodium*. *L. Vanuxemii* is, I admit, more problematical; but Schimper could scarcely have supposed it to be a fern or a fucoid allied to *Caulerpa* had he noticed that both in my species and the allied *L. pennæformis* of Gœppert, which he does not appear to notice, the pinnules are articulated upon the stem, and leave scars where they have fallen off. When in Belfast in 1870, my attention was again directed to the affinities of these plants by finding in Professor Thomson's collection a specimen from Caithness, which shows a plant apparently of this kind, with the same long narrow pinnæ or leaflets, attached, however, to thicker stems, and rolled up in a circinate manner. It seems to be a plant in vernation, and the parts are too much crowded and pressed together to admit of being accurately figured or described; but I think I can scarcely be deceived as to its true nature. The circinate arrangement in this case would favor a relationship to ferns; but some Lycopodiaceous plants also roll themselves in this way, and so do the branches of the plants of the genus *Psilophyton*.

The specimen consists of a short erect stem, on which are placed somewhat stout alternate branches, extending obliquely outward and then curving inward in a circinate manner. The lower ones appear to produce on their inner sides short lateral branchlets, and upon these and also upon the curved extremities of the branches, are long narrow linear leaves placed in a crowded manner. The specimen is thus not a spike of fructification, but a young stem or branch in vernation, and which when unrolled would be of the form of those peculiar pinnate

* Canadian Naturalist, 1878.

Lycopodites of which *L. Vanuxemii* of the American Devonian and *L. pennæformis* of the European Lower Carboniferous are the types, and it shows, what might have been anticipated from other specimens, that they were low tufted plants, circinate in vernation.

As these plants constitute a small but distinct group, known only, so far as I am aware, in the Lower Carboniferous and Erian or Devonian, they deserve a generic name, and I proposed for them in my Paper on Scottish Devonian Plants, 1878, that of *Ptilophyton*, a name sufficiently distinct in sound from Psilophyton, and expressing very well their peculiar feather-like habit of growth. The genus was defined as follows:

"Branching plants, the branches bearing long slender leaves in two or more ranks, giving them a feathered appearance; vernation circinate. Fruit unknown, but analogy would indicate that it was borne on the bases of the leaves or on modified branches with shorter leaves."

The Scottish specimen above referred to was named *Pt. Thomsoni*, and was characterized by its densely tufted form and thick branches. The other species known are:

Pt. pennæformis Gœppert, L. Carboniferous.
Pt. Vanuxemii Dawson, Devonian.
Pt. plumula Dawson, L. Carboniferous.

Shumard's *Filicites gracilis*, from the Devonian of Ohio, and Stur's *Pinites antecedens*, from the Lower Carboniferous of Silesia, may possibly belong to the same genus. The Scottish specimen referred to is apparently the first appearance of this form in the Devonian of Europe.

I have at a still later date had opportunities of studying considerable series of these plants collected by Professor Williams of Cornell University, and have prepared a note in reference to them for the American Association, of which, however, only an abstract has been published. I have also been favored by Professor Lesquereux and Mr. Lacoe of Pittston, with the opportunity of studying the specimens referred to *Trochophyllum*.

Professor Williams's specimens occur in a dark shale associated with remains of land plants of the genera *Psilophyton*, *Rhodea*, etc., and also marine shells, of which a small species of *Rhynchonella* is often attached to the stems of the *Ptilophyton*. Thus these organisms have evidently been deposited in marine beds, but in association with land plants.

The study of the specimens collected by Professor Williams developes the following facts: (1.) The plants are not continuous fronds, but slender stems or petioles with narrow linear leaflets attached in a pinnate manner. (2.) The pinnules are so articulated that they break off leaving delicate transverse scars, and the lower parts of the stems are often thus denuded of pinnæ for the length of one or more inches. (3.) The stems curve in such a manner as to indicate a circinate vernation. (4.) In a few instances the fronds were observed to divide dichotomously toward the top; but this is rare. (5.) There are no indications of cells on the pinnules; but, on the other hand, there is no appearance of fructification unless the minute granules which roughen some of the stems are of this nature. (6.) The stems seem to have been lax and flexuous, and in some instances they seem to have grown on the petioles of ferns preserved with them in the same beds. (7.) The frequency of the attachment of small brachiopods to the specimens of *Ptilophyton* would seem to indicate that the plant stood erect in the water. (8.) Some of the specimens show so much carbonaceous matter as to indicate that the pinnules were of considerable consistency. All these characters are those rather of an aquatic plant than an animal organism or a land plant.

The specimens communicated by Professor Lesquereux and Mr. Lacoe are from the Lower Carboniferous, and evidently represent a different species with similar slender pitted stems, often partially denuded of pinnules below; but the pinnules are much broader and more distant. They are attached by very narrow bases, and apparently tend to lie on a plane, though they may possibly have been spirally arranged. On the same slabs are rounded sporangia or macrospores like those of *Lepidodendron*, but there is no evidence that these belonged to *Trochophyllum*. On the stems of this plant, however, there are small rounded bodies apparently taking the places of some of the pinnules. These may possibly be spore-cases; but they may be merely imperfectly developed pinnules. Still the fact that similar small granules appear on the stems of the Devonian species, favors the idea that they may be organs of fructification.

The most interesting discovery, however, which results from the study of Mr. Lacoe's specimens, is that the pinnules were cylindrical and hollow, and probably served to float the plant. This would account for many of the peculiarities in the appearance and mode of occurrence of the Devonian *Ptilophyton*, which are readily explained if it is supposed to be an aquatic plant, attaching itself to the stems of submerged vegetable remains and standing erect in the water by virtue of its hollow leaves. It may well, however, have been a plant of higher organization than the algæ, though no doubt Cryptogamous.

The species of *Ptilophyton* will thus constitute a peculiar group of aquatic plants, belonging to the Devonian and Lower Carboniferous periods, and perhaps allied to Lycopods and Pillworts in their organization and fruit, but specially distinguished by their linear leaves serving as floats and arranged pinnately on slender stems. The only species yet found within the limits of Canada is *Pt. plumula* found by Dr. Honeyman in the Lower Carboniferous of Nova Scotia; but as *Pt. Vanuxemii* abounds in the Erian of New York, it will no doubt be found in Canada also.

II. Note on Erian Trees of the Genus Dadoxylon, Unger (*Araucarites* of Gœppert, *Araucarioxylon* of Krans.)

Large woody trunks, carbonized or silicified, and showing wood-cells with hexagonal areoles having oval pores inscribed in them, occur abundantly in some beds of the Middle Erian in America, and constitute the most common kind of fossil wood all the way to the Trias. They have in the older formations, generally, several rows of pores on each fiber, and medullary rays composed of two or more series of cells, but become more simple in these respects in the Permian and Triassic series. The names *Araucarites* and *Araucarioxylon* are perhaps objectionable, inasmuch as they suppose affinities to *Araucaria* which may not exist. Unger's name, which is non-committal, is therefore, I think, to be preferred. In my Acadian Geology and in my Report on the Geology of Prince Edward Island, I have given reasons for believing that the foliage of some at least of these trees was that known as *Walchia*, and that they may have borne nutlets in the manner of Taxine trees (*Trigonocarpum*, etc.). Grand d'Eury has recently suggested that some of them may have belonged to *Cordaites*, or to plants included in that somewhat varied and probably artificial group.

The earliest discovery of trees of this kind in the Erian of America, was that of Matthew and Hartt, who found large trunks, which I afterwards described as *Dadoxylon Ouangondianum*, in the Erian Sandstone of St. John, New Brunswick, hence named by those geologists the "Dadoxylon sandstone." A little later, similar wood was found by Professor Hall and Professor Newberry in the Hamilton group of New York and Ohio, and the allied wood of the genus *Ormoxylon* was obtained by Professor Hall in the Portage group of the former State. These woods proved to be specifically distinct from that of St. John, and were named by me *D. Halli*, *D. Newberryi*, and *Ormoxylon Erianum*. The three species of *Dadoxylon* agreed in having composite medullary rays, and would thus belong to the group *Palæoxylon* of Brongniart. In the case of *Ormoxylon* this character could not be very distinctly ascertained, but the medullary rays appeared to be simple.

I am indebted to Professor J. M. Clarke of Amherst College, Massachusetts, for some well preserved specimens of another species from the Genesee shale of Canandaigua, New York. They show small stems or branches, with a cellular pith surrounded with wood of Coniferous type, showing two to three rows of slit-formed bordered pores in hexagonal borders. The medullary sheath consists of pseudo-scalariform and reticulated fibers; but the most remarkable feature of this wood is the structure of the medullary rays, which are very frequent, but short and simple, sometimes having as few as four cells superimposed. This is a character not before observed in Coniferous trees of so great age, and allies this Middle Erian form with some Carboniferous woods which have been supposed to belong to Cordaites or Sigillaria. In any case this structure is new, and I have named the species *Dadoxylon Clarkii*, after its discoverer. The specimens occur, according to Professor Clarke, in a calcareous layer which is filled with the minute shells of *Styliola fissurella* of Hall, believed to be a Pteropod; and containing also shells of *Goniatites* and *Gyroceras.* The stems found are only a few inches in diameter, but may be branches of larger trees.

It thus appears that we already know five species of Coniferous trees of two genera in the Middle Erian of America, an interesting confirmation of the facts otherwise known as to the great richness and variety of this ancient flora. Professor Gœppert informs me that he has recently recognized similar wood in the Devonian of Germany, and there can be no doubt that the fossil wood discovered by Hugh Miller in the Old Red Sandstone of Scotland, and described by Salter and McNab, is of similar character, and probably belongs to the genus *Dadoxylon.* Thus this type of Coniferous trees seems to have been as well established and differentiated into species in the Middle Devonian as in the succeeding Carboniferous.

III. The Genus Cladoxylon in America.

In the Report of the Fossils of the Devonian rocks of Thuringia, by Unger and Richter,* the former has described and figured certain fossil stems showing structure, to which he gives the name *Cladoxylon*, and makes them the types of a Family *Cladoxyleæ*, which he regards as allied to Lycopods. He describes the stem of *C. mirabile* as having a slender cellular pith surrounded by a series of vertical plates of scalariform tissue, adhering internally, and separating and sometimes forking toward the exterior, the whole surrounded by a thick cellular investment.

Professor Clarke has been so fortunate as to find in the *Styliola* limestone, which contains the branches of *Dadoxylon*, a specimen showing the structure of *Cladoxylon*, and so similar to Unger's species, *C. mirabile*, that I think it may safely be referred to it. The stem is 1·5 centimeter in diameter, and marked with about fifteen longitudinal ribs; which are the edges of the

* Vienna, 1856.

radiating plates of scalariform vessels. In the cross section, the axis consists of vertical but wavy radiating bands of pseudoscalariform tissue, with intervening cellular matter. Enclosing the axis is a cylinder of thin-walled cellular tissue traversed by a few bundles of fibers. The outer surface has a dense cortical structure, but unfortunately shows no external markings. This discovery affords another interesting link of connection between the Erian flora of Eastern America and that of Europe.

We know from the rocks and fossils of Gaspé and St. John, that in the Middle Devonian period there was much land on the eastern side of the North American Continent. But at this period the regions of western New York and Ohio and of western Canada, were covered by the sea. It thus happens that the land flora of the Hamilton and associated rocks of the interior portion of the Continent, consists merely of drifted and macerated remains carried out to sea. The number and variety of these remains, however, testify in a remarkable manner to the richness of the flora, representing as they do, though in an imperfect manner, many species of Conifers, Tree-ferns, and Arborescent Lycopods, all of which probably grew on limited insular areas.

To Professor Clarke we are also indebted for the discovery of a remarkable tree of the Hamilton period (*Celluloxylon primævum* Dn.); and Mr. B. M. Wright of Penn Yan, N. Y., has recently added to the plants of the Portage and Chemung the singular types of tree-fern, *Asteropteris Noveboracensis* Dn., an equisetaceous plant, *Equisetites Wrightiana* Dn., and *Cyclostigma affine*, a plant allied to the well-known *Cyclostigma* of the Irish Devonian. These species have been described in the Journal of the London Geological Society for May, 1881.

IV. Psilophyton and Rhodea.

Reference is made to the abundant occurrence of the species *P. princeps* and *P. robustius* in the Lower Erian near Campbellton, and the corroboration which the specimens afford of the author's previous statements as to the structure and affinities of these plants so characteristic of the Erian both in Europe and America.

As it has, however, been suggested by some botanists that *Psilophyton* may have been allied to the ferns of Stur's genus *Rhodea*, I may state here that after the study of hundreds of specimens, in every state of preservation, I have found no trace of any fronds on the branches, but on the barren branches minute acicular leaves, while the spore-cases, though in the form of sacks, having some resemblance to those of *Archæopte-*

ris, are entirely different in their habit of growth, and also very much larger.

In this connection I may mention that in specimens from the Chemung shales of New York, recently obtained from Professor Williams, I have found plants which may be referred to *Rhodea*. They are slender delicately striated or smooth petioles, giving off pinnate divisions, which ultimately bifurcate frequently and appear to terminate in flat blade-like or cuneate leaves or fronds. They are the same objects which I described, from fragmentary specimens obtained from Professor Hall, as *Rhachiopteris pinnata*, in my paper on Devonian plants, in the Journal of the Geological Society of London, vol. xviii. In a note on Professor Williams' plants, presented last year to the American Association for the Advancement of Science, I have described these specimens and have suggested the name *Rhodea pinnata* for them. They may be defined to be stems bearing slender opposite branches in a decussate manner, the branches again dividing in a dichotomous or pinnate mode, and terminating in small cuneate or linear leaves. The fructification of these plants I have not seen, but they are in appearance and habit of growth altogether distinct from *Psilophyton*. I may also observe here that the stems of *Psilophyton* are much more woody, and in their round central scalariform axis, present much more of structural affinity to Lycopods than to Ferns.

Art. XXXVIII.—*Brief Notice of Observations on the Triassic Trap Rocks of Massachusetts, Connecticut and New Jersey*; by W. M. Davis.

During the past summer I have examined the Triassic trap rocks in Massachusetts, Connecticut and New Jersey at a number of points where they are shown in characteristic development. The detailed statement of these observations will soon be published in the Bulletin of the Museum of Comparative Zoology, Cambridge, with full reference to previous work; in the mean time the following brief account of the results attained is presented.

The traps occur in three distinct conditions: first, in dikes crossing the strata of sandstones and shales; these or similar ones not yet revealed by erosion were undoubtedly the passages of supply for the trap sheets; second, in intruded sheets often of great extent and thickness, lying in nearly all cases conformably between the layers of stratified rocks; third, as overflow sheets poured out during the formation of the sandstone, in thickness and extent equal to the intrusions, and similar to them in topographic effects.

None of the dikes are surely known in Massachusetts, but Connecticut gives numerous examples at Wallingford, East and New Haven and elsewhere; in New Jersey they are rarely seen, but farther southwest they are frequently mentioned. None that I have seen are amygdaloidal; their sides are generally uneven and are sometimes very ragged, implying an eruption before the formation of joints in the sandstone; their metamorphic effect on the adjoining rocks is slight, so far as determined; not extending more than half a foot to two feet from a ten-foot dike, or eight to twelve feet from a hundred-foot dike. The largest dikes that I have seen are Mill and Pine Rocks, New Haven: they are one to two hundred feet thick, of medium coarse texture in the middle, fine at the sides, compact throughout; they break through gently inclined, coarse sandstone strata about at right angles to the bedding, and have a rough transverse columnar structure. It is probable that few of the supply-dikes which fed the largest sheets are yet laid bare.

The intruded sheets are recognized by a distinct metamorphic effect on the strata above as well as below them, and by the absence of amygdaloids; they very probably cut across the adjoining strata at some points, but this cannot always be used for their detection as they are sometimes seen to be evenly interbedded for as much as one hundred feet. They are like the dikes in being younger than the strata which enclose them, but their age is not surely determinate, as will be shown below. The range from West Rock northward from New Haven, and the Palisades along the Hudson are the largest and finest examples: the latter shows as marked a metamorphic effect on the strata on its back as on those below it; the former has produced less alteration, but there is no doubt of its intrusive character. Other smaller intrusions are found along the Delaware. It may be here noted that the Triassic trap sheets have been regarded as intrusive by nearly all authors who have written upon them; Mr. I. C. Russell has recently stated this view of the origin of the First Newark Mountain, N. J. (incorrectly, as I think), as well as for the Palisades. Professor Dana considers all the sheets intrusive, and does not mention overflows in his Manual of Geology, 1880.

The overflow or contemporaneous origin for the trap sheets was first clearly stated by E. Hitchcock, 1833 and 1841; it was later advocated by Principal Dawson for Nova Scotia, and recently by Professor Emerson of Amherst,* but it has never had many advocates.

The overflow sheets are known from being commonly very amygdaloidal on their back or upper surface, and sometimes

* See this Journal for September, 1882.

within the mass or at its base; they exert a small metamorphic effect on the underlying stratum, and none at all on the overlying bed which was deposited conformably upon them. They are sometimes accompanied by a tufaceous deposit, presumably of ashes thrown into the Triassic estuaries; and the overlying sandstone sometimes contains trap fragments. Examples of overflows are the Turner's Falls–Deerfield Range, as lately shown by Emerson; Mts. Holyoke and Tom, first proved by Hitchcock, and their extension southward into Connecticut to the Hanging Hills at Meriden; Lamentation Mountain and some others to the south of it, with their subordinate lateral ranges nearly to Long Island Sound; and First and Second Newark Mountains in New Jersey. The evidence is not equally complete for all of these.

The general history of these Triassic deposits seems to be as follows: Their strata were laid down about horizontally; Rogers' suggestion that their present dip comes from an original oblique deposition cannot be adopted. During their accumulation, heavy sheets of trap overflowed their surface, and sometimes rose above the Triassic waters, so that fragments of trap were mixed with the next formed beds. The common occurrence of foot-prints in the strata not far above the trap is, as was shown Hitchcock, a singular confirmation of this point. These eruptions did not occur simply because the region was disturbed, for many regions of much greater disturbance show no igneous rocks; but very probably because the disturbance was a downfolding and not a general upfolding as in most mountain ranges. The deposition of more strata and the overflow of more trap ceased when the downfolding, that had begun and deepened the Triassic troughs, changed (for some unknown reason) to disturbance with uplifting.

The general monoclinical structure of the several Triassic belts is not considered the result of original oblique deposition as proposed by Rogers; or of broad anticlinal folding as suggested by Kerr and Russell; or of a simple monoclinal tilting as assumed by Hitchcock and LeConte; but is regarded rather as the effect of lateral compression, producing a peculiar distortion. The style of the distortion is best recognized by means of the overflow trap ridges, which are generally continuous for several or many miles; for these, when once proved to be overflows, are established as well marked horizons in the generally monotonous sandstones and shales; satisfactory evidence can thus be obtained to show that the strata as a whole are both folded and faulted. The folds take the form of shallow oval dishes or boats, of gentle curvature, canted over a little and faulted on the side of the general monoclinal dip; and the outcropping edges of the hard trap sheets then necessarily take the crescentic form, first fully recognized by Percival, with their bold convex side toward the up-slope of the monoclinal, and their horns toward the down-slope. The existence of such folds is well proven for several cases by finding that the strike of the neighboring sandstone is closely parallel to the trend of the curved ridge, and that the dip is directed in toward the center of the curve. This has been shown but not fully appreciated by several observers.

Faults are known by the reappearance of certain strata, or series of strata. In this way it may be made very probable that the Hanging Hills sheet reappears in Lamentation Mountain, and again in the several strong ridges as far south as Lake Saltonstall; the face of most if not all of these ridges being characterized by sandstone, amygdaloidal trap, limestone, shale and heavy trap, always occurring in this (ascending) order: smaller examples could also be named. But no sufficient reason has been found to show why a general monoclinal tilting should have taken place.

The New Jersey and Massachusetts areas have few folds and faults shown by trap ridges; they are made on a larger pattern; but faults may occur, unperceived, in their sandstone. Connecticut is decidedly the best field for the study of all the points above mentioned in the history of the Triassic formations.

The age of the intruded sheets has been referred to as indeterminate: it is not as yet susceptible of good limitation. The early writers, who considered all the trap intrusive, often looked on it as the agent of disturbance of the sandstone; later writers, as Dana and Russell, regard it as intrusive after the tilting of the sandstones had been accomplished by some other force. As opposed to these views, I would present the following evidence of its intrusion before the tilting and perhaps nearly contemporaneous with the appearance of the overflows. The dikes and the intruded sheets, where seen to break across the strata, show irregular or ragged edges, as above noted: their intrusion therefore took place before the production of joints, now very distinct in many parts of the sandstone, and hence probably before the tilting, for the joint-making almost surely could not have been later than the tilting and may have been earlier. Moreover, if the intrusions took place during or after the tilting, there is no reason why they might not appear at any part of the Triassic belts; but as a matter of fact the large and well proved intruded sheets occur only near the base of the formation, close to the adjoining crystalline rock; and the only reason that I can assign for so peculiar a limitation is that the interbedded intrusions took place only under a considerable pressure of overlying rocks, as was the case with the western Laccolites which these intruded sheets resemble in many ways. Finally, the intruded sheets, as well as the overflows, outcrop along curved lines; this curvature in the overflows results from a bending after their eruption; therefore the others also were probably bent after their intrusion. But it must be borne in mind that all of this is only presumptive evidence and not final proof; the age of the intrusions is not yet determined.

Cambridge, Mass., Oct. 5, 1882.

Art. XXXIX.—*The Deerfield Dyke and its Minerals*; by Ben. K. Emerson, Professor of Geology in Amherst College.

[Concluded from page 278.]

Kaolin.—Along the shore in Greenfield opposite Turner's Falls, and especially on the new road between these towns, the decomposition of the radiated prehnite has very frequently taken a different course. The nodules are in whole or part changed into a white kaolin (?), the change uniformly commencing from the different centers of radiation and proceeding regularly outward. Under the microscope the kaolin-like material separates into opaque granules so extremely minute that they show in water the Brownian movement with wonderful perfection.

Calcite.—Among the minerals associated with prehnite we may distinguish those which are enclosed by and themselves enclose the latter, those which are only enclosed in it, and those which are superimposed upon it and are of later formation.

In the first category calcite is the most common. The trap at the base of the prehnite effervesces with acid, and sometimes cleavage surfaces of the latter resemble closely graphic granite on a small scale, the prehnite taking the place of quartz, and if pieces where the calcite is specially abundant be thrown in acid, there remains a delicate frost-work of prehnite on the trap, and similar groups of imperfect crystals are exposed and fall to the bottom of the glass, being surrounded on all sides by calcite. The calcite which is thus intimately associated with prehnite appears at times in quite large masses of transparent Iceland spar; more commonly in white granular portions. Sometimes it is yellow and is perhaps ankerite. The calcite is most abundant immediately after the prehnite and accompanies in varying forms all the later numbers of the series. It also occurs independently in the uppermost layer of the dyke to the depth of a meter in the immediate vicinity of the quartz veins mentioned later, though the two remain strictly separate. Here it fills large steam pores 10–30^{mm} in diameter, which rise vertically 10–15^{cm}. The walls are coated with a thick layer of diabantite and they are filled with brick-red and transparent calcite in layers.

2. EPIDOTE.—Occurs rarely low down in the prehnite; more commonly in drusy surfaces in its upper part, or spread in delicate tufts of flat blades upon the spindle-shaped crystals. It is included also, with interrupted crystallization, in the calcite which follows upon the prehnite. The maximum size of the crystals is 3^{mm}. They are mostly thick plates, and under the microscope show as brilliant luster and as rich dark green as the specimens from the Dauphiny. It encloses as an aggregate prehnite, sphalerite, chalcopyrite and calcite, but the separate crystals are perfectly pure and transparent. The thickest crystals are deep pistachio green; the thin plates are deep brown-red, sometimes half colorless.

AXINITE.—Jet black, opaque crystals, the largest 10–12^{mm} in length, imbedded in prehnite and calcite and resting on prehnite. The crystals are thick plates, resembling, as do many of the minerals found here, the simpler forms from Bour d'Oisans—the faces P and *u* large and striated vertically, and P also striated horizontally parallel to the intersection edge of P and *r*. The face *r* is smaller and striated horizontally. Rarely the faces *v*, *l* and *s* appear. Two very distinct distant cleavages, especially clear under the microscope, parallel to the two striations upon P, and nearly at right angles to this face, thus nearly cubical. Thin splinters show brilliant trichroism, deep bottle-green, plum blue and clove brown, and are glassy and easily transparent under the microscope, and entirely free from all impurities. The mineral has occurred also at the old locality, east of Deerfield village, and appears in the State Collection, Nos. 86, 87, labeled "Black Augite in Greenstone, Deerfield." Also, opposite Turner's Falls a single perfect crystal 4^{mm} long, black, with shade of brown, resting upon a botryoidal layer of diabantite in an amygdule.

CHALCOPYRITE.—Occurs disseminated in particles in the trap, in the prehnite, and in the calcite above, the latter rarely in tetrahedra up to 2^{mm} in length in cavities in the prehnite and in minute, fresh-looking striated tetrahedra in calcite. Also on botryoidal diabantite and in the "chlorophocite" in Gill.

SPHALERITE.—Rarely in red-brown grains 5–6^{mm} long, fresh-looking and of high luster in the interior, but generally surrounded by a bright red rust layer. In prehnite, epidote and calcite, and in the light gray diabase, filling cavities lined with diabantite, with curious many-faceted globules.

PYRITE appears in minute fresh striated crystals in prehnite and calcite and in limonite pseudomorphs in the same situation.

Also alone, as one of the most modern minerals present, in broad, flattened rosettes in comparatively fresh fissures in the trap.

GALENITE.—Extremely rare in minute grains in prehnite, chlorophœite, and calcite.

QUARTZ.—Only in a single specimen from the Cheapside veins did quartz occur associated with the zeolitic minerals. Here a few minute, elongated prisms appear in and on prehnite. Toward the upper surface of the dyke occur veins 4–5^{cm} wide, coarse comby quartz whose terminations interlace irregularly at the center. Between the wall on one side and the regular cockscomb quartz a layer 10^{mm} thick of broken-up quartz crystals, re-cemented by quartz, showing that the vein had once partly filled itself and then by the rubbing together of the walls the work was interrupted. In other parts of the vein the quartz is much gashed by broad, thin cavities which are often as many as twelve, one above the other, and parallel to the walls as well as scattered in various directions. They seem to have been produced by the repeated formation of a layer of some mineral, now wholly gone, probably selenite or barite. Quartz occurs more abundantly in the veins east of Deerfield than at Cheapside in form of amethyst, agate, carnelian and calcedony, as mentioned by President Hitchcock, and in the main replaces the prehnite of the latter veins.

SELENITE.—Professor Hitchcock mentions that selenite had been found in the Deerfield trap by Professor Silliman (this Jour., vol. v, p. 212), and described moulds of unknown crystals left in the quartz of the zeolitic veins east of Deerfield. Casts taken from these moulds show that the mineral which has disappeared was selenite which occurred here very abundantly and in well-formed crystals 20^{mm} long. The quartz rises into the moulds in sharp parallel crests where it had penetrated between the laminæ of the selenite along the perfect cleavage.

In the Cheapside veins similar, but smaller negative crystals occur in the prehnite which at times rose around and covered the selenite, before its disappearance, forming thus rude pseudomorphs; and I suspect that part or all of the abundant gashing of the prehnite, quartz and datolite may be due to this mineral.

FLUORITE.—Emerald-green dodecahedra-like beads strung upon a satin thread occur half imbedded in and scattered over and among the last-formed fibrous prehnite, the crystals ·03^{mm} in length, also in the same relation to epidote and enclosed in the calcite which succeeds these. In a single case each, emerald-green octahedra and cubo-octahedra, ·03^{mm} in size, in a drusy cavity in epidote, and in green cubes upon prehnite.

CALCITE.—*Of the minerals which succeed to the prehnite*, calcite and datolite are the most important and most abundant and generally replace each other in different veins. In some a large development of calcite occurs with much axinite, in others an equally large development of datolite. The axinite shows that boracic acid was not wanting during the formation of the prehnite and during the subsequent increase of the calcite in the veins where the datolite fails to appear, and the presence of epidote and the more abundant development of prehnite indicate more elevated temperature in the latter, while in the other veins the supply of boracic acid was greatly increased so that nearly all the calcite was absorbed in the formation of datolite.

Excepting quartz all the minerals enumerated above as enclosures in prehnite occur as enclosures in the calcite which follows it, and when pieces where the latter is abundantly developed are thrown in acid and the calcite nearly dissolved away, specimens of great beauty are obtained, the delicate frost-work of prehnite, chalcopyrite, epidote, and the black stout axinite being set off against the brilliant luster of the etched calcite, the whole being sprinkled over with minute pale green dodecahedra of fluor. It occurs abundantly in distinct crystals and drusy surfaces over the prehnite; $-\frac{5}{4}$R small with rounded edges; 1^5 bristling over large surfaces; 1^6, *O*, 4R *i*, 1^3, with curved and striated faces; 1^{12} with deeply striated faces and often distorted; 1^7, $-\frac{1}{2}^5$, the first striated parallel to $-\frac{1}{2}$R, and the form either acuminate or truncated by a single face of R. Other delicately suspended forms had at one end a single broad face of R and rose in a group of sharp scalenohedra at the other end. Every where the crystals were small and affected the most elongate forms with rounded edges and rounded, striated and distorted faces, as if to imitate as closely as possible the prehnite with which they were associated, while on the datolite the forms 2R or −2R, R invariably appear in large perfectly transparent crystals up to 18^{mm} in length, and with a luster equal to that of the datolite itself.

DATOLITE.—The datolite is second only to prehnite in abundance at the new cutting, and surpasses all the minerals occurring here in beauty, perfectly pellucid crystals up to 12^{mm} long being not uncommon, and many of the same showing a great range of rare faces and curious and perplexing distortions. It occurs also in thin veins, developing no crystals on the north side of the river and rarely in the amygdules in the light gray diabase. The mineral fills the veins often completely with a white saccharoidal deposit from 10 to 50^{mm} thick, with only here and there cavities in which fine crystals have come to development. It rests sometimes upon the trap itself, which is there quite fresh, and where slickensides occur they are of light gray color, due to the mixture of datolite and trap, without the appearance of any of the chloritic or serpentinous products of decomposition which darken the same formation in the prehnite. More commonly it rests upon a thin layer of massive prehnite, rarely with several alternations of datolite and prehnite in calcite or upon the thick layers of spindle-shaped crystals of the former mineral, where the separate attached crystals reach the greatest perfection. The crystals of datolite, which resemble those of Farmington in their glassy clearness and general habit, are remarkable for the great number of faces represented and for the distinctness of the types into which they are grouped, as well as for the manifold and intricate forms produced by the unique development sometimes of single faces and sometimes of all the faces on one side of the vertical plane.

The following is a list of all the forms represented, arranged according to the table given by E. S. Dana.* $i i$ (a), $i \breve{i}$ (b), O (c), I (M), i-2 (o), i-3 (l), -1-i (u), $-\frac{4}{3}$-i (v), -2-i (x), -6-i (s), 4-i (Π), 2-i (ξ), $\frac{1}{2}$ $\breve{i}$ (Ω), 1-$\breve{i}$ (σ), $\frac{4}{3}$-$\breve{i}$ (t), 2 $\breve{i}$ (g). 4-$\breve{i}$ (m), -4 (n), 2 (ε), $\frac{4}{3}$ (λ), 1 (μ), $\frac{4}{5}$ $(\varkappa)$, -6-3 (q), -4-2 (δ). 4 2 (θ), 12 $\frac{3}{2}$ (π), -16-2 (R), -8-2 (β), -4-2 (Q), $-\frac{8}{3}$ 2 (U), -2-2 (γ), 2-2 (α), $\frac{8}{3}$-2 (i), 8-2 (B), $\frac{8}{5}$-2 (C.) [new], $\frac{2}{5}$-3 (E), $\frac{5}{2}$-3 (F), $\frac{5}{2}$-5 (K), $\frac{9}{4}$-9 (G).

For convenience of description the crystals may be divided into three types:

I. *The regular.*—In this almost spherical forms are produced by the equal development of a large number of faces. In one crystal x, ε, m were slightly larger than the rest; a, M, n, o, β, Q, equally developed c, q, B, very small.

Another very stout, prismatic and resembling the Andreasberg crystals somewhat in the distribution of its faces, except that the elongation in the direction of the clinodiagonal axis was only slight, had the faces x, ε, λ, g, m, largest; $i i$, M, -4, β, Q, O, μ, $i\breve{i}$, about equal; u, v, q, θ, ξ, o, π, α, $\varkappa$, smaller.

A third was formed by the nearly equal development of a, x, g, m, ε, λ, μ, M, o, n, β, B, with O, s $(-6i)$ q and γ subordinate.

A fourth minute but very beautiful crystal was unique for this locality in having the face o large and square and $i i$ elongated vertically, the faces g, m, u, x, a, n, M, ε, λ, o, β, Q, U, α about equally large, ξ, q, μ, i, F small.

Several of the larger crystals of this type showed a new face in the zone λ $(\frac{4}{3})$, g (2-$\breve{i}$; and o (i-2), c (O) $= \frac{8}{5}$-2 to which I have in the preceding list applied the letter C.

II. *Prismatic type.*—By the great enlargement of x and two opposite faces of m, a prism of 116° is formed, elongated in

* Tsch. Min. Mitth., 1874, p. 5.

the direction of the axis of the zone *x*, *o*, *m*, the sharp edges of which are beveled by *n* and *o* elongated into narrow planes. The other planes are grouped in a very confusing way around the ends of this prism. The uniform dullness of the face *x* is a characteristic feature.

The crystal under this type which was richest in faces showed the following combination *a*, *b*, *c*, M, *o*, *x*, *g*, *m*, *n*, ε, λ, μ, *q*, β, Q, U, B, α, *i*; another lacked the faces *b*, *k*, and those in the zone B, *o*, β. Other crystals showed the faces R, π, and τ, in traces.

III. *The tabular type.*—The roughened faces of *x* are large and nearly circular and approached so as to reduce the crystal to a thick plate, around the edge of which the other faces are placed. The crystals of this type resemble closely the Haytorite pseudomorphs, some of them having the same faces in the same relative development as in the latter, others being even richer in forms than any I have seen described from the Haytor mine.

One crystal contained twenty-eight distinct forms, several only as fine lines, but all capable of quite close measurement. The crystal was peculiar in having the face α (2·2) striated in two directions, forming a series of V's, as is common with the face *o* from other localities. The latter face is here finely polished. This striation was apparently parallel to the intersection edges which the face α produced would make with *o* and *i*-*ì*. The forms present were *a*, *c*, M, *o*, *u*, *s*′, *Π*, ξ, *Ω*, σ, *g*, *m*, *n*, ε, λ, μ, χ, *g*, θ, β, Q, U, α, B, E, F, K, G. Another crystal of this type went to the extreme of simplicity, being bounded by the faces *a*, *c*, M, *o*, ξ, *g*, *m*, *n*, ε, λ, μ, *q*, all quite large except *q* and O, and the face ξ unusually large and shield-shaped.

Similar tabular forms have been recently described from the spheres of chalcedony from Theiss in Tyrol.*

Enclosures in Datolite. *Calcite.*—When the datolite is thrown in acid much calcite is dissolved and a vesicular mass left; and similar pieces are found in the vein itself, showing that the same operation has been performed by natural agencies.

Selenite? Barite?—In the thick veins the minerals are often abundantly gashed by the removal of broad, thin blades of some mineral, possibly selenite or barite, and the surfaces drused over by minute, very distorted crystals of datolite.

Axinite.—Some of the finest crystals of axinite occur in the datolite. The crystals are here sometimes short stout prisms.

Prehnite.—Small portions of prehnite are enclosed rarely in the lower portion of the datolite, also small patches of the chloritic mineral identical with that derived from the decomposition of the former.

* C. Vrba, Zeitsch. Kryst., v, 425.

Sphene.—Very rarely small brown crystals of this mineral appear, resembling exactly the similar occurrence at Bergen Hill.

Tourmaline.—A single minute greenish-brown, hexagonal prism with trihedral termination, which seemed to agree exactly with the sharper one, common in tourmaline, rested upon epidote.

Chalcopyrite.—Small particles of chalcopyrite and pyrite complete the list, the datolite being generally exceptionally free from enclosures.

BOTRYOLITE.—One large cavity of the trap and nearly globular, with vesicular walls, was filled with datolite, which was compact in the vesicles of the trap, above fine granular, like loaf sugar and much gashed, and at the surface coated with a layer of small botryoidal or globular botryolite, which would have been taken for hyalite, if it had not proved fusible with green flame before the blow-pipe.

HEMATITE.—Occurs rarely in extremely minute, flat crystals, blood-red by transmitted light, upon prehnite, and quite abundantly, as the coloring matter of the red diabase.

WAD.—Occurs scattered over much of the prehnite in dots often massed together over a surface otherwise clean, in long diamond shapes, the shadows of elongated calcite scalenohedra which have disappeared.

CUPRITE.—In minute octahedra superficially altered into malachite occurs on datolite and in a single case stains of malachite upon prehnite.

HYALITE.—A colorless hyalite of fine botryoidal structure covers with a thick layer broad surfaces in the dark-gray diabase from the cuttings for the new road from Greenfield to Turner's Falls, where also pearly-white botryoidal layers are very abundant and seem in many cases to be of very recent origin, and to have coated minute rootlets which had penetrated the fissures and lay across the botryoidal surface.

The minerals of the third group, natrolite, stilbite, heulandite, chabazite, analcite and pyrite, associated still with calcite and fluor, appear after the formation of the preceding silicates had ceased entirely, and after much had been removed from the veins by the action of water.

NATROLITE.—This mineral occurs in loose tufts of very minute needles ·01 to ·004^{mm} in diameter, coating prehnite, especially in those specimens where epidote was abundant. It was not found associated with datolite or any of the succeeding minerals. The needles were colorless when fresh, but large pieces of the rock were thickly covered with brown tufts of apparently the same mineral which gave a black bead with the blow-pipe and seemed to be nearly transformed into limonite.

Other groups were shining-black from a coating of an oxide of manganese.

PRODUCTS OF DECOMPOSITION OF NATROLITE. *Saponite.*—In many cases the natrolite has changed peculiarly into saponite. At first the tips of the needles become opaque and crumbling, and this extends to the whole group, and the whole sinks down into small masses from milk-white to straw-color, which are spread over the surface of the prehnite like a thick layer of dried cream with abundant shrinkage-cracks. The hardness is one or less. It gives up only a little iron with hydrochloric, and is quickly decomposed by hot sulphuric acid. A portion introduced into a drop of water falls asunder much like starch —which it every way resembles—with a series of slight explosions which occur at first in rapid succession and continue, growing fainter and farther apart for some little time, until the whole is spread in a broad circle upon the glass. This process exposes minute glassy fragments of prehnite. The flakes after their dispersion present a peculiar appearance under the microscope. The first impression is strikingly that of a slide of nearly dried blood corpuscles of uniform size ·005–·007^{mm}, the single discs being variously attached to each other. Separate groups of discs often simulate closely in shape the grub of the common May beetle. The scales polarize brightly in bluish tints and are indistinguishable from kaolin. In many cases a small mass of the mineral seems to have undergone this vermiculite-like reaction in the vein itself, and a delicate bloom is spread in a circle over the prehnite or epidote surrounding a minute hollow cup of the same white or straw-colored material. In one curious case a minute hollow cube with a side broken in, has a tuft of natrolite needles perched in and around it, these latter having minute dodecahedra of fluor strung upon them as described below. The whole is now transformed into or coated with the saponite, and a delicate bloom of the same coats the surrounding epidote.

It occurs also in hollow pseudomorphs—acute prisms modified by the brachydome and resembling epistilbite.

The natrolite is succeeded in the prehnite-epidote veins only by calcite, acute scalenohedra enclosing whole tufts of the former mineral, and by fluorite, which is speared upon the delicate needles of the natrolite in minute transparent colorless octahedra, pierced through a hexahedral axis. From one to four of these are strung upon a single needle, often at the very tip, and in one field of the microscope (× 40), I counted seventeen; and the whole, having as a background the deep green polished faces of the epidote crystals, upon which the group rested, made an object of great beauty.

THE STILBITE-CHABAZITE VEINS. *Stilbite.*—This occurs generally in separate, narrow fissures with comparatively fresh walls, associated only with heulandite, chabazite, calcite, pyrite and diabantite, but it is found sometimes resting upon prehnite. It appears (*a*) in circular forms with radiated structure 10–20^{mm} in diameter and up to 2^{mm} thick, either spread separately or aggregated so thickly as to cover the whole surface, or in small hemispheres. Farther south, opposite Deerfield, fine globular forms as large as a marble rest upon the gashed quartz, and secondly (*b*) in small, stout scopiform crystals *i-ĭ*, *i-ī*, *o*, of dull yellow color. The first form occurs associated with calcite, and rarely chabazite. The second with heulandite and chabazite, and I examined a flat surface of the trap, four feet square, one-half of which was covered with radiated stilbite, at first thickly covering the surface, then separating into distinct discs, and then quite suddenly replaced by heulandite with which was associated chabazite, and rarely the small prismatic crystals of stilbite. A third form of stilbite (*c*) is in interlaced crystals, 4^{mm} long, perfectly pellucid, with even, highly-polished faces *i-i*, *i-ĭ*, *o*. Under the microscope the mineral shows a fine, rigid lining parallel to *o* which seems to mark lines of growth, and has no effect upon the polarization. At right angles to this run (*a*) long lines of flat water cavities, often negative forms in whole or part, or such forms many times repeated and indicating quite rapid crystallization, and (*b*) sharply marked lines of multiple twinning, the whole crystal being made up of fine plates which increase in number from below upward, new plates being intercalated and old ones obliterated as in a compound coral. The new plates sometimes appear as points and increase upward with curved faces, and sometimes the old crystal develops a P-face upon which the new one is based.

PRODUCTS OF THE DECOMPOSITION OF STILBITE. *Kaolin* (?).—Many broad surfaces of the trap are covered with snow-white stellate patches of stilbite which show all stages of the decomposition of the mineral into kaolin (?). In specimens already become snow-white and opaque the kaolin can be seen under the microscope in minute rounded scales and aggregations of these into beaded lines which are crowded between the laminæ of the stilbite, the latter showing no signs of change but remaining limpid and polarizing apparently as vividly as in the freshest specimen. In other pieces where the change is nearly complete the mass shows only aggregate polarization, and only traces of the stilbite remain.

Heulandite.—This mineral occurs quite abundantly at the new cutting in small, stout prisms, *i ĭ*, 2*ĭ*, -2*ĭ* up to 2^{mm} in length with sharp edges and no indication of other faces. It is almost always coated with a thin varnish of limonite, while the chabazite and stilbite, associated with it, show entirely fresh faces. It is the lincolnite of President Hitchcock, and the specimens studied by me agree exactly with those labeled lincolnite by him, and coming from the old locality east of Deerfield. The mineral collection at Amherst contained a few crystals, also identical with the above, from the Fitchburg cutting, and these were separated by Professor Shepard from heulandite under the name lincolnite.*

After careful study I find all these crystals identical with each other and with heulandite, both optically and crystallographically.

ANALCITE.—Occurred (*a*) in a single crystal upon prehnite; (*b*) in flat eight-sided plates 10–12^{mm} across, striated and formed by the growth of the trapezohedron, in a narrow fissure; (*c*) in milk-white films circular and octagonal, 5–10^{mm} across; (*d*) in extremely fine botryoidal surfaces with crystalline structure, with here and there a system of curious concentric depressed rings, like the siliceous annulations on some fossils (Beckite). They are as if formed by pressing several rings each smaller than the other into a soft mass, so that it should rise as a series of thin concentric combs between them, (*e*). Other pieces which seem to me to have been analcite of the form (*b*) are now wholly decomposed into a yellow ferruginous kaolin (?).

Associated with the analcite (*b*) and resting against the separate crystals on all sides is opaque white calcite, $\frac{5}{4}R$ and 1^5, grouped in parallel clusters, the faces all rounded and the clusters looking as if they had been made of some soft material which had "run." This grouping of the calcite around the separate crystals of the analcite may explain the annulations mentioned above, the two minerals having increased alternately and the calcite afterward having been removed.

CHABAZITE.—At Cheapside it occurs in small pellucid rhombohedra with delicately striated faces. Crystals 1^{mm} in length. It rests always upon the trap and never upon the heulandite with which it is associated, though when they come in contact the latter penetrates the chabazite and is the older mineral.

Farther south, east of Old Deerfield, it occurs in the same association. Most of the specimens agree in all respects with those already described but are whitened and opaque from incipient decomposition. Rarely much larger crystals occur which are 6–8^{mm} in length. These are quite fresh, the faces of good luster but faceted in a very intricate manner, indicating that the twinning by which the apparent rhombohedra are

* C. U. Shepard, Catalogue of Minerals found within 75 miles of Amherst College. Amherst, 1876.

built up has reached here an unusual complexity. The crystals are commonly twinned on *O*, and in three cases very perfect twins, composition face *R*, occur, both halves being developed to perfect rhombohedra. In a single instance the apex of a crystal is replaced by three large deeply striated faces of a flatter rhombohedron apparently ½. The striæ run parallel to the combination edge of *R* and ½ and are plainly formed by the oscillatory combination of ½ and *O*. The character of the face did not allow accurate measurement. In thin fissures it encrusts broad areas producing a tessellated surface made up of a great number of flattened crystals showing each a single face of *R*, the adjacent ones being in twin position and the whole reflecting the light together like a single face of a very large crystal.

The paragenesis of the stilbite-chabazite veins is—

1. Radiated stilbite.
2. Chabazite.
3. Calcite.
4. Pyrite; or

1. Prehnite.
2. Heulandite.
3. Prismatic stilbite.
4. Chabazite.
5. Calcite.

Below is a general table of the paragenesis of the minerals found. The oldest is first, and the overlap of the words corresponds approximately to the overlap of the minerals.

Minerals produced at elevated temperature.	Diabantite. Albite. Prehnite. Epidote. Axinite. Tourmaline. Calcite. Fluor. Sulphides. Datolite. Sphene. Calcite. Sulphides.
At ordinary temperature.	Natrolite. Stilbite. Heulandite. Analcite. Calcite. Fluor. Sulphides. Chabazite. Calcite. Fluor. Pyrite.
Products of decomposition.	Saponite. Chlorophæite. Kaolin Malachite. Limonite. Wad.

ART. XL.—*Notice of the remarkable Marine Fauna occupying the outer banks off the Southern Coast of New England, No. 7, and of some additions to the Fauna of Vineyard Sound;* by A. E. VERRILL. (Brief Contributions to Zoology from the Museum of Yale College: No. LIII.)

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DURING the present season, as in 1881, the headquarters of the U. S. Fish Commission were at Wood's Holl, Mass. The organization of the party was nearly the same as last year.* The special object, this year, was to continue the exploration of the sea-bottom, and its fauna beneath the edge of the Gulf Stream, which had been so successfully carried on during the two previous seasons. Owing to the unusual delay of the government appropriations, our work was delayed about a month, in the best part of the season, for we could not begin our dredging until August. Unfavorable weather and other causes afterward prevented us from making more than five trips to the Gulf Stream slope this year. But these were very successful.

One trip, occupying three days, was also made to the region east of Cape Cod. On this trip very cold bottom-water was found at moderate depths. It extended southward the known range of a number of northern species, previously unknown on this part of our coast, but did not reveal any new forms. Among the species of most interest taken on this occasion, are the following: several examples of *Urticina multicornis* V. (of which only one specimen was known previously), 55 to 90 fathoms; *Porania spinulosa* V., large, 90 fath., sta. 1088; *Solaster endeca* F., many, large and small, 32 to 90 fath.; *Hippasteria phrygiana* Ag., several, large, 34 to 90 fath.; *Astrophyton Agassizii* St., many, 55 to 61 fath., off Chatham, sta. 1078, 1079; *Pentacta frondosa*, large, 34 to 37 fath.; *Pandalus borealis*, 90 to 110 fath.; *Geryon quinquedens*, 110 fath.; *Balanus Hameri*, 33 fath.; *Rossia Hyatti*, several, large, 44 to 90 fath.

Of the five Gulf Stream trips, one was made southeastward

* The scientific party, associated with the writer in carrying on the dredging operations and making the collections, this year, consisted of Mr. Richard Rathbun; Mr. Sanderson Smith; Mr. J. H. Emerton (as artist); Professor L. R. Lee; Mr. B. F. Koons; Mr. H. L. Bruner; Professor Edwin Linton. Professor S. I. Smith was with us for a few days. Mr. Peter Parker and R. H. Miner, midshipmen, U. S. N., took charge of the fishes. John B. Blish, midshipman, U. S. N., kept the records of soundings and temperatures, and Capt. H. C. Chester had charge of the dredging apparatus, as in previous years. The dredgings were all made by the "Fish Hawk," commanded by Lieut. Z. L. Tanner, U. S. N., as during the two previous years. The writer, as usual, had general charge of these explorations, and of the investigation of the invertebrate fauna.

from Nantucket, farther east than any of those of 1880 and 1881, while another was made to the region about 100 miles south of the eastern end of Long Island, farther west than any of the former ones; the other three were in the intermediate region, off Martha's Vineyard. Our dredgings, in this region, therefore, now cover a belt about 150 miles, east and west, mostly between the 100 and 600 fathom lines. The total number of successful hauls made along this belt, in more than 100 fathoms, is now over one hundred. These have nearly all been made with the large improved trawls; a few have also been made with a large rake-dredge. Probably no other part of the ocean-basin, in similar depths, has been more fully examined than this region.

The total number of species of Invertebrata, already on our lists of the fauna of this belt, is about 575. This number includes neither the Foraminifera, nor the Entomostraca, which are numerous, and but few of the sponges. Probably the total list of Invertebrata, already obtained, when completed will include not less than 700 species. Of these less than one-half were known on our coast before 1880. Of fishes, there are, perhaps, 75 species. Of the whole number, already determined, about 265 are Mollusca, including 14 Cephalopoda; 85 are Crustacea; 60 are Echinodermata; 35 are Anthozoa; 65 are Annelida.

The Steamer "Fish Hawk," with which we have explored this region during the past three seasons, was built particularly for use in the hatching of shad eggs, in the mouths of shallow rivers, and is, therefore, not adapted for service at sea, unless in very fine weather. A much larger steamer, the "Albatross," of 1000 tons, has been built for the use of the Fish Commission, and is now being fitted up expressly for deep-sea service, for which she will be, in every respect, well adapted, and will have the best equipment possible for all such investigations, and at all depths. The examination of the bottom beyond the depth of about 600 fathoms has, therefore, been deferred by us till the completion of the "Albatross." Nevertheless the apparatus that we have used on the "Fish Hawk" has been better, in some respects, than most other vessels engaged in such work have had, whether American or foreign. This year several new improvements have been made, especially in the deep-sea thermometers. New forms of traps for capturing bottom animals have also been devised. The "*trawl-wings*," first introduced by us last year, have been used this year with great success, for they have brought up numerous free-swimming forms, from close to the bottom, which could not otherwise have been taken. The use of steel wire for sounding, and of wire rope for dredging, has enabled us to obtain a much greater number of dredgings* and temperature observations than would have been possible, under the old system, adopted on the "Challenger."

Of Echinoderms, nearly all of the species previously enumerated from this region and several additional ones were obtained. Among those of special interest were *Goniocidaris papillata*, 156 to 158 fath.; *Brissopsis lyrifera*, 158 to 194 fath.; *Spatangus purpureus*, 89 to 158 fath.; *Schizaster canaliferus*, 100 fath., several; *Echinus Wallisi* A. Ag., 640 fath.; *E. gracilis*, numerous and of large size at stations 1097 and 1098, in 156 to 158 fath.; *Phormosoma Sigsbei* A. Ag., station 1123, in about 700 fathoms,† several, both large and small, the largest 124^{mm} in diameter; *Porania grandis* V., abundant in 156 to 158 fath.; *Odontaster hispidus* V., abundant in 89 fathoms.

Among those added to the fauna this year are a *Diadema-like* sea-urchin; *Solaster Earllii* V., of which a large nine-armed specimen, bright scarlet in color, was obtained in 234 fath., sta. 1121; *Lophaster furcifer*, several from 234 and 640 fath.; *Astrogonium granulare*, from 156 and 640 fath.; *Astrophyton Lamarckii*, color bright orange, several from 194 fath. *Asteronyx Loveni* M. & Tr., sta. 1123, in about 700 fath., on a pennatulid, color bright orange; *Ophioscolex*, new sp., with four arm-spines, and a small tentacle-scale, 234 fath.; *Rhizocrinus Lofotensis*, young, from 640 fath.

Most of the Anthozoa of the previous years were again obtained, with some additional ones, including a remarkable new Pennatulid belonging to a new genus,‡ and two Gorgonians;

* As an illustration of the rapidity with which this work has been done, by employing persons skilled in the various operations, and using the wire rope, reeled upon a large drum, I give here a memorandum of the time required to make a very successful haul. In 640 fathoms, at station 1124, the large trawl was put over at 4:29 P. M.; it was on the bottom at 4:44, with 830 fathoms of rope out; commenced heaving in at 5:17; it was on deck at 5:44 P. M.; total time for the haul, 1 hour, 15 minutes. The net contained several barrels of specimens, including a great number and large variety of fishes, as well as of all classes of invertebrata, probably more than 150 species altogether, several of them new.

At station 1125, in 291 fathoms, the trawl was put over at 6:03 P. M.; on bottom at 6:10, with 500 fathoms of rope out; commenced heaving in at 6:32; on deck at 6:50; total time 47 minutes. This was a very good haul, but not so large as 1124. This was the seventh successful haul of the trawl made that day. All the specimens were assorted, labelled and packed away in alcohol, before 9 P. M.

† The trawl was put down, at this station, in 780 fathoms, but before it was taken up the depth had become 627 fathoms.

‡ *Distichoptilum* V., gen. nov. Slender pennatulids, with an axis through the whole length, and polyps arranged alternately, in a simple row, on each side; calicles bilobed, appressed; zooids three to each polyp, one in front and one on each side of each cell; spicula abundant in the calicles, rachis, and stalk.

Distichoptilum gracile V., sp. nov. Long and slender, with a long stalk. Polyp-calicles, rather large, rigid, closely appressed, with two sharp terminal lobes, filled with spicula, concealing the opening, and overlapping the base of the calicle in front; zooids small, not exsert, showing as small white spots at each side and in front of each polyp cell; stalk long, slender, with a long narrow bulb; color bright orange-red, due to the spicula; end of bulb yellowish; length, 18 inches, or 456^{mm}; breadth in middle, 2^{mm}; length of stalk, 100^{mm}.

List of off-shore Stations occupied by the Fish Hawk in 1882, *to Sept.* 8.

Stat.	Locality.	Fath.	Bottom.	Date.	Temp. F. Bottom.	Temp. F. Surface.	Hour.
	Off Cape Cod.			Aug.			
1078	Nauset Beacon, NW ¼ N, 10 m.	55	fine sandy mud	2	37°	63°	7.30 A. M.
1079	" NW by W ½ W, 8¼ m.	61½	fine sand	2	37	63·5	8.40 "
1080	" NW by W ½ W, 6½ m.	55	fine sand	2	37	61·5	9.40 "
1081	" W by S, 5½ m.----	33½	gravel and pebbles	2	39	59	10.50 "
1082	Cape Cod Lt., NW ¾ N, 11½ m.	28	coarse gravel	2	40	59	11.45 "
1083	" W by N, 15 m. ---	83½	--------	2	38	64	12.45 P. M.
1084	" WNW ⅜ W, 8 m.--	37½	coarse sand	2	38	62·5	2.30 "
1085	Race Point, S 33° E, 2 m. ----	34½	fine sandy mud	3	39	64	6.15 A. M.
1086	" S 20° W, 2¾ m. ---	34	fine sand	3	39·5	64	7.00 "
1087	Cape Cod Lt., SSW, 7 m.-----	44	gray sand	3	39	62·5	8.30 "
1088	" SW ¾ W, 9½ m.---	90	coarse sand	3	38	62	9.50 "
1089	" SW ¾ W, 14 m. ---	110	gray mud	3	38·5	63	10.10 "
1090	" SW ¾ W, 13¾ m.--	110	gray mud	3	38·5	62	11.50 "
	Off Martha's Vineyard.						
	N. Lat. W. Long.						
1091	40° 03′ 00″; 69° 44′ 00″	65	gray sand, shells	11	46	75	5.30 "
1092	39 58 00 ; 69 42 00	202	gray sand	11	41	75	6.54 "
1093	39 56 00 ; 69 45 00	349	sandy blue mud	11	40	75	8.35 "
1094	39 57 00 ; 69 47 00	301	blue mud	11	40	76	10.10 "
1095	39 55 28 ; 69 47 00	321	soft green mud	11	40	76	11.55 "
1096	39 53 00 ; 69 47 00	317	green mud	11	40	75·5	1.39 P. M.
1097	39 54 00 ; 69 44 00	158	fine sand	11	45	75·5	3.10 "
1098	39 53 00 ; 69 43 00	156	fine sand	11	43·5	75	4.35 "
1107	40 02 00 ; 70 35 00	116	gray mud	22	48	71	6.00 A. M.
1108	40 02 00 ; 70 37 30	101	fine sandy gray mud	22	48	71	6.55 "
1109	40 03 00 ; 70 38 00	89	gray mud	22	49	71	7.55 "
1110	40 02 00 ; 70 35 00	100	fine sandy gray mud	22	47	72	9.10 "
1111	40 01 33 ; 70 35 0?	124	fine sand	22	47	72	10.45 "
1112	39 56 00 ; 70 35 00	245	green sandy mud	22	43	72	12.43 P. M.
1113	39 57 00 ; 70 37 00	192	green mud	22	43	72	1.45 "
1114	39 58 00 ; 70 38 00	171	green mud	22	43	72	2.40 "
1115	39 59 00 ; 70 41 00	146	green sandy mud	22	45	72·5	3.28 "
1116	39 59 00 ; 70 44 00	144	hard sandy mud	22	46	72	4.20 "
1117	40 02 00 ; 70 45 00	89	fine sand	22	48	72	5.30 "
1118	40 03 00 ; 70 45 00	70	fine sand	22	49	72	6.20 "
	Off Nantucket, S.S.E.						
1119	40° 08′ 00″; 68° 45′ 00″	97	sand, shells	26	48	65	6.32 A. M.
1120	40 05 00 ; 68 48 00	194	fine sand, stones	26	43·5	65	7.41 "
1121	40 04 00 ; 68 49 00	234	fine s'nd, foss. stones	26	41·5	65	9.05 "
1122	40 02 00 ; 68 50 00	351	sand and stones	26	40·5	67	10.28 "
1123	39 59 45 ; 68 54 00	780	green sandy mud	26	39	69	12.00 M.
1124	40 01 00 ; 68 54 00	640	fine s'nd, foss. stones	26	39	65	4.01 P. M.
1125	40 03 00 ; 68 56 00	291	sandy mud	26	40	64	5.45 "
	Off Block Island, S.			Sep.			
1137	39° 40′ 00″; 71° 52′ 00″	173	fine sand	8	46	70	6.00 A. M.
1138	39 39 00 ; 71 54 00	168	fine soft sand	8	46	71	7.24 "
1139	39 37 00 ; 71 55 00	291	sandy mud	8	44	72	8.48 "
1140	39 34 00 ; 71 56 00	374	sandy mud, gr'vel, peb.	8	40	73	10.35 "
1141	39 32 00 ; 71 57 00	389	sandy mud	8	40	74	12.27 P. M.
1142	39 32 00 ; 72 00 00	322	fine sandy mud, peb.	8	41	74	1.52 "
1143	39 29 00 ; 72 01 00	452	sandy mud	8	40	74	3.36 "
1144	39 31 00 ; 72 06 00	386	soft sandy mud	8	41	74	6.00 "

Acanthogorgia armata V., 640 fath., and *Paramuricea borealis* V., from 234 fath.; the former, when living, was bright orange; the latter was pale salmon. Of those previously taken, one of the most interesting was *Pennatula borealis*, obtained in 192, 317 and 640 fath. The largest one, from 317 fath., was 21·5 inches high and 5·25 broad.

Of Pycnogonida, we took some large and interesting forms, including two examples of *Colossendeis colossea* Wilson, station 1123, in about 700 fath., of which the larger was 19·5 inches across; *C. macerrima* W., from 317 fath.; and several of *Nymphon Strömii*, from 234 to 640 fath.

Crustacea* were much less abundant than in previous years, but large numbers of large shrimp, *Pandalus leptocerus* and *P. propinquus* occurred, the latter inhabiting the deeper waters, 158 to 640 fath. *Cancer borealis* was frequent in 90 to 194 fath. Among the more interesting species were *Geryon quinquedens*, taken in considerable numbers and of large size, at stations 1140 to 1143, in 322 to 452 fath.; *Lithodes maia*, at station 1125, in 291 fath.; *Pentacheles sculptus* Smith, one large, at station 1140, in 374 fath.; *Ceraphilus Agassizii* S., several times, in 291 to 640 fath.; *Sabinea princeps* S., stations 1140 and 1143, in 374 to 452 fath.; *Boreomysis tridens*, in 351 fath.; *Hippolyte Liljeborgii*, frequent in 144 to 640 fath.; *Janira spinosa* Harger, in 640 fath.; *Astacilla granulata* (Sars) H., in 291 to 640 fath.

Many of the other species formerly taken also occurred. Several new species were also added to the fauna; among these are two fine species allied to *Munida*.

Of Cephalopods, besides the usual forms, we took one new species,† belonging to the genus *Abralia* of Gray, a genus not known from the American coast before. A *living* specimen of the *Argonauta argo* was caught in a dip-net, while swimming at

* The Crustacea of 1880 were enumerated and described by Prof. S. I. Smith, in Proc. Nat. Mus., iii, pp. 413–452, 1880: some of those of 1881 are included by him in his report on the "Blake Crustacea," Bulletin Mus. Comp. Zool., pp. 1–108, (16 plates), June, 1882. The more difficult species, here enumerated, have been identified by Professor Smith.

† *Abralia megalops*, sp. nov. Small, eyes large; caudal fin, about two-thirds as long as the mantle, and much broader than long, transversely elliptical; 2d and 3d pairs of arms equal; dorsal a little shorter; ventrals shortest. Sessile arms with two rows of hooks, which are replaced by small suckers on the distal third; tentacular clubs with two alternating rows of hooks, and with marginal suckers distally, on each side, alternating with the median hooks, and with proximal and terminal groups of smaller suckers. Color pale, with numerous small dark brown chromatophores above, larger and more crowded on the head and bases of arms; lower side with several larger, round, symmetrically placed, purplish brown spots and with minute ones between them. Length of mantle, 15^{mm}; diameter of body, 7^{mm}; length of fin, 11^{mm}; breadth across fins, 18^{mm}; breadth of head, 7^{mm}; diameter of eye, $4·5^{mm}$; length of dorsal arms, 13^{mm}; length of second pair, 14^{mm}; of third pair, 14^{mm}; of tentacular arms, 25^{mm}; of ventral arms, 10^{mm}. Probably this specimen is young. Described from alcohol.

the surface, by Dr. Kite, surgeon. This was taken about 100 miles south of the eastern end of Long Island. We took a fine large specimen of *Eledone verrucosa* V., in about 700 fathoms (sta. 1123); and the second known example of the large *Rossia megaptera* V., in 640 fathoms (sta. 1124), the first one having been taken from a halibut's stomach, at the Grand Banks.

Several shells were added to our lists, some of them of special interest. Among these is a fine new species of *Trophon*,* from 70 fathoms, and four species of Chitonidæ, of which one from 640 fathoms, represents an Australian genus, *Placophora*,† not before known in the Atlantic. The other three are *Hanleyia mendicaria*, 317 fathoms; *Leptochiton alveolus*, in 291 and 640 fathoms; and what appears to be the true *Trachydermon exaratus* (G. O. Sars) in 194 fathoms. *Choristes elegans* was again found in old skates' eggs, in 640 fathoms, and in the same situation we found *Cocculina Beanii* and *Addisonia paradoxa* Dall. The latter was taken several times, in 89 to 640 fathoms. A fine living specimen of *Dolium Bairdii* was taken in 192 fathoms. Two living specimens of *Mytilimeria flexuosa*‡ occurred in 349 fathoms, associated with *Pecchiolia gemma* V., also living;

* *Trophon Lintoni* Verrill & Smith. Shell stout, rough, with six very convex, somewhat shouldered whorls, crossed by about nine very prominent, thick, obtuse ribs; whole surface covered with strong, elevated, obtuse, scaly, revolving cinguli, usually alternately larger and smaller, separated by narrow, deep grooves; they are crossed by arched scales or lines of growth. Aperture broad; canal short, narrow, a little curved; umbilical pit distinct, but small. Length, 28^{mm}; breadth 17^{mm}; length of canal and body-whorl, 19^{mm}; length of aperture, $15{\cdot}5^{mm}$; its breadth, $7{\cdot}5^{mm}$. Station 1118. Named in honor of Professor E. Linton, of our party.

† *Placophora* (*Euplacophora*) *Atlantica* V. & Smith. Broad ovate, with the marginal membrane very broadly expanded in front, and covered with fine spinules, above and below, distinctly radially grooved beneath, and with intermediate rows of small verrucæ. Edge of mantle, in front of head, digitately divided into about seven lobes, the anterior ones slender, acute. Gills about 16 on each side, occupying more than two-thirds the length of the foot. Shell, broad-ovate, with short, broad anterior valves, the posterior one very small, lunate, and a little emarginate at the posterior edge; anterior one very broadly rounded, short, hind edge with a slight rounded median notch, surface uniformly granulous and faintly radially grooved; inserted edge narrow, with about 30 irregular denticles; middle valves have a slight median beak at the hind edge, their lateral areas are strongly marked, crossed with diagonal rows of low, rounded granules, separated by narrow radial grooves; central areas with smaller and less distinct granules, and transverse lines of growth. Color, rusty brown. The largest example is, in alcohol, 32^{mm} long; breadth, 26^{mm}; length of shell, 21^{mm}; breadth of shell, 18^{mm}; length of anterior valve, 4^{mm}; breadth, $15{\cdot}5^{mm}$.

I am indebted to Mr. W. H. Dall for the generic determination of this species.

‡ The animal of this shell, in alcohol, has a small and short anal tube, surrounded by small papillæ, and a very much larger incurrent orifice, occupying a ventral position, and surrounded by numerous long and large tentacle-like papillæ; the orifice for the foot is small; the edge of the mantle is bordered by very small papillæ. There is a slender, translucent byssus. The hinge-ligament is strengthened by a distinct ossicle, placed lengthwise, more or less ovate in form, with the smaller end next the hinge-teeth, and somewhat truncated.

Pecchiolia gemma also has an ossicle, similarly placed, with the posterior end broader and notched in the middle, the narrower end truncated.

a fresh valve of *Pholadomya arata*, in 108 fathoms; *Axinopsis orbiculata* G. O. Sars, in 202 fathoms; *Modiolaria polita* V. & S., in 321 fathoms. In trawl-wings, station 1141, 389 fathoms, we took four examples of *Clione papilionacea* Pallas, associated with a lving specimen of *Cavolina longirostris.*

The southern species of Pteropods were comparatively scarce this season, and the very large species of *Salpa*, so abundant hitherto, was only met with once, this year, but the small species (*S. Caboti*) occurred in large numbers, and with it several very brilliant species of *Saphirina* were taken.

Evidence of great destruction of life last winter.

One of the most peculiar facts, connected with our dredging this season, was the scarcity or total absence of many of the species, especially of Crustacea, that were taken in the two previous seasons, in essentially the same localities and depths, in vast numbers,—several thousands at a time. Among such species were *Euprognatha rastellifera*, *Catapagurus socialis*, *Pontophilus brevirostris*, and a species of *Munida*. The latter, which was one of the most abundant of all the Crustacea, last year, was not seen at all this season. An attempt to catch the "tile-fish" (*Lopholatilus*) by means of a long trawl-line, on essentially the same ground where eighty were caught, on one occasion, last year, resulted in a total failure this year. It is probable, therefore, that the finding of vast numbers of dead tile-fishes floating at the surface, in this region, last winter, as was reported by many vessels, was connected with a wholesale destruction of the life at the bottom, along the shallower part of this belt (in 70 to 150 fathoms), where the southern forms of life and higher temperatures (48° to 50°) are found. This great destruction of life was probably caused by a very severe storm that occurred in this region, at that time, which, by agitating the bottom-water, forced outward the very cold water that, even in summer, occupies the great area of shallower sea, in less than 60 fathoms, along the coast, and thus caused a sudden lowering of the temperature along this narrow *warm zone* where the tile-fish and the crustacea referred to were formerly found.

As the warm belt is here narrow, even in summer, and is not only bordered on its inner edge, but is also underlaid by much colder water, it is evident that even a moderate agitation and mixing up of the warm and cold water might, in winter, reduce the temperature so much as to practically obliterate the warm belt, at the bottom. But a severe storm, such as the one referred to, might even cause such a variation in the position and flow of the tidal and other currents as to cause a direct flow of the cold inshore waters to temporarily occupy this area, pushing outward the Gulf Stream water. The result would be the same, in either case, and could not fail to be destructive to such species as find here nearly their extreme northern limits.

In order to test this question more fully, Professor Baird also employed a fishing vessel, the "Josie Reeves," to go to the grounds and fish systematically and extensively for the tile-fish. On her first trip, ending September 25, she did not find any "tile-fish," but took another food-fish (*Scorpæna dactyloptera*), known on the European coast, and first taken by us, in 1880.

Additions to the fauna of Vineyard Sound; Surface dredgings.

During the intervals between the Gulf-Stream trips, shore collecting and a large amount of surface dredging, both by day and night, were done in the vicinity of Wood's Holl, by means of the two steam launches belonging to the Fish Commission. In the surface-dredging, Mr. Emerton took the most active part. The surface work was very productive this season, not only affording a vast number of larval forms of Crustacea, Echinodermata, Annelida, Mollusca, etc., but also a large number of adult Annelida, belonging to the Syllidæ and various other families, including a number of very interesting new species. Certain species of *Autolytus* were unusually abundant. Many thousands of specimens of *A. varians* V. (formerly *A. ornatus* V.) were often taken in a single evening, the males of both the red and green varieties being far more numerous than the females, which were always bright red, when containing eggs. The males of a much larger species, the *A. ornatus* (*Procerœa ornata* V., 1873, stem-form), were also abundant; the much larger females, which are transversely banded with red, were taken in smaller numbers. A small, but very remarkable, new species (*A. mirabilis*),* first discovered

* *Autolytus mirabilis* V., Trans. Conn. Acad., iv, pl. 13, figs. 8–10. Stem-form long and slender. Antennæ, tentacular cirri, first pair dorsal cirri, and caudal cirri very long and slender, 4–6 times the breadth of the body; median antenna and first dorsal cirrus longest; second dorsal cirri twice the breadth of body; others varying in length, but mostly longer than breadth of body; two long, narrow epaulets, extending from the head back to third body-segment. Stomach large, oblong; pharynx slender, with one flexure, denticulate at the end. The most anterior formation of the sexual young takes place behind the fiftieth segment; in one individual (see fig. 8, loc. cit.) six female individuals follow one another, the largest one being nearly ready to separate, and having 22 segments, with a well developed head, four eyes, and long antennæ. Some detached females, bearing eggs, have, however, no more than 16 to 20 segments.

Vineyard Sd. and off Gay Head, 4 to 8 fath., among hydroids, 1881 and 1882.

Female: Small, with only one pair of slender cirri, longer than breadth of head, on the buccal segment; two anterior body-segments with only short setæ; capillary setæ begin on the third segment; two pairs of eyes close together, the anterior larger; three antennæ nearly equal, long and slender, three or four times the breadth of the head; caudal cirri, when fully developed, about as long as the antennæ; dorsal cirri slender, longer than breadth of body. Length, 3 to 3·5^{mm}. Color, when containing eggs, dark olive-brown; after eggs are laid, pale greenish;

by us in 1881, was not uncommon, but only the females were taken at the surface. The stem-form occurred among hydroids and ascidians at moderate depths. This species is remarkable for the large number of sexual individuals that may be developing, simultaneously, from the stem-form. It is not uncommon to find it carrying five or six sexual individuals, in various stages, one behind another.

A very singular Syllidian,* of which only the sexual forms are known, was taken several times at the surface, in the evening. We also took these in 1880 and 1881. They have probably been detached from a very different stem-form. The genus is allied to *Chætosyllis* Mgn., but the head is entirely destitute of antennæ. It has four large eyes and swims very actively.

Odontosyllis lucifera V., of both sexes, was very common in the surface nets all through August and to Sept. 15th, but mainly in the evening. With the latter a smaller and more delicate species usually occurred, but in less abundance. This belongs to the genus *Eusyllis*† and has been known to me for a number of years.

eyes dark brown. Wood's Holl, surface, evening, Aug. 2 to Sept. 18, 1882; off Gay Head, with the stem-form, 1881. Description from life.

* *Tetraglene* Grube, 1863. Sexual forms: Head distinct, with four large eyes, but with no other appendages. Segments behind the head similar, all bearing large parapodia, with long setæ, a long dorsal cirrus, and a smaller slender ventral cirrus. Caudal cirri two, long, sub-moniliform.

Tetraglene agilis V., sp. nov. Trans. Conn. Acad., iv, pl. 25, fig. 10. Rather large and stout, head broader than long, subtruncate, or even emarginate in front, constricted abruptly behind; eyes large with front lens round, the two pairs near together, the anterior a little larger and wider apart. Body-segments separated by deep constrictions; parapodia with large setigerous lobe, as long as the breadth of the segments; setæ numerous, longer than the parapodia, the shorter ones with a long, slender article; capillary setæ begin on the third segment; cirri more or less moniliform, slender, tapered, about four times as long as the breadth of the head; caudal cirri similar to dorsal; ventral cirri slender, smooth. Color of males, yellowish white; of females, pale orange-yellow or salmon; eyes brown; eggs reddish, laid Aug. 5, 1882. Length of largest (♀) about 25^{mm}; males about 20^{mm}. Taken in the evening, at the surface, near Nomansland, Sept., 1880; Wood's Holl, Aug. 4, 1881, and from Aug. 5 to Sept. 12, 1882. Description from life.

† *Eusyllis tenera* Verrill, Trans. Conn. Acad., iv., pl. 13, fig. 12; pl. 14, figs. 4, *a, b*. Slender, 5 to 7^{mm} long, with very long, slender antennæ and cirri, which are often curled in spirals, and irregularly transversely constricted, smoothish in full extension. Pharynx short, straight, with a large, sharp median tooth at the extreme anterior end; the edge of the tube is divided into numerous (about 30) small, sharp denticles, becoming obsolete on the lower side; sheath of pharynx with a circle of larger, soft papillæ (about 13) in front of the tube. Stomach large, oblong; intestine with a pair of short, rounded, lateral pouches at the end of the stomach. The median antenna and upper tentacular cirri are 3 to 6 times as long as the breadth of the body; lateral antennæ and lower tentacular cirri shorter; the longest dorsal cirri are 5 to 6 times as long as breadth of body; shorter dorsal cirri alternate irregularly with the long ones. The palpi are very flexible and changeable in form, prominent, flattened, tapered or oblong, obtuse. Head rounded in front, widest in front of the middle, opposite the largest eyes. Eyes six; four larger ones nearly equal, the anterior a little larger and wider apart, near the sides of the head; the minute frontal eyes are near the inner bases of

Another interesting new species, which was taken at the surface, both this year and last, appears to belong to the genus *Syllides.** Among the less common forms of Syllidæ were

the antennæ. Setæ with an oblong, blade-shaped terminal article, obtuse and slightly bidentate at tip.

Sexual individuals have, also, fascicles of long capillary setæ, beginning on the fourteenth setigerous segment.

Color translucent bluish white, pinkish or purplish brown anteriorly, and more or less purplish brown or blue-gray on the sides of the body and more decidedly on the bases of the parapodia; cirri white; pharynx and stomach pale brown; intestine brown or olive-green, constricted between the segments; eggs showing through, purplish brown; eyes dark red.

New Haven to Vineyard Sound; frequent at surface in evening, at Wood's Holl, from Aug. 2 to Sept. 15, 1881, 1882. Also dredged in Vineyard Sd., in 8–12 fath., among bryozoa and *Amorœcium pellucidum.* Allied to *Syllis fragilis* Webs., which probably also belongs to *Eusyllis.* Described from life.

* *Syllides setosa* V., sp. nov. Trans. Conn. Acad., pl. 24, figs. 11, 11c. Body not very slender, with about 50 segments and large parapodia. Head changeable, usually short, obtusely rounded or subtruncate in front, rounded laterally, closely united to buccal segment. Palpi short, often not visible from above; below they appear as flat lobes. Eyes six; two median ones largest, close to sides of head; posterior ones a little smaller and nearer together, and close to the others; front ones very small, close to the outer bases of the palpi. The antennæ and four tentacular cirri are all similar in size, form and color, but the odd antenna is a little the longest (about three times breadth of head), and the tentacular cirri are usually somewhat shorter than the lateral antennæ (or about twice the breadth of the head); all are contractile and somewhat changeable in form; usually they are distinctly clavate, with narrow bases and obtuse, swollen, transversely wrinkled tips. Anterior dorsal cirri long, slender, usually more or less clavate, with a distinct basal joint and numerous annulations, becoming more marked distally; they are as long as the antennæ, or longer, and about three times the breadth of the segments; they often increase in length on the first few segments, but are apt to vary irregularly; the longest are more than four times as long as the breadth of the segments. The ventral cirri are slender, tapered, with a distinct oblong terminal article; they arise far out on the parapodia and project beyond the setigerous lobe, but are not a third as long as the dorsals, anteriorly, posteriorly they are relatively longer. The parapodia are very large in the middle region of the body, with a swollen base and long setigerous lobe. Caudal cirri three; lateral ones very long, transversely annulated, tapered, acute, often coiled spirally; median one small and slender. Setæ numerous, the compound ones with a long, narrow terminal blade, bidentate at the tip; simple long setæ begin singly on the eighth or ninth setigerous segment; fascicles of capillary setæ appear on the eighteenth, in our largest example. Pharynx very dark colored, large, short, stout, straight, surrounded with a broad sheath, apparently unarmed, but sometimes showing a pale, oblong spot, that might be taken for a feeble tooth, near the anterior end; its sheath has a circle of soft papillæ in front; stomach brown, large, oblong, usually slightly constricted near the front end, equal in length to about four segments (or to six in alcohol); intestine very large, with two rounded brown lobes close to the stomach. Color generally dull orange-yellow, or orange-brown, medially, due to the internal organs; the external parts are whitish; buccal segment brownish, intestine yellowish brown. Length of the largest specimen, in alcohol, 12^{mm}. Taken at the surface, evening, July 22, 29, and August 15, 1881; August 3 to September 12, 1882. Described from life. Another very much smaller form, with about 32 segments, perhaps distinct from the above, occurred. In this the antennæ and tentacular cirri are shorter, more decidedly clavate; palpi shorter, scarcely visible from above; setæ with a shorter and less slender article. The stomach and pharynx are dark brown. Bunches of capillary setæ begin on the tenth body-segment. Length about 3^{mm}.

Grubea Websteri V.,* *Sphærosyllis*, sp., *Pædophylax longiceps* V., etc. The *Nereis megalops* V., both in the heteronereis-form (*Nectonereis*) and in the nereis-form (*N. alacris* V.), frequently occurred in our night excursions, and in September the young of this species of all sizes, from those with only six or eight segments, up to those that were 10^{mm} or more in length, occurred abundantly at the surface. These young are very active, translucent, and nearly white, with small, red specks over the surface. A very interesting new species, *Acrocirrus Leidyi* V.,† belonging to a genus hitherto not recorded from our coast, was taken at the surface several times this year, and also in 1881. *Podarke obscura* V. was often abundant at the surface, as well as in the soft mud, among eel-grass, in the harbor. Among other surface Annelida were *Cirrhinereis phosphorea* V. and *C. fragilis*, and a species of *Prionospio*, probably identical with *P. tenuis* (*Spiophanes tenuis* V., 1880). This was also taken from the harbor mud, in shallow water, last year. When perfect it has four pairs of gills, all fringed on one side, (Tr. Conn. Acad., iv, pl. xix, fig. 7). A singular larval form, probably belonging to this species, occurred once (September 9) at the surface.

Among the various larval forms of Annelids we were fortunate in obtaining a very large number of *Chætopterus pergamen-*

* *Grubea Websteri* V., sp. nov., Trans. Conn. Acad., iv, pl. 24, figs. 6–8. Small, slender, whitish, with about 33 segments. Three antennæ, both pairs of tentacular cirri, dorsal and caudal cirri all similar in shape, long-fusiform, thickest below the middle, tapering and acute, not differing much in size nor in length, but the first pair of dorsal cirri, and those following the eighth, are a little longer than the others or the antennæ; cirri longer than the breadth of the body opposite; ventral cirri small, slender. Head short, rounded in front and laterally; palpi large and prominent, tapered, united above nearly to the obtuse, rounded tips; eyes six; frontal ones minute, median largest and farthest apart, close to sides of head. Pharynx narrow, straight, a little swollen anteriorly, with a well-marked tooth close to the front edge; stomach oblong, occupying two to three segments, according to their extension; intestine with two rounded lobes, close behind stomach. Setæ with a rather long, flat, blade-like article, strongly fringed on the edge, with the tip distinctly bidentate, and not very slender; long, capillary, sexual setæ begin (when present) on the ninth setigerous segment, and continue on thirteen to seventeen. The eggs and young are carried on these same segments, usually four to each segment. Some examples (op. cit., pl. 25, fig. 2) similar in other respects, have no sexual setæ and only two eggs to a segment). Three to eight hind segments are without sexual setæ and eggs. Length, 3^{mm} to 4^{mm}. Surface, Newport, R. I., 1880; Wood's Holl, Mass., July 28 to September 12, 1881, 1882. Described from life.

† *Acrocirrus Leidyi* V., sp. nov., Trans. Conn. Acad., iv, pl. 19, fig. 2. Body slender, with distinct segments covered with small papillæ. Head changeable, usually rounded, obtuse; eyes four, the front pair very minute; hind pair larger and wider apart; two large, long, usually clavate antennæ on front of head, near together. A pair of large, long, clavate cirri on first four segments, like the antennæ, but larger, the length three or four times the breadth of body. Ventral, compound setæ, with a very long, curved and hooked terminal article, begin, singly, on the second segment-bearing cirri; long, slender, capillary dorsal cirri begin singly on the fourth segment, but form fascicles of six to nine farther back. Color dark olive-green to dark brown; cirri and antennæ paler green with yellow tips. Length, 10 to 15^{mm}; diameter of largest, about 1^{mm}. Wood's Holl, surface, evening, August 2 to September 9, 1881 and 1882. Described from life.

taceus, in various stages, from very young ones up to those having the adult characters distinctly developed. Of these Mr. Emerton made an excellent series of drawings. The adults of this interesting species were dug from the sand just below low-water mark, at Naushon I.,* by our party. The largest of these had U-shaped tubes, 28 to 31 inches in length and over an inch in diameter in the middle. In each tube there was usually a crab (*Pinnixa chætopterana* St.), associated with the worm. These tubes show, very beautifully, the way in which their size is continually increased by the occupant, which is incapable of emerging from it. The worm makes longer or shorter slits in the parchment-like tube, wherever it is to be enlarged (probably using for this purpose the sharp, stiff, lance-like setæ of the anterior segments), and after spreading the tube, from within, to the desired extent, it closes up the opening by means of a fusiform patch (like a "gore" or "gusset"), of the same material as the original tube, but differing slightly in color or luster, so that when the tube is cut open these neat patches show very distinctly on its inner surface.

From the sands of Naushon, at Hadley Harbor, our party also procured several living examples of an European shell, *Tellimya* (or *Montacuta*) *ferruginosa*, not before found on our coast. It was associated, at low-water mark, with living specimens of *M. bidentata* and another species of the family Kelliadæ, *Corbula contracta*, etc. Drawings were made of the animals of all these by Mr. Emerton.

Of Gastropod veligers, about twenty species were taken in the surface nets. Some of these occurred in vast numbers, but I have not yet been able to identify more than half of the species. Among those recognized are *Anachis avara*, *Astyris lunata*, *Triforis nigrocincta*, etc. One of the largest and most interesting was that of a *Natica*. This had the velum divided into four long, narrow lobes, beautifully marked with brown at the tips. Many of these were kept till they lost the velum and developed the characterstic foot of *Natica*. The species is uncertain.

In a region that has been so thoroughly dredged in past years as Vineyard Sound, it was not to be expected that many new forms would be found, unless among the more minute species, or in those groups not hitherto studied on our coast. Yet one new Planarian,† of large size and with conspicuous colors, was taken, as well as various undescribed Rhabdocœla and Annelida.

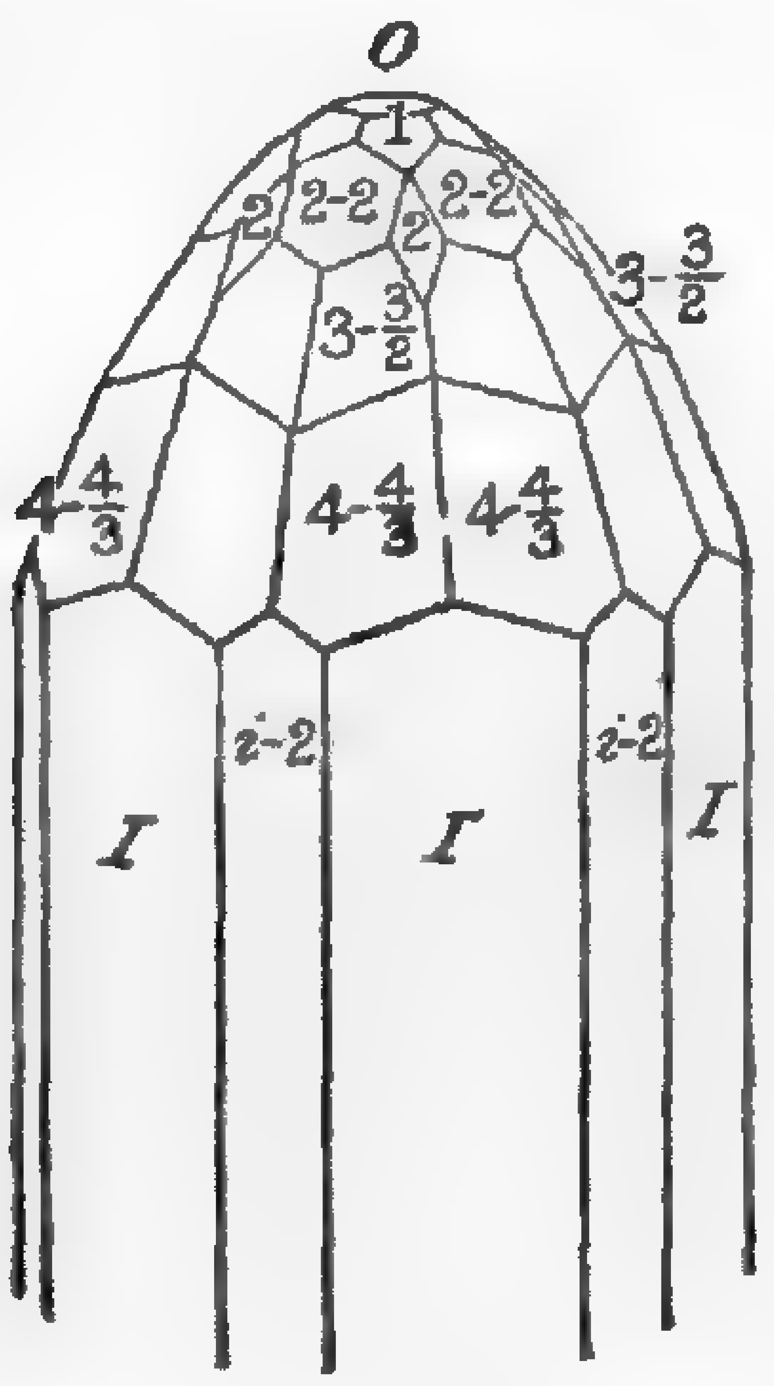
* This species was first discovered at this place in 1880 by Mr. Chas. Webster and Mr. Vinal N. Edwards, from whom I received specimens at that time.

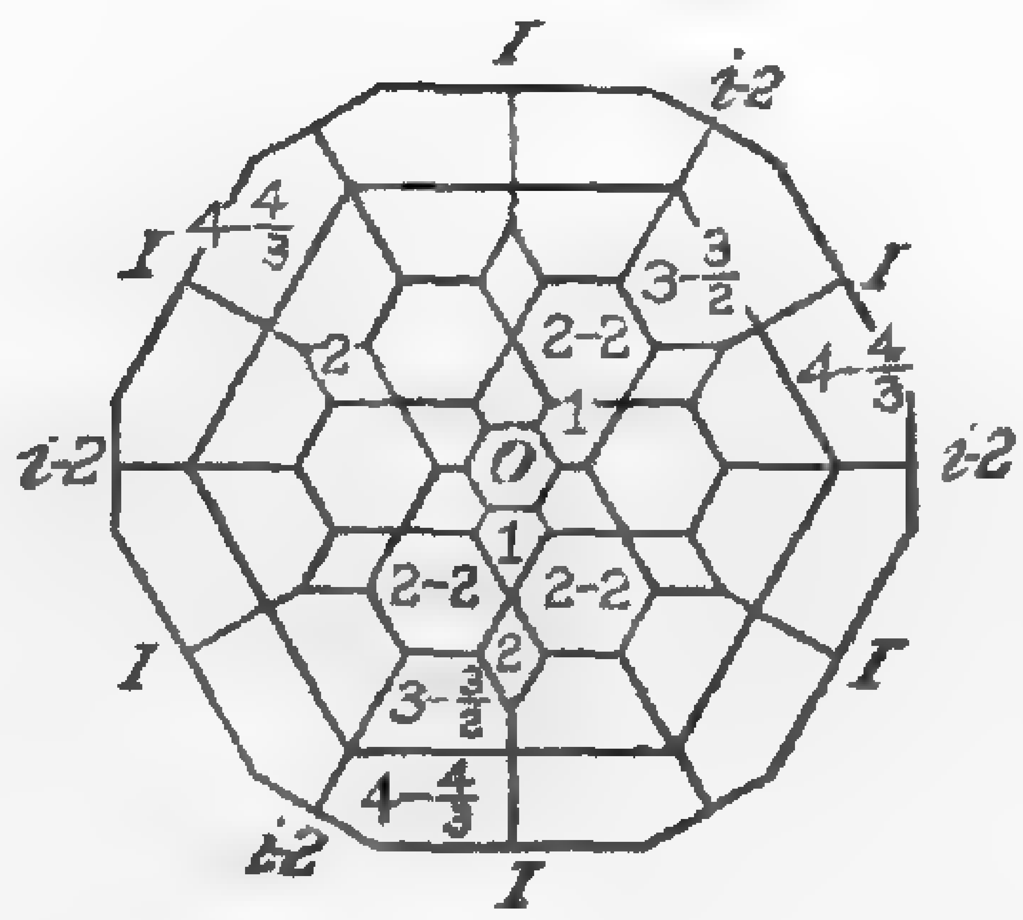
† *Stylochopsis zebra* V., sp. nov. Body broad-elliptical, rather thick, or somewhat swollen. Tentacles small, near the front end, bearing several small ocelli; a cluster of small dorsal eyes in front of tentacles; minute, marginal ocelli, along the front edges. Color brown and pale yellow or whitish, in narrow, alternating, transverse stripes, which run directly across in the middle, but become more and more V-shaped as they approach each end. Length about 20^{mm}, breadth 12^{mm}. Great Harbor, shore; off Menemsha, 10 to 12 fathoms, September 6.

ART. XLI.—*Notes on some North Carolina Minerals;* by W. EARL HIDDEN.

[Continued from vol. xxii, p. 25.]

BERYL.—The accompanying figures represent the form of a remarkable crystal of beryl found some years since in Alexander county, North Carolina. It was found lying loose in the surface soil, on the land known as the Pendergrass land, which adjoins to the east that of the "Emerald and Hiddenite Mining Company." Soon after its discovery it went into the collection of Mr. J. A. Stephenson of Statesville, N. C., who yet retains it. It is of nearly faultless transparency, with only a slight aquamarine tint. All its planes are brilliantly polished. It is about 1^{cm} long and 30^{mm} in diameter.





The large development on this crystal of the rare planes $3-\frac{3}{2}$ and $4-\frac{4}{3}$ is unprecedented in mineralogical records. The work now going on in this new mineral region brings to light occasionally crystals of emerald and of beryl, exhibiting this same development of rare planes, but with the basal plane [*O*] very much larger in proportion.

COLUMBITE.—The mineral thought to be *æschynite* from Ray's mica mine, Yancey county, N. C., has, upon analysis, proved to be columbite. The crystals are unusually well formed and have been found in groups weighing over a pound. Their common parallel grouping is interesting.

URANINITE.—Careful determinations of the specific gravity of uraninite from Mitchell county, N. C., gave the following results for three different specimens: 8·968, 9·05, 9·218. Thus proving that it is not entirely free from alteration, though it has an appearance very much like magnetite.

"EUXENITE."—At my request Professor J. W. Mallett has lately examined the so-called "euxenite," from Wiseman's mica mine, N. C., with results differing widely from those of Dr. J. L. Smith. The material for this analysis was obtained at the locality by the writer. The analyses by both Mallett and Smith are given below:

	Mallett.	Smith.
Nb_2O_5	47·09	54·12
SnO_2+WO_3	·40	·21
Y_2O_3	13·46 }	24·10
Ce_2O_3	1·40 }	
$Di_2O_3+La_2O_3$	4·00	
CaO	1·53	5·53
U_2O_3	15·15	9·53
FeO	7·09	·31
MnO		·08
H_2O	9·55	5·70
	99·67	99·58

Titanium was carefully sought for by Mallett but none was found; it is essential to true euxenite. I incline to the opinion of Professor Mallett, who, in a late letter to me, stated he had concluded that this so-called "euxenite" was only *altered samarskite.* Its intimate association with samarskite, its uncrystalline form, and the varying analyses, point to this conclusion.

FERGUSONITE.—Through the kindness of Professor Mallett I am enabled to give an analysis of the fergusonite from the new locality discovered by the writer in Burke county, N. C., where it was found to exist quite abundantly in the placers of the Brindletown gold district. The occurring form is a very acute octahedron, with the basal and hemihedral planes. Color, brown-black and crystals mostly covered with a gray crust, the faces hardly smooth. Sp. gr. 5·87 (Smith).

	Mallett.	Smith.
Nb_2O_5	43·78	48·12
Ta_2O_5	4·08	
SnO_2+WO_3	·76	
Y_2O_3, etc.	37·21	40·20
Ce_2O_3	·66	
$Di_2O_3+La_2O_3$	3·49	
U_2O_3	5·81	5·81
FeO	1·81	2·75
CaO	·65	
H_2O	1·62	1·50
	99·87	98·38

Prof. Mallett states further: "That it is useless to attempt any separation of the earths grouped under the head of yttria (in an analysis made on a few grams of material) so long as competent chemists, working on many pounds of material, have not only not found any means of accurate separation, but are not even agreed as to the independent existence and number of the earths to be separated."

This Burke county fergusonite is thought to be identical with Shepard's "rutherfordite," described from the same locality many years ago on a very small amount of material.

ALLANITE.—I have lately identified this mineral at two new localities in North Carolina, i. e. at the emerald locality in Alexander county, in the feldspar veins of the gneiss; and in a decomposed feldspar at the Wiseman mica mine in Mitchell county. At the first-mentioned locality the mineral occurs as small, well-polished prisms, of a light brown color, sparsely distributed in the feldspar (oligoclase for the most part), and is not otherwise noteworthy excepting an unusually high percentage of La_2O_3, viz: 14 per cent. From the second named locality the crystals are of unusually perfect form for allanite, and contain over 8 per cent of yttria. Some of the crystals were 2^{cm} long and over 1^{cm} in thickness. They were all more or less covered with a thin reddish-gray crust due to alteration. Some few had become entirely altered into an allanite-gummite.

Below is an analysis by Mallett on the purest material then obtainable; its color was pitchy black, through thin edges slightly greenish:

	Mallett.	Norway.
SiO_2	39·03	33·60
Al_2O_3	14·33	12·58
Y_2O_3	8·20	20·83
Ce_2O_3	1·53	4·56
Fe_2O_3	7·10	13·48 (with FeO)
FeO	5·22	
MnO	trace,	$Na_2O+K_2O=$ ·62
MgO	4·29	1·60
CaO	17·47	9·59
H_2O	2·78	3·34
	99·95	100·20

The relatively small proportion of cerium, writes Professor Mallett, and larger amount of yttrium, is remarkable, though paralleled by a Norway orthite. The oxygen ratio is essentially that of allanite and orthite.

Stony Point, N. C., Sept. 11, 1882.

ART. XLII.—*Martite of the Cerro de Mercado, or Iron Mountain, of Durango, Mexico, and certain iron ores of Sinaloa;* by B. SILLIMAN.

1. *Cerro de Mercado.*

A COLLECTION of specimens from the famous Iron Mountain of Durango has lately been placed in my hands by Mr. Edward P. North, Engineer of the Sinaloa and Durango Railroad Company, who obtained them, last year, in the discharge of his professional duties. At first sight the octahedral crystals of very various size suggested only magnetite, but the magnet failed to attract the ore, while the streak immediately indicated hematite, and left no reasonable doubt that the whole mass was martite.

Fortunately, Mr. John Birkinbine, Engineer, of Philadelphia, had the goodness, about the time I received Mr. North's collections, to send me his "Report upon the Iron Mountain of Durango," of date March, 1882, from which I glean some facts which are of interest to mineralogists respecting this remarkable iron mass, which, so far as I am informed, is new to science.

The Cerro de Mercado rises abruptly from the plains on which stands the city of Durango, about one and a half miles to the north of the city. This hill is one mile long, a third of a mile wide, and from four hundred to six hundred feet high. Mr. Birkinbine does not confirm the statement of some observers that this deposit is a solid mass of iron ore. The surface of the hill, indeed, everywhere exposes masses of ore, which appear to be derived from one or more immense beds, or veins, of specular iron standing nearly vertical, the fragments of which form a talus on the slopes of the mountain and conceal completely the enclosing walls of rock. From samples of the country rock which I find in Mr. North's collection, these walls are of purple porphyry. Mr. Birkinbine finds "indications that the deposit is not all above ground, but extends far beneath the plain from which it projects." The striking view of the bold escarpment and cliffs of this mountain which accompanies Mr. Birkinbine's paper is by his courtesy reproduced herewith.

In the collection from Mr. North I find the crystals of martite of all sizes, from those measuring more than one inch on the side to druses of two to three millimeters. They are all simple crystals, the larger ones dull, sometimes iridescent, the smaller lustrous and quite black. There are no isolated crystals like those found in the original locality described by Spix and Martius, and mentioned, with other Brazilian locali-

Iron Mountain of Durango.

ties, by Mr. Derby in his paper published in May of this year.* All are firmly attached to the massive ore, some masses of which in my hands weigh ten to twenty pounds. There is nothing in the mode of occurrence of this ore, or in the chemical constitution, which lends any support to the opinion of Gorçeix that martite is derived from the transformation of pyrite. In support of this statement I am permitted to cite the analysis of an average sample made up from twenty-seven pieces of the Durango ore collected by Mr. Birkinbine, and submitted by him to Mr. Andrew S. McCreath, chemist to the second Geological Survey of Pennsylvania, being a commercial sample of the whole ore mass and not presenting fairly the constitution of the pure mineral. This "sample" gave the following results, viz:

Magnetic oxide of iron	2·071
Ferric oxide	77·571
Manganic oxide	·113
Titanic acid	·710
Lime	5·050
Magnesia	·364
Sulphuric acid	·212
Phosphoric acid	3·041
Silica	7·760
Loss on ignition (water, etc.)	1·984
Undetermined (Al_2O_3, etc.)	1·124
	100·00

corresponding to metallic iron 55·8 per cent. A purer specimen of the mineral gave separately 62·775 per cent metallic iron.

The powder of this ore is attracted by the magnet, but fragments of the size of grains of wheat are not affected by a magnet of moderate power.

This enormous mass of valuable iron ore, thanks to the near approach of the railway system of Mexico, is now likely to become of commercial importance.

2. *Sinaloa iron ores.*

In this connection it is interesting to note the chemical composition of certain other ores of iron from the State of Sinaloa in Mexico, also placed at my disposition by Mr. North. The analyses were made in the Iron Masters' Laboratory, Philadelphia, by Mr. Blodget Britton. In these the transformation of magnetite into martite, has proceeded only so far as to leave still about one-third of the original magnetite unchanged. Naturally these samples are more sensibly affected by the magnet. They are from Tepuche, Bescuino and Cosolu.

* This Journal, III, xxiii, p. 373.

Names of Iron Mines.

Composition.	Tepuche.	Bescuino.	Cosolu.
Metallic iron	65·08	66·75	67·25
Oxygen with the iron	26·98	27·85	28·01
Water	1·26	1·87	1·06
Silica	5·08	2·68	2·46
Phosphoric acid	·146	·075	·225
Sulphur	none	none	none
Titanic acid	none	none	none
Manganese	·08	trace	trace
Undetermined	1·374	·775	·995
	100·000	100·000	100.000
Ferric oxide	65·88	72·82	71·82
Magnetic oxide	26·18	21·68	23·44
Phosphorus with 100 metallic iron	·099	·047	·123

A few notes on the localities of these three iron deposits are of interest in this connection.

Tepuche is near the town of this name on the Rio de Humaya, ten or twelve miles west of the city of Culiacan. The iron occurs in porphyry resembling that of the Cerro de Mercado. It is a massive ore showing no crystalline forms, and occurs in blocks of a cubic yard and less, scattered along the apparent outcrop of a bed which shows again on another hill one-quarter of a mile off. It is cut by a strong stream of water 436 feet below the top of the ridge, the sides of the gulley being strewn with blocks and debris of this ore. Good lime exists abundantly within one and a half miles of this locality which is also on the line of the Sinaloa and Durango Railroad, in a country abounding in various hard woods and covered with dense underbrush, up to an elevation of about 1000 feet above sea level. Above this level and up to 5,000 or 6,000 feet, pines and other Coniferæ come in place of the hard woods.

Bescuino.—Little is known of this locality, which was not personally explored by Mr. North. It is reported to be a hill of 400 to 500 feet in elevation, less abundantly timbered than Tepuche. It is nearly due east from Culiacan, about twenty miles.

Cosolu.—The ore at this locality was all in loose masses; none was found in place. The summit of the hill on which it was found is 270 feet above the bottom of a dry arroyo. The surrounding rocks are calcareous. As Cosolu is an old mining region abounding in low grade veins of gold and silver; timber and wood for fuel is not found within 30 or 40 miles.

The question of the renovation of forests on the Gulf slopes of Sinaloa is one of much interest. In reply to my inquiry, Mr. North says: "I do not believe the hard woods can be of rapid growth, but I think it safe to say that they will grow again, and in fact old clearings are seen covered with trees of second growth."

F. G. Weidner, Surveyor General of Sinaloa, is authority for the statement that the annual rain-fall at Culiacan in 1870 was 23 inches; in 1880, at Mazatlan, the chief seaport of Sinaloa, it was 35 inches, and in 1881 an exceptionally wet year, it reached the quantity (estimated) of 60 inches. It is remarkable that across the Gulf of California, namely, in the peninsula of Lower California, the rain-fall seldom reaches four inches.*

ART. XLIII.—*Contributions from the Physical Laboratory of Harvard College. The Thomson Effect;* by JOHN TROWBRIDGE and CHARLES BINGHAM PENROSE.

SIR WILLIAM THOMSON † first discovered that when an electrical current passes through a piece of metal, the ends of which are of different temperatures, it carries heat with it; the direction depending upon the character of the metal and the direction of the current. This phenomenon is known as the Thomson Effect. Le Roux ‡ subsequently verified Thomson's results, and gave an incomplete table of the effect in different metals. No especial pains have been taken hitherto in experimenting with pure metals. We have therefore thought it would be valuable to test the effect in as pure a metal as we could obtain by electrolysis. We have also extended Le Roux's table by the addition of the effect in nickel, which Thomson was unable to obtain, and also in carbon. An endeavor has been made to ascertain if the effect is reversible, and also to discover if it is modified in a magnetic field.

The strip of nickel, 45 centimeters long, 2·6 wide, and 2 millimeters in thickness, was placed with its flat surface horizontal. One face of a thermopile was placed at a fixed point on the surface of the nickel, separated from it by a thin piece of mica. A weight pressed upon the other surface. The thermopile was connected with a Thomson's reflecting galvanometer of six ohms resistance. The two extremities of the strip of nickel were connected with a battery of six Grove cells, the wires first passing through a key so that the direction of the current could be reversed. One end of the nickel was kept at

* The Topography, Ethnography and the Natural and Mineral Resources of Sinaloa; by Frederick G. Weidner, M. and C. E., Surveyor General of Sinaloa. Read before the Geog. Soc. of the Pacific, Nov., 1881. San Francisco, 1882.

† Phil. Trans., 1856, vol. iii, p. 661.

‡ Ann. de Chim. et Phys., 1867 [4], vol. x, p. 258.

the temperature of the air, 15° C.; the other at a constant red heat by means of a Bunsen burner. The metal was heated in this way from 9 A. M. to 3 P. M., until it reached a condition of thermal equilibrium, as shown by the galvanometer. The scale of the galvanometer was then moved until the spot of light came to 0. The current from the Grove cells was then passed for one minute, alternately in opposite directions, and the deflections of the galvanometer were read every quarter of a minute. Before the direction of the current was changed the circuit was each time broken, and the spot of light was allowed to fall to 0. The following table gives the results. The column marked "C–H" gives the deflections when the current was passing from cold to hot. The small numbers show which deflections in each pair were taken first.

C—H. Deflections taken every ¼ minute.					H—C. Deflections taken every ¼ minute.				
1	2	1	2	1	2	1	2	1	2
4·1	4·2	4·0	4·3	4·4	3·3	4·0	3·6	3·8	4·1
6·3	6·4	6·5	6·4	6·4	5·0	6·2	5·4	5·9	6·0
7·3	7·2	7·5	7·0	7·2	5·8	6·7	6·2	6·5	7·0
7·4	7·6	7·6	7·3	7·7	6·1	7·3	6·5	6·8	7·2

From this table it is obvious that more heat is evolved by a constant current per unit time in passing from the cold to the hot end of the nickel, than in passing in the opposite direction. The Thomson Effect in pure nickel is consequently negative; i. e., heat is absorbed by a current in passing from hot to cold, and evolved in passing from cold to hot. The above results were confirmed by many similar experiments, as will be seen later.

It was next determined to find whether the Thomson Effect was reversible; that is, whether the heat absorbed by a current in passing across a section of temperature t was equal to the heat evolved by the same current when passing in the opposite direction across the same section. This subject has important bearings on the thermodynamical theory of thermo-electricity.

The following method was pursued: Both ends of the nickel were at the temperature of the air, 15° C. The current from six Grove cells was passed as before, and the deflections of the galvanometer were observed every half-minute. The apparatus was arranged exactly as before. Column I of the accompanying table gives the deflections. One end of the nickel was now placed in melting ice. After one hour it reached a condition of thermal equilibrium, and the current from the Grove cells was passed alternately in opposite directions. The deflections are given in II and III.

If the deflections in II and III are subtracted from the corresponding deflections in I, we get the amount of deflection due to the Thomson Effect. It will be observed that all the deflections in II are less than those in I, and those in III are greater, as they obviously should be. The only inaccuracy in

I. Deflections taken every ½ minute.	II. H—C. Deflections every ½ minute.	III. C—H. Deflections every ½ minute.	II—I.	III—I.
1·8	1·8	2·0	0·0	0·1
2·6	2·4	2·8	0·2	0·2
2·9	2·65	3·15	0·25	0·25
3·1	2·75	3·25	0·35	0·15

this determination is due to the fact that we neglected the alteration in electrical resistance of the nickel due to the slight change in temperature.

The numbers in these tables are obviously too small to draw any conclusions. They, however, confirm the preceding results as to the direction of the Thomson Effect, and tend rather to prove than to disprove the reversibility of the effect. The experiment was repeated several times, but with no better result.

Experiments were also made to test the influence of magnetism on the Thomson Effect. Nothing but negative results were, however, obtained.

The strip of nickel was placed horizontally, with its flat surface perpendicular to the axis of a large electro-magnet—the strip being between the two poles of the magnet. One surface of the nickel was pressed against one pole; on the other surface was placed one face of the thermopile, while the opposite face was in contact with the second pole of the magnet. Mica was used, as in the previous experiments, to protect the faces of the pile. The whole was wedged, and pressed tightly together, and clamped by means of wire, the object being to prevent any motion of the nickel when the magnet was made. One end of the nickel was heated by a Bunsen burner, the other was at the temperature of the air. Six hours were required for the apparatus to reach a condition of thermal equilibrium. The electro-magnet was connected with thirty-eight freshly set-up bichromate of potash cells, with plates of large size. A current from eight Grove cells was now passed along the nickel, with and without the circuit of the magnet being made. The deflections of the galvanometer were exactly the same in each case, showing that in a magnetic field—at least of the strength in the experiment—the Thomson Effect was unaltered.

It is unfortunate that the strength of the field could not be accurately obtained, as the batteries had been running about thirty minutes by the time the experiment was completed. The field, however, was very much stronger—as shown by rough tests—than in another experiment where the minimum value was found to be 184 times the vertical intensity of the earth's magnetism.

The determination of the relative value of the Thomson Effect in nickel, by the following method, gives, of course, but approximate results. The value, however, is probably as accurate as those given by Le Roux for other metals.

A strip of copper, of about the same dimensions as the nickel used before, was arranged exactly as the nickel had been. The thermopile was insulated from the strip by the same piece of mica, and the same weights were placed on the upper surface. One end of the copper was heated in boiling water, and when the apparatus had reached a condition of equilibrum, the deflection of the galvanometer was 35 centimeters. A current from four amalgamated Grove cells was now passed alternately in opposite directions along the bar, the deflections of the spot being taken, in each case, after one minute. The results are given in the left hand table.

C—H deflections taken every minute.	H—C deflections taken every minute.	Differences between the corresponding deflections.	C—H deflections taken every minute.	H—C deflections taken every minute.	Differences between the corresponding deflections.
12·0 [2]	13·0 [1]	1·0	14·5 [1]	13·3 [2]	1·2
12·3 [1]	13·1 [2]	0·8	14·3 [2]	13·3 [1]	1·0
12·1 [1]	13·4 [2]	1·3	14·3 [1]	13·4 [2]	·9
12·0 [2]	12·8 [1]	0·8	14·8 [2]	13·3 [1]	1·5
Mean difference=0·97			Mean difference=1·15		

The strip of nickel was now substituted for the copper, everything else remaining exactly the same. One end of the nickel was heated, and the thermopile was placed on such a spot that the galvanometer gave a deflection of 35 centimeters.

The same current was passed as above. The results are given in the right hand table. Let $d=$ the mean difference in first table, and $d'=$ that in the second, d and d' are then proportional to the elevation of temperature of the part of the bars under the pile, on account of the Thomson Effect. Let $\sigma=$ coefficient of Thomson Effect, that is, σ is such a quantity that $\sigma d\theta$ represents the heat absorbed per unit current per unit time in passing from section at temperature θ to section at temperature $\theta+d\theta$. The heat evolved in unit section when the temperature is increased by $\frac{1}{2}d$. K is $\frac{1}{2}\mathrm{K}d$ SD. Where K is a constant depending on the galvanometer, S is the specific heat, and D the density of the metal. If we consider the Thomson Effect to be constant under the pile, and θ and θ' to represent the temperatures of the ends of the space covered by the pile we have:

$$\sigma\,(\theta-\theta_{\prime})=K\frac{d}{2}SD$$

and the similar expression for nickel:

$$\sigma_{\prime}(\theta-\theta_{\prime})=K\frac{d_{\prime}}{2}S_{\prime}D_{\prime}$$

$$\therefore \qquad \frac{\sigma_{\prime}}{\sigma}=\frac{d'}{d}\cdot\frac{S'}{S}\cdot\frac{D_{\prime}}{D} \qquad \text{I}$$

Equation I then gives the relative value of the coefficient of the Thomson Effect at any temperature θ.

$S=\cdot095 \quad S_{\prime}=\cdot108 \quad D=8\cdot9 \quad D_{\prime}=8\cdot3 \quad d=0\cdot97 \quad d'=1\cdot15$

$$\therefore \qquad \frac{\sigma'}{\sigma}=1\cdot25 \quad \therefore\ \sigma'=1\cdot25\sigma.$$

In Le Roux's table $\sigma=2$. $\therefore$ $\sigma'=2\cdot50$, σ and σ' are, however, of opposite sign. Introducing nickel Le Roux's table becomes:

+		−	
Sb	64	Fe	31
Cd	31	Bi	31
Zn	11	Arg	25
Ag	6	Pt	18
Cu	2	Ni	2·25
		Al	0·1
		Sn	0·1

The Thomson effect in carbon was next investigated. The carbon used was the graphite of the common carpenter's lead-pencil. The pencils which gave the best results were Faber's.

Attempts were first made to measure the direction of the Thomson Effect in the same way as in the case of nickel, that is, by placing a face of the thermopile on one surface of the carbon; the two ends of the carbon being maintained at constant temperatures, and passing the electric current alternately in opposite directions. This method was unsuccessful from the fact that one Grove cell heated the carbon to such a degree that in one minute the spot of light was thrown off the galvanometer scale; thus rendering it impossible to measure, with any accuracy, the rate at which the deflection increased.

The method of Le Roux was then tried of using two strips of carbon, each face of the pile being in contact with one strip. This method not only doubles the deflection due to the Thomson Effect, but also greatly diminishes the deflection due to the heat evolved on account of the electrical resistance of the carbon. If the two strips of carbon were exactly the same in all their physical properties, and the contacts with the faces of the thermopile were the same on each side, the latter deflections would evidently be entirely eliminated.

Two carpenters' pencils were split longitudinally, the lead being left in one-half of the wood. They were then tightly bound, parallel, against each face of the thermopile, and insulated from it by thin pieces of mica. Especial care was taken to fasten the carbons firmly so as to prevent any motion from the passage of the current. The pencils were placed perpendicularly, the lower ends in two vessels of mercury, surrounded by melting ice; the upper ends were at the temperature of the air. The upper ends were electrically connected and the wires from a battery of three Grove cells were placed in the vessels of mercury. The thermopile was connected with a reflecting galvanometer of six ohms resistance.

When the system had reached a condition of thermal equilibrium, the current from the battery was passed, and the observations were made. The vessels of mercury and the corresponding pencils are denoted by "*a*" and "*b*." The current entered alternately in "*a*" and *b*," the deflections of the galvanometer being taken, in each case, every half minute. The deflections showed that the pencil "*a*" was warmer than "*b*," but the difference of temperatures was greater in one case than in the other.

The following table represents the results of two sets of experiments. The small numbers at top show which column of each pair was taken first.

First Experiment.

Current enters at "*a*."	Current enters at "*b*."	Difference proportional to 47 E.
2	1	
21·0	20·8	0·2
34·5	32·4	2·1
2	1	
21·2	21·0	0·2
34·5	33·0	1·5
2	1	
21·4	20·6	0·8
34·3	32·8	1·5
2	1	
21·7	21·6	0·1
36·0	34·3	1·7
42·4	40·0	2·4
2	1	
23·0	21·7	1·3
38·2	35·0	3·2
45·5	41·2	4·3
2	1	
23·5	23·0	0·5
39·0	37·0	2·0
45·8	43·8	2·0

Second Experiment.

Current enters at "*a*."	Current enters at "*b*."	Difference proportional to 47 E.
1	2	
20·8	20·2	0·6
34·7	32·8	1·9
1	2	
19·5	18·2	1·3
31·0	29·3	1·7
37·0	34·2	2·8
1	2	
19·8	18·0	1·8
31.8	29·2	2·6
37·3	34·0	3·3
1	2	
20·0	18·8	1·2
32·6	30·4	2·2
38·7	35·7	3·0
1	2	
21·0	19·8	1·2
33·8	31·3	2·5
39·8	36·3	3·5
1	2	
20·0	19·0	1·0
32·2	29·8	2·4
37·4	34·3	3·1

From this table it appears that the Thomson Effect in ordinary graphite is negative; that is, heat is apparently evolved when the current passes from cold to hot, or the negative current carries heat with it. The differences in the last columns are obviously proportional to four times the Thomson Effect—assuming that the effect is reversible. It also appears from the table that the effect increases as the temperature increases, which is in accordance with Tait's assumption.

These experiments were repeated with the graphite from other kinds of pencils, but in no case was the effect nearly as marked as in Faber's. Even in the case of Faber's pencils many trials were made before satisfactory results were obtained.

Equations representing the thermal condition of a bar when acting as a conductor of heat and electricity may be deduced as follows: One end of the bar is supposed to be maintained at a constant temperature, the other at that of the air, and the electric current is supposed to be constant. For simplicity we will assume that the specific electrical resistance of the bar is constant throughout, i. e. is independent of slight differences of temperature.

The quantity of heat, H, evolved by the current in time δt, in the section of the bar $S\delta x$—S being the area of a section—is represented by

$$H = I^2 RS\delta x \, . \, \delta t \qquad \text{I}$$

x = distance of the section from heated end. If we assume that the thermal conductivity is unaltered by the slight rise in temperature due to the current, it can easily be seen that the flow of heat due to conduction is unaltered by the current. Hence we can consider that the heat evolved by the current is partly used in raising the temperature of the section $S\delta x$, and that all the rest escapes from the surface by radiation.

The Thomson Effect is, at present, purposely neglected.

The bar is supposed to have reached a permanent condition as regards conduction before the current was passed. Let θ be the temperature of the section of the bar we are considering before the current passes. Let h = the exterior conductivity or velocity of cooling.

Let p = the rise of temperature above θ when the current passes.

Assuming Newton's law of cooling, the heat radiated on account of the rise of temperature p is proportional to ph, and the quantity radiated from the section in time δt, from the same cause, is

$$H_1 = phl\delta x \, . \, \delta t \qquad \text{II}$$

l = the periphery of the bar.

In time δt the increase of temperature p becomes $p+\delta p$, and the heat developed in the section by this increment is

$$H_2 = CSD\delta x \,.\, \delta p \qquad \text{III}$$

As we saw that the heat of the current was expended only in the ways represented by II and III, we have

$$H = H_1 + H_2 \qquad \text{IV}$$

If we now consider the influence of the Thomson Effect, we simply add that a certain quantity of heat is absorbed or evolved by the current in the section $S\delta x$—distinct from that represented by I_2R.

If $\sigma =$ the coefficient of the Thomson Effect, the heat absorbed or evolved due to this effect is, in time δt,

$$H_3 = I\sigma\delta\theta \,.\, \delta t \qquad \text{V}$$

The effect being proportional to the current, and σ being defined as such a quantity that $\sigma\delta\theta$ represents the heat absorbed, or evolved, in passing from a point at temperature θ to $\theta+\delta\theta$, per unit current per unit time. Introducing this effect in IV,

$$H = H_1 + H_2 + H_3 \qquad \text{VI}$$

As the total value of the excess of heat—due to the current—in the section can be considered as made up of these quantities. Substituting the values in VI from I, II, III, V, and transposing

$$plh\delta x \,.\, \delta t = I^2RS\delta x \,.\, \delta t - CSD\delta x \,.\, \delta p - I\sigma\delta\theta \,.\, \delta t$$

$$\therefore \quad phl = I^2RS - CSD\frac{\delta p}{\delta t} - I\sigma\frac{\delta\theta}{\delta x}$$

or at the limit:—

$$\frac{dp}{dt} = \frac{1}{CSD}\left[I^2RS - phl - I\sigma\frac{d\theta}{dx}\right] \qquad \text{VII}$$

This equation gives the rate at which the temperature rises when the current passes, and will approximately apply to the preceding experiments.

When the temperature of the bar becomes permanent,

$$\frac{dp}{dt} = 0$$

and VII becomes

$$I^2RS - phl - I\sigma\frac{d\theta}{dx} = 0$$

$$\therefore \quad p = \left[I^2RS - I\sigma\frac{d\theta}{dx}\right]\frac{1}{hl} \qquad \text{VIII}$$

giving the excess of temperature due to the current in the permanent condition of the bar.

The values in VIII are all easily determined except σ and h. The differential coefficient $\frac{d\theta}{dx}$—the rate of change of temperature due to conduction along the bar—can readily be found by experiment; or deduced by analysis, as in the case of an infinite square bar where

$$\theta = a\epsilon^{-kx} \quad \text{and} \quad \frac{d\theta}{dx} = -ak\epsilon^{-kx}.$$

As p may easily be determined by experiment, the equation can be used to determine σ as

$$\sigma = \frac{I^2 RS - phl}{I\frac{d\theta}{dx}} \qquad \text{IX}$$

If Tait's assumption that $\sigma = MT$, where M is some constant and T the absolute temperature, is true, we might obtain two values of σ, for two points of the bar, the temperature of which was known, eliminate h from the two equations, and thus obtain a value for M. If we performed the same operation for two other points, we should get another value for M, and could verify Tait's assumption if this value was equal to the preceding.

The sources of error in the preceding investigation are due to assuming Newton's law of cooling, to neglecting the change of electrical resistance due to a change of temperature, and to partly neglecting the change of thermal conductivity due to the same cause.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Carbon dioxide of the Atmosphere.*—The statement is commonly made in text-books that the amount of carbon dioxide in the atmosphere varies from four to six volumes in ten thousand; being based on the investigations of De Saussure, Boussingault and others. Two important memoirs have been lately published upon this subject which show that the value above given is very considerably too high. The first of these is by Reiset. The apparatus which he employed consisted of two aspirators, which, to secure accuracy, were of large size, containing about 600 liters each. They were made of strong galvanized iron and were provided with stopcocks of brass. Each was mounted, with the axis vertical, upon a cart carrying also a small shed in which was the absorption apparatus. The aqueous vapor was absorbed by a weighed tube containing fragments of pumice moistened with concentrated sulphuric acid. The carbon dioxide was absorbed in bulb tubes containing a solution of barium hydrate already saturated with carbonate. The barium solution was titred with a graduated sulphuric acid both before and after the known volume of air had been passed through it. The difference gave the barium which had been converted into carbonate.

On the scale of the experiments an error of an entire cubic centimeter in the amount of CO_2 is of comparative unimportance, since it represents only $\frac{1}{500000}$ of the whole. The experiments were made at a field station about 8 kilometers from Dieppe at an altitude of 96 meters above the sea. Here one of the aspirators was permanently installed while the other was transported from place to place. Three series of experiments were made with the former apparatus. The first extended from September 9, 1872, to August 20, 1873, 92 experiments. The second from June 17 to November 14, 1879, 91 experiments. The third from June 19 to August 28, 1880, 37 experiments. The results are given in tabular form, the final mean being given as follows:

Number of series.	Number of experiments.	Volume of dry air at 0° and 760 in liters.	Carbon dioxide at 0° and 760 in cubic cent.	Carbon dioxide in 100,000 volumes of air.
Series 1	92	532·906	156·8	29·42
Series 2	91	527·539	157·1	29·77
Series 3	37	513·717	152·5	29·68
Mean of	220 expts.	524·720	155·5	29·62

The aspirator contained as a mean 678·294 grams of dry air at 0° and 760 mm. This contained 0·307 gram CO_2; giving by weight 4·52 parts of CO_2 in 10,000 of air as the mean of the 220 experiments. The absolute maximum observed was 35·18 volumes in 100,000, observed July 23, 1880; the absolute minimum 27·43, observed on September 2, 1879. The air at night contained more CO_2 than during the day. Cloudy weather and fog increase the CO_2, clear weather diminishes it. It is less in summer than in winter. With the second aspirating apparatus, a series of 27 experiments were made in a grove of young trees and gave 29·17 volumes CO_2 in 100,000 of air. Air taken near a vigorous growth of clover red with flowers, in the month of June, contained 28·98 volumes CO_2. Air taken 3 dm. above the ground in a field of barley mixed with lucerne, in July, gave 28·29 volumes CO_2. Since during the same periods, the CO_2 in the air at the field station was 29·02, 29·15 and 29·33 volumes, the reduction by the vegetation is evident. Experiments made in Paris, in the Rue de Vigny near the Parc de Monceaux in 1873, 1875 and 1879, showed a mean of 31·68 volumes CO_2 in 100,000; the maximum being 35·16 on the 27th January, 1879, and the minimum 29·13 on May 31, 1875.

The second memoir is by MÜNTZ and AUBIN. They determined the carbon dioxide by absorbing it by pumice stone moistened with potassium hydrate; the gas being subsequently set free and its volume measured. By means of a gasometer of 300 liters capacity, a known volume of air was passed, at the rate of three liters per minute, through a tube 85 to 90 cm. long and 20 mm. in diameter, containing pumice in fragments the size of a bean moistened with 50 c.c. of a solution of potassium hydrate free from CO_2. These absorption tubes were prepared previously in sufficient number, being drawn to a point at each end and sealed till wanted. After the absorption they were again sealed and the

CO_2 was determined at leisure. Two stations for the lower levels were used, one at the Conservatoire des Arts et Metiers in Paris, 6 meters above the ground, the other near the farm of the Institut Agronomique at Gravelle, 4 meters high. As the result of 35 experiments in the open plain of Vincennes, the amount of CO_2 as a mean was found to be 2·84 volumes in 10,000 of air. Within the court of the Institut Agronomique, as a mean of 12 experiments 2·98 volumes. And in Paris, as a mean of 30 experiments, 3·19 volumes. For the higher levels, the Pic du Midi was selected, situated in the Pyrenees and 2,877 meters above the sea. As a mean of 14 observations, made from the 9th to the 14th of August, 1881, the amount of CO_2 was found to be 2·86 volumes in 10,000; thus showing the uniformity of the diffusion of carbon dioxide gas in the atmosphere.

In a note upon these researches, DUMAS gives an excellent summary of them as well as those of Schulze and Schlœsing, the latter upon the preservation of the balance by the dissociation of the hydro-calcium carbonate in the water of the sea whenever the CO_2 in the air falls below its normal value. Schulze found the CO_2 for 1869 to be 2·8668 volumes, for 1870 to be 2·9052 volumes and for the first half of 1871 to be 3·0126 volumes in 10,000 of air.—*Ann. Chim. Phys.*, V, xxvi, 145, 222, 254, June, 1882.

G. F. B.

2. *On a Basic Copper Sulphate.*—STEINMANN has produced a basic copper sulphate by heating a cold saturated solution of blue vitriol for about thirty minutes to the temperature of 240° to 250° in a close vessel. Crystalline crusts of a green color are deposited, insoluble in water but soluble in acids. On analysis, the salt gave 68·0–69·2 CuO, 23·1 SO_3 and 7·8–7·9 water; corresponding to the formula $(CuO)_6(SO_3)_2(H_2O)_3$ which requires 69·0 of CuO, 23·2 of SO_3 and 7·8 of water.—*Ber. Berl. Chem. Ges.*, xv, 1411, June, 1882.

G. F. B.

3. *On the Relation between Magnetic Rotatory Polarization and Chemical Composition.*—PERKIN has studied the influence of chemical composition upon the power of rotating the plane of polarization when under magnetic influence. The apparatus employed was that of Becquerel, the substances to be examined being placed in tubes about 10 cm. long, closed by glass plates, the ends being inserted a short distance into openings in the armature of an electro-magnet. Water and carbon disulphide were used as standards of comparison. At first the magnetic rotatory effect of unit-lengths of the liquids was determined; but the results seemed to bear little or no relationship to the chemical composition of the bodies examined. Moreover, no useful result could be expected from the calculated differences obtained from liquid substances; since, as the homologous series is ascended, the effect of increasing the molecule by CH_2 upon a unit-length becomes smaller and smaller, as also does any property which, like that of rotation, is based upon it. Since, however, unit-lengths of vapors contain equal numbers of molecules, the exam-

ination of vapors would give results free from this objection. The apparatus required to determine the magnetic rotatory power of gases is bulky and complicated. By multiplying the observed rotation of the liquid, however, by its molecular weight, and dividing the product by the density, an accurate molecular value is obtained. This, divided by a similar value given by the standard, yields a constant which the author calls the "molecular coefficient of magnetic rotation." Taking water as unity, the numbers calculated in this way show very clearly the dependence of magnetic rotation on chemical composition. With the iodides of the alcohol radicals, for example, the molecular rotatory power is as follows: methyl 9·07, ethyl 10·19, propyl 11·39, amyl 13·4; the differences for an increase of CH_2 being 1·12, 1·20 and 2·00 ($=1·0\times2$) respectively. Taking De la Rive's and Becquerel's work in conjunction with his own, the author finds 1·06 for the difference of CH_2 between methyl and ethyl, and between ethyl and propyl alcohols, 1·14 between propyl and butyl alcohols, and 1·12 between butyl and amyl alcohols. The molecular rotatory power of amylene was found to be 5·87; and since C_5H_{10} is $CH_2\times5$, the value for amylene calculated would be 5·5. De la Rive had shown that isomeric and metameric bodies give different magnetic rotations; the molecular rotatory power of amyl alcohol being 5·95, and that of amylene hydrate being 5·81. Perkin finds that ethylidene chloride gives a lower number than ethylene chloride. Further results are promised.—*J. Chem. Soc.*, xli, 330, July, 1882.
G. F. B.

4. *On the Vapor density of Chlorine peroxide.*—Pebal and Schacherl have determined experimentally the vapor density of chlorine peroxide, with a view to fix its molecular formula. The gas was prepared by gently heating a mixture of oxalic acid, potassium chlorate and dilute sulphuric acid (one of acid and two of water); Schacherl having shown that the gas thus obtained contains scarcely a trace of free chlorine. That the peroxide is a definite chemical compound Pebal had proved by showing that its composition did not change by diffusion into an indifferent gas. The gas as evolved was collected in a tube placed in a freezing mixture, where it condensed to a liquid. When about 5 or 6 c.c. had accumulated, the entrance tube was closed by a ground stopper, and the delivery tube connected by a ground joint to the weighing cylinder. This was a tube of 130 c.c. capacity closed at both ends with glass cocks, and immersed in water contained in a tinned iron cylinder and kept at a temperature one degree above the boiling point of the peroxide. On removing the freezing mixture from the tube, the liquid in it boiled and the heavy vapor streamed through the weighing tube and escaped into a chimney. Water at 30° surrounded this tube constantly and its temperature was kept uniform by agitation. When the liquid had nearly all evaporated, the lower cock of the weighing tube was first closed, and then the upper, the temperature of the water and the barometric pressure being noted. The

tube was then removed and weighed. The constants of the tube having been previously determined, the new weight after making the necessary reductions, gave the density at 10·7° C. and 718·05 mm. as 2·3894 referred to air as unity or as 34·50 referred to hydrogen. The density calculated from the formula ClO_2 is 33·64 and from Cl_2O_4 is 67·29. Hence the authors conclude that there is no ground for the assumption that molecules of the composition Cl_2O_4 have any actual existence.—*Liebig's Ann.*, ccxiii, 113, June, 1882. G. F. B.

5. *On Perchloric acid.*—BERTHELOT has made a study of perchloric acid with special reference to its thermo-chemical relations. He confirms Roscoe's three hydrates, $HClO_4$, $HClO_4H_2O$ and $HClO_4(H_2O)_2$. The first of these he has obtained crystallized by placing the liquid acid containing a few per cent of water in excess in a freezing mixture. The crystals are freed from the mother liquor, melted and again crystallized. An acid is thus obtained melting about 15°, having the above composition and possessing so strong an attraction for water as to give off thick white fumes in the air. When the liquid acid, $HClO_4$, is dissolved in 100 times its weight of water at 19°, it evolves 20·3 calories; an enormous quantity surpassing that given by any other acid known. This result explains the remarkable difference which exists between this acid when diluted with water, in which condition it is nearly as stable as dilute sulphuric acid, and the undiluted acid $HClO_4$, which inflames HI gas and acts with explosive violence on oxidizable bodies. Indeed in dilute solution perchloric acid is not reduced by any known substance. Neither sulphurous oxide, hydrogen sulphide, hyposulphurous acid, hydrogen iodide, free hydrogen, zinc in presence of acids, sodium amalgam in presence of pure water, acids or alkalies, nor even electrolysis, exerts any action. The perchlorates when dissolved are as stable as the sulphates. The second hydrate, $HClO_4H_2O$, evolves 7·7 calories, and the third, $HClO_4(H_2O)_2$, evolves 5·3 calories on being dissolved; and therefore they appear to be but a little more active than the dilute acid. The heat of formation of liquid $HClO_4$ (from HCl gas and O_4) evolves 2·9 calories; while from $Cl+O_{3\frac{1}{2}}+HO_{\frac{1}{2}}$ gaseous, 9·9 calories, or 14·9, if the water be liquid, are evolved. Dilute $HClO_4$, from HCl dilute and O_4, causes no heat change; and from Cl gaseous $+O_{3\frac{1}{2}}+HO_{\frac{1}{2}}$ liquid, there is an absorption of 4·9 calories. These numbers account for the difference in the stability of the concentrated and the dilute acid, and also for the readiness with which the former is decomposed. Again, in the decomposition of the perchlorates, $KClO_4$ solid $=KCl$ solid $+O_4$ absorbs 7·5 calories; $NaClO_4$ solid $=NaCl$ solid $+O_4$ absorbs 3·0 calories; and $Ba_{\frac{1}{2}}ClO_4$ solid $=Ba_{\frac{1}{2}}Cl$ solid $+O_4$ absorbs 1·1 calories. Hence when a perchlorate changes into a chloride heat is absorbed, the change not being explosive; contrary to what is true of the chlorates. Hence the change of potassium chlorate into perchlorate by heat is exothermic. Ammonium perchlorate should be explosive, since NH_4ClO_4 solid $=Cl+O_2+$

$N+(H_2O)_2$ liquid, evolving 58·3 calories; or if the resulting water be in vapor 38·3 calories. In fact, when melted, this salt becomes incandescent, taking the spheroidal form, the brilliant globule decomposing rapidly into free chlorine, oxygen and water, with the production of a yellowish flame; resembling somewhat ammonium nitrate in its action.—*Bull. Soc. Ch.*, II, xxxviii, 1, July, 1882. G. F. B.

6. *Diffusion of Gases.*—K. WAITZ concludes from his observations that the diffusion coefficient for the free diffusion of two gases into each other, is not a constant. It decreases after the beginning of the diffusion, in a given section, and soon reaches for any given section a constant limit. The change of this limiting value from one section to another is proportional to the distances of the sections from the free surface of the diffusion vessels.—*Ann. der Physik und Chemie*, No. 10, 1882, pp. 201–236. J. T.

7. *Diamagnetism of Bismuth in absolute measure.*—Various observers differ in regard to the diamagnetism of bismuth. H. A. v. ETTINGSHAUSEN has made a new determination of it by four different methods, and has obtained the mean value of $k = 13{\cdot}9910^{-6}$.—*Ann. der Physik und Chemie*, No. 10, 1882, 272–305. J. T.

8. *Pressure of Saturated Mercury Vapor.*—The results of Regnault and of later observers differ. Hagen has lately made some determinations, which in turn are scrutinized by H. HERTZ. The latter finds results which are smaller than those of Regnault, but approximate to those of the latter with increasing temperature, and nearly coincide with them at 220°. They are, however, greater than Hagen's above 80°, coincide very nearly with his between 80° and 100°, and are smaller below 80°. The pressure of mercury vapor at the ordinary temperature of the air is less than one thousandth of a millimeter.—*Ann. der Physik und Chemie*, No. 10, 1882, pp. 193–200. J. T.

9. *The Microphone.*—In a paper on the recent progress in Telephony, read at the Southampton meeting of the British Association, Mr. W. H. PREECE referred to the theory that the action of the microphone is due to the effect of heat which is generated by a current of electricity passing between points of carbon which are at variable distance. This theory appeared to him to be the true one. Carbon is inoxidizable and infusible, is a poor conductor, and has its resistance lowered when heated. These properties make it especially suitable for microphones. The resistance of microphones is very variable. Theory demands that a carbon transmitter should have the lowest possible resistance, but this is not true in practice. Theory also asserts that the resistance of the secondary coil of the induction coil should be equal to that of the line it works, but practice proves the reverse. The conditions due to heat in the microphone and to self-induction in the induction coil are apparently too complicated to be brought yet into the region of mathematical analysis.—*Nature*, Sept. 21, 1882. J. T.

10. *Telegraphy without a Cable.*—Mr. W. H. PREECE recently tried the following experiment. "Large metal plates were im-

mersed in the sea at Portsmouth and Ryde, six miles apart, and at Hurst Castle and Sconce point, one mile apart. The Portsmouth and Hurst Castle plates were connected by a wire passing through Southampton, and the Ryde and Sconce Point plates by a wire passing through Newport; the circuit was completed by the sea, and signals were passed easily so as to be read by the Morse system, but speech was not practicable."—*Nature*, Sept. 21, 1882.
J. T.

11. *Sunlight and Skylight at High Altitudes.* From the Proceedings of the Meeting of the British Association at Southampton, (*Nature*).—Professor LANGLEY, following Captain Abney, observed: The very remarkable paper just read by Captain Abney has already brought information, upon some points which the one I am about, by the courtesy of the Association, to present, leaves in doubt. It will be understood then that the references here are to his published memoirs only, and not to what we have just heard.

The solar spectrum is so commonly supposed to have been mapped with completeness, that the statement that much more than one half its extent is not only unmapped but nearly unknown, may excite surprise. This statement is, however, I think, quite within the truth, as to that almost unexplored region discovered by the elder Herschel, which lying below the red and invisible to the eye, is so compressed by the prism, that though its aggregate heat effects have been studied through the thermopile, it is only by the recent researches of Capt. Abney that we have any certain knowledge of the lines of absorption there, even in part. Though the last named investigator has extended our knowledge of it to a point much beyond the lowest visible ray, there yet remains a still remoter region, more extensive than the whole visible spectrum, the study of which has been entered on at Allegheny, by means of the linear Bolometer.

The whole spectrum, visible and invisible, is powerfully affected by the selective absorption of our atmosphere, and that of the sun; and we must first observe that could we get outside our earth's atmospheric shell, we should see a second and very different spectrum, and could we afterward remove the solar atmosphere also, we should have yet a third, different from either. The charts exhibited, show:—

1st. The distribution of the solar energy as we receive it, at the earth's surface, throughout the entire invisible as well as visible portion, both on the prismatic and normal scales. This is what I have principally to speak of now, but this whole first research is but incidental to others upon the spectra before any absorption, which though incomplete, I wish to briefly allude to later. The other curves then indicate:—

2d. The distribution of energy before absorption by our own atmosphere.

3d. This distribution at the photosphere of the sun.

The extent of the field, newly studied, is shown by this drawing (chart exhibited). Between H in the extreme violet, and A in the farthest red, lies the visible spectrum, with which we are familiar, its length being about 4,000 of Ångström's units. If, then, 4,000 represent the length of the visible spectrum, the chart shows that the region below extends through 24,000 more, and so much as this as lies below wave-length, 12,000, I think, is now mapped for the first time.

We have to $\lambda = 12,000$, relatively complete photographs published by Capt. Abney, but, excepting some very slight indications by Lamansky, Desains, and Mouton, no further guide.

Deviations being proportionate to abscissæ, and measured solar energies to ordinates, we have here (1) the distribution of energy in the prismatic and (2) its distribution in the normal spectrum. The total energy is in each case proportionate to the area of the curve (the two very dissimilar curves inclosing the same area), and on each, if the total energy be roughly divided into four parts, one of these will correspond to the visible, and three to the invisible or ultra-red part. The total energy, at the ultra violet end, is so small then as to be here altogether negligable.

We observe that (owing to the distortion introduced by the prism) the maximum ordinate representing the heat in the prismatic spectrum is, as observed by Tyndall, below the red, while upon the normal scale this maximum ordinate is found in the orange.

I would next ask your attention to the fact that in either spectrum, below $\lambda = 12,000$ are most extraordinary depressions and interruptions of the energy, to which, as will be seen, the visible spectrum offers no parallel. As to the agent producing these great gaps, which so strikingly interrupt the continuity of the curve, and as you see, in one place, cut it completely in two. I have as yet obtained no conclusive evidence. Knowing the great absorption of water vapor in this lowest region, as we already do, from the observations of Tyndall, it would, *à priori*, seem *not* unreasonable to look to it as the cause. On the other hand, when I have continued observations from noon to sunset, making successive measures of each ordinate, as the sinking sun sent its rays through greater depths of absorbing atmosphere, I have not found these gaps increasing as much as they apparently should if due to a terrestrial cause, and so far as this evidence goes, they might be rather thought to be solar. But my own means of investigation are not so well adapted to decide this important point as those of photography, to which we may yet be indebted for our final conclusion.

I am led from a study of Capt. Abney's photographs of the region between $\lambda = 8,000$ and $\lambda = 12,000$ to think that these gaps are produced by the aggregation of finer lines, which can best be discriminated by the camera, an instrument, which, where it can be used at all, is far more sensitive than the bolometer; while the latter, I think, has on the other hand some advantage in affording direct and trustworthy measures of the amount of energy inhering in each ray.

One reason why the extent of this great region has been so singularly underestimated is the deceptively small space into which it appears to be compressed by the distortion of the prism. To discriminate between these crowded rays I have been driven to the invention of a special instrument. The bolometer, which I have here, is an instrument depending upon principles which I need not explain at length, since all present may be presumed to be familiar with the success which has before attended their application in another field, in the hands of the President of this Association.

I may remark, however, that this special construction has involved very considerable difficulties and long labor. For the instrument here shown, platinum has been rolled by Messrs. Tiffany, of New York, into sheets, which as determined by the kindness of Professor Rood, reach the surprising tenuity of less than $\frac{1}{25000}$ of an English inch (I have also iron rolled to $\frac{1}{15000}$ inch), and from this platinum a strip is cut $\frac{1}{125}$ of an inch wide. This minute strip, forming one arm of a Wheatstone's bridge, and thus perfectly shielded from air currents, is accurately centered, by means of a compound microscope, in this truly turned cylinder, and the cylinder itself is exactly directed by the arms of this Y.

The attached galvanometer responds readily to changes of temperature of much less than $\frac{1}{10000}$° Fahr. Since it is one and the same solar energy, whose manifestations we call "light" or "heat," according to the medium which interprets them, what is "light" to the eye is "heat" to the bolometer, and what is seen as a dark line by the eye is felt as a cold line by the sentient instrument. Accordingly if lines analogous to the dark "Frauenhofer lines" exist in this invisible region they will appear (if I may so speak) to the bolometer as cold bands, and this hair-like strip of platina is moved along in the invisible part of the spectrum till the galvanometer indicates that all but infinitesimal change of temperature caused by its contact with such a "cold band." The whole work, it will be seen, is necessarily very slow; it is in fact a long groping in the dark, and it demands extreme patience. A portion of its results are now before you.

The most tedious part of the whole process, has been the determination of the wave-lengths. It will be remembered that we have (except through the work of Capt. Abney, already cited, and perhaps of M. Mouton) no direct knowledge of the wave-lengths in the infra-red prismatic spectrum, but have hitherto inferred them from formulas like the well-known one of Cauchy's, all of which that are known to me appear to be here found erroneous by the test of direct experiment; at least in the case of the prism actually employed.

I have been greatly aided in this part of the work by the remarkable concave gratings lately constructed by Professor

Rowland of Baltimore, one of which I have the pleasure of showing you.

The spectra formed by this fall upon a screen in which is a fine slit, only permitting nearly homogeneous rays to pass, and these, which may contain the rays of as many as four overlapping spectra are next passed through a rock-salt or glass prism placed with its refracting edge parallel to the grating lines. This sorts out the different narrow spectral images, without danger of overlapping, and after their passage through the prism we find them again and fix their position by means of the bolometer, which for this purpose is attached to a special kind of spectrometer, where its platinum thread replaces the reticule of the ordinary telescope. This is very difficult work, especially in the lowermost spectrum, where I have spent over two weeks of consecutive labor in fixing a single wave-length.

The final result is I think worth the trouble however, for as you see here, we are now able to fix with approximate precision, and by direct experiment, the wave-length of every prismatic spectral ray. The terminal ray of the solar spectrum, whose presence has been certainly felt by the bolometer, has a wave-length of about 28,000 (or is nearly two octaves below the "great A" of Frauenhofer).

So far it appears only that we have been measuring *heat*, but I have called the curve that of solar "energy," because by a series of independent investigations, not here given, the selective absorption of the silver, the speculum-metal, the glass and the lamp-black (the latter used on the bolometer-strip), forming the agents of investigation, has been separately allowed for. My study of lamp-black absorption, I should add in qualification, is not quite complete, I have found it quite transparent to certain infra-red rays, and it is very possible that there may be some faint radiations yet to be discovered even below those here indicated.

In view of the increased attention that is doubtless soon to be given to this most interesting but strangely neglected region, and which, by photography and other methods, is certain to be fully mapped hereafter, I can but consider this present work less as a survey than as a sketch of this great new field, and it is as such only that I here present it.

All that has preceded is subordinate to the main research, on which I have occupied the past two years at Allegheny, in comparing the spectra of the sun at high and low altitudes, but which I must here touch upon briefly. By the generosity of a friend of the Allegheny Observatory, and by the aid of General Hazen, Chief Signal Officer of the U. S. army, I was enabled last year to organize an expedition to Mount Whitney in Southern California, where the most important of these latter observations were repeated at an altitude of 13,000 feet. Upon my return I made a special investigation upon the selective absorption of the sun's atmosphere, with results which I can now only allude to.

By such observations, but by methods too elaborate for present description, we can pass from the curve of energy actually observed, to that which would be seen, if the observer were stationed wholly above the earth's atmosphere, and freed from the effect of its absorption.

The salient and remarkable result is the growth of the blue end of the spectrum, and I would remark that while it has been long known from the researches of Lockyer, Crova and others, that certain rays of short wave-length were more absorbed than those of long, that these charts show *how much* separate each ray of the spectrum has grown, and bring, what seems to me, conclusive evidence of the shifting of the point of maximum energy without the atmosphere toward the blue. Contrary to the accepted belief, it appears here also that the absorption on the whole grows less and less, to the extreme infra-red extremity: and on the other hand, that the energy before absorption was so enormously greater in the blue and violet, that the sun must have a decidedly bluish tint to the naked eye, if we could rise above the earth's atmosphere to view it.

But even were we placed outside the earth's atmosphere, that surrounding the sun itself would still remain and exert absorption. By special methods, not here detailed, we have at Allegheny compared the absorption, at various depths, of the sun's own atmosphere for each spectral ray, and are hence enabled to show with approximate truth, I think for the first time, the original distribution of energy throughout the visible and invisible spectrum, at the fount of that energy, in the sun itself. There is a surprising similarity you will notice, in the character of the solar and telluric absorptions, and one which we could hardly have anticipated *à priori.*

Here too, violet has been absorbed enormously more than the green, and the green than the red, and so on, the difference being so great, that if we were to calculate the thickness of the solar atmosphere on the hypothesis of a uniform transmission, we should obtain a very thick atmosphere, from the rate of absorption in the infra-red alone, and a very thin one from that in the violet alone.

But the main result, seems to be still this, that as we have seen in the earth's atmosphere, so we see in the sun's, an enormous and progressive increase of the energy toward the shorter wave-lengths. This conclusion, which, I may be permitted to remark, I anticipated in a communication published in the *Comptes Rendus* of the Institute of France as long since as 1875, is now fully confirmed, and I may mention that it is so also by direct photometric methods, not here given.

If then we ask how the solar photosphere would appear to the eye, could we see it without absorption, these figures appear to show conclusively that it would be *blue.* Not to rely on any assumption, however, we have by various methods at Allegheny, reproduced this color.

Thus (to indicate roughly the principles used), taking three Maxwell's discs, a red, green and blue, so as to reproduce white, we note the three corresponding ordinates at the earth's surface spectrum, and comparing these with the same ordinates in the curve giving the energy at the solar surface; we re-arrange the discs, so as to give the proportion of red, green and blue which would be seen *there*, and obtain by their revolution a tint which must approximately represent that at the photosphere, and which is most similar to that of a blue near Frauenhofer's "F."

The conclusion then is that while all radiations emanate from the solar surface, including red and infra-red, in greater degree than we receive them, that the blue end is so enormously greater in proportion, that the proper color of the sun, as seen at the photosphere, is blue—not only "blueish," but positively and distinctly blue; a statement which I have not ventured to make from any conjecture, or on any less cause than on the sole ground of long continued experiments, which, commenced some seven years since, have within the past two years irresistibly tended to the present conclusion.

The mass of observations on which it rests must be reserved for more detailed publication elsewhere; at present I can only thank the Association for the courtesy which has given me the much prized opportunity of laying before them this indication of methods and results.

II. Geology and Natural History.

1. *Contributions to Mineralogy;* by F. A. Genth.—Dr. Genth has recently published some new observations bearing upon the subject of the alteration of corundum, so ably investigated by him in 1873 (see this Journal, vi, 461). The cases noted by him are as follows: (1) *Corundum altered into spinel.* At the Carter mine, Madison County, N. C., corundum is found in white and pink crystals, and in irregular grayish white or white cleavage masses enveloping a variety of a delicate pink color. This corundum is often more or less completely changed to a massive greenish black spinel of a fine granular structure, but rarely showing octahedral crystals in the compact mass. The spinel occasionally shows scales of prochlorite into which it finally passes; an analysis showed it to have essentially the composition $(Mg, Fe)Al_2O_4$. The corundum from Shimersville, Penn. (see p. 156), is also in part altered to spinel; the crystals contain numerous brilliant crystals of menaccanite. (2) *Corundum altered into zoisite.* A new locality has been found in Towns County, Ga. (3) *Altered to feldspar and mica* (damourite). Cases of the probable alteration of corundum into feldspar have been observed at Unionville, and at the Black Horse Farm near Media, Penn. At the Presley Mine, Haywood County, N. C., feldspar and mica have been observed together as alteration products; the large crystals of corundum of a grayish-blue color contain patches of

white, cleavable feldspar often surrounded by mica, in other cases a small nucleus of the original mineral is surrounded by an aureole of delicate sub-fibrous mica; one crystal of muscovite contained in the center remnants of a smooth bluish-gray cleavable corundum; another mass resembled a coarse granite consisting of albite, muscovite and scattered remnants of grayish-blue corundum; large (one foot in diameter) crystals of corundum occur at Belts' Bridge, Iredell County, N. C., which are more or less completely altered to mica, though they also contain radiating crystalline masses of black tourmaline; from the mica schists near Bradford, Coosa County, Alabama, fine hexagonal crystals have been obtained, consisting of a central part of corundum of a brown and bronze color, inclosing grains of menaccanite, and surrounding this is a perfect ring of sub-fibrous greenish-white mica; other crystals are almost entirely altered, and, often being flattened out, they form irregular nodules in the mica schist, the mica is sometimes scaly, sometimes very fine-grained and compact. Flattened nodules of mica, enclosing a nucleus of corundum also occur at the Haskell mine, Macon County, N. C. (4) *Corundum altered to margarite:* various new localities are mentioned by Dr. Genth. (5) *Altered into fibrolite:* crystals from Shoup's Ford, Burke County, N. C., consist of brown corundum with a thin shell (5mm.) of fine fibrous radiating white fibrolite. (6) *Altered into cyanite:* a specimen from Statesville, Iredell County, N. C., consisted of a nucleus of pink corundum with pale blue cyanite crystallized about it and presumably having resulted from its alteration; in another specimen from Wilkes County, N. C., the cyanite was still further altered to mica.

Dr. Genth also mentions cases of the alteration of orthoclase into albite from Upper Avondale, Delaware County; of talc into anthophyllite from Castle Rock, Delaware County, Penn.; of talc pseudomorph after magnetite from Dublin, Harford County, Md.; of altered gahnite from North Carolina and Cotopaxi. Numerous analyses are given of the various products of alteration mentioned above, and also of the following minerals: sphalerite and prehnite from Cornwall, Pa.; pyrophyllite from the Cross Creek colliery, Drifton, Luzerne County, Pa.; of beryl and allanite from Alexander County, N. C.; of niccolite from Silver Cliff, Colorado.

2. *Anthracite in Sonora, Mexico.*—Professor E. T. Cox, in an account of his observations in the Western States, presented to the American Association at Montreal, stated that near the Zaqui River, 120 miles east of Guaymus, anthracite of excellent quality constitutes two beds, 15 feet apart, in a formation that is probably of true Carboniferous age. The upper bed is 6 to 7 feet thick, the lower 12; and the associated rocks are siliceous shales and coarse breccia conglomerates dipping 35° to the eastward. A few fragments of fossil plants were obtained which Professor Cox has placed in the hands of Dr. Dawson for examination and report. Close to the anthracite are beds of lava and also quartz lodes, some of them rich in silver ores.

3. *Manual of Blowpipe Analysis, Qualitative and Quantitative, with a complete System of Determinative Mineralogy;* by H. B. CORNWALL. 308 pp. 8vo. New York, 1882. (D. Van Nostrand).—This volume includes the general range of topics ordinarily discussed under the head of Blowpipe Analysis. It is characterized by the excellent fullness and clearness with which the directions for manipulation and the statement of the various reactions are given, and will consequently be found easy of use by the beginner.

4. *A new family of Rugose Corals*, and description of the Genera Cyclophyllum, Aulophyllum and Clisiophyllum, by JAMES THOMSON, F.G.S. Proc. Phil. Soc. of Glasgow.—A valuable paper reviewing the history and characters of the genera mentioned, and instituting the family Diplocyathophyllidæ, based partly on the double cup, presented in a longitudinal section at the superior extremity of the corallum.

5. *Trees and Tree-culture.*—Two pamphlets before us are specially to be commended, viz:

The Culture and Management of our Native Forests for development as Timber or Ornamental Wood. By H. W. S. CLEVELAND. Published by the author, at Chicago (97 Washington st.). 16 pages, 8vo.—It is "an Essay, read by invitation to a committee of the Massachusetts Legislature, and to the National Forestry Congress at Cincinnati." Of this essay an "eminent botanist and tree-culturist in Illinois" writes: "I do not know when I have read anything on the subject so sensible, well put, and so clearly the outgrowth of practical observation and experience. It is refreshing to read anything which so readily commends itself to sound judgment and plain common sense." We think so too.

Notes on the Native Trees of the Lower Wabash and White River Valleys in Illinois and Indiana. By ROBERT RIDGWAY. —A pamphlet of 50 papes, extract from the Proceedings of the U. S. National Museum; very interesting statistics relative to trees of a district peculiarly rich and luxuriant in its native forest growth.

And now, at this moment, we receive the first number of

The American Journal of Forestry, edited by FRANKLIN B. HOUGH, Ph.D., Chief of the Forestry Division, U. S. Department of Agriculture (Cincinnati: Clark & Co. $3 per annum), commenced with much spirit by a gentleman who has devoted a great part of his life to this subject, and is the most prolific writer upon it. To this opening number he contributes an article on "The Forestry of the Future." Professor Spalding of Ann Arbor writes on "Forestry in Michigan." Dr. Wander on Larch-wood, and Mr. H. C. Putnam on "Forest Fires," which, we are glad to see, are preventable by proper regulations. A. G.

6. *Familien Podostemaceæ. Studier af* Dr. EUG. WARMING. VI Afhandling.—Warming has now brought out the second part of his studies of *Podostemaceæ*, the first part having been devoted mainly to our *Podostemon ceratophyllum.* The present part, just

issued, treats of the organs of vegetation of *Castelnavia princeps* from Brazil, and two species of *Dicræa* from Ceylon; also of the fructification of *Podostemon*, *Mniopsis*, *Dicræa* and *Castelnavia*, with 9 plates. The letter-press is in Swedish; but an abstract and the detailed explanation of the plates are added in French. Dr. Warming has removed to Stockholm, where he is now professor of botany in the High-school. A. G.

7. Professor G. L. GOODALE, of Harvard University, has returned from his year's absence in Europe, mainly devoted to a study of Botanical Laboratories and Gardens, and has resumed his work at Cambridge.

8. *Bulletin of the U. S. Geological and Geographical Survey of the Territories*, F. V. HAYDEN, Geologist-in-charge. Vol. vi, No. 3. 598 pp. 8vo. Washington, 1882.—This Bulletin, the last of the series,—a very valuable series to science—contains the following papers: Preliminary lists of the works and papers relating to the orders of Cete and Sirenia, by JOEL A. ALLEN, pp. 397–563; New Moths with partial catalogue of Noctuæ, by A. R. GROTE; New Moths, principally collected in Maine, with notes on noxious species and remarks on classification, by A. R. GROTE.

9. *On the Young Stages of Osseous Fishes*, by ALEXANDER AGASSIZ. Part iii, with 20 plates. July, 1882. From the Proceedings of the American Academy of Arts and Sciences, vol. xvii.

III. ASTRONOMY.

1. *A Method for Observing Artificial Transits;* by J. M. SCHAEBERLE. (Communicated by the author.)—As many astronomers who intend to observe the coming transit of Venus have neither the time nor means for making the necessary arrangements to practice on artificial transits, the simple method here proposed may be advantageously employed. Instead of observing an artificial sun and planet placed at a distance of several thousand feet from the observer, I would suggest that the real sun be observed, and the planet Venus to be represented by a circular disk, held, in the common focus of the objective and eye-piece, by means of a narrow metallic arm fastened to the eyepiece.

The relative motion of the sun and Venus can then be produced by so adjusting the rate of the driving clock that the angular motion of the telescope on the hour axis shall exceed the diurnal motion of the sun by seventeen seconds of time per hour. In this way, as the atmospheric disturbances of the sun's limb are real, a near approach to the phenomena observed during an actual transit will result. If a light shade-glass is employed, the opaque disk will be seen before it comes into apparent contact with the sun. The observer can, however, by an exercise of the will, confine his whole attention to the sun's limb.

By using a heavier shade-glass the disk will not be seen until it is projected against the image of the sun. The angular diameter of Venus at the time of transit being about 65″, the diameter of the opaque disk should be $65 \cdot l \sin 1'' = 0 \cdot 00031 \cdot l$, l being the focal length of the telescope used. The position angle of the point of contact can be changed at will by simply moving the telescope in declination.

Ann Arbor, Mich., Oct. 9, 1882.

2. *Annals of the Astronomical Observatory of Harvard College.* Vol. xiii, Part I. *Micrometric Measurements*, made with the Equatorial Telescope of fifteen inches aperture during the years 1866–1881, under the direction of JOSEPH WINLOCK and EDWARD C. PICKERING, successive Directors of the Observatory. 204 pp. 4to. Cambridge, 1882.—The micrometric measurements here published include all the miscellaneous micrometric work made in the Harvard Observatory during the years mentioned up to the beginning of 1882. They are but a small part of the work of the Observatory, and since 1879 this has been mainly photometric. The results are given under the heads: Double Stars; Nebulæ; Satellites of Saturn, Uranus and Neptune; Satellites of Mars, 1877 and 1879; Asteroids; Comets; Occultations. The observations on Double Stars were mostly made under the direction of Professor Winlock, but to these are added a few others made by Professors W. C. and G. P. Bond, published by the American Academy of Arts and Sciences and the Astronomische Nachrichten, and also of Mr. L. Waldo published in the latter journal. Along with the results of micrometric measurements of Nebulæ are also given the results of spectroscopic observations and descriptive notes. The dates of a few unreduced observations are also given.

3. *On the Photographic Spectrum of Comet (Wells) I*, 1882; by WILLIAM HUGGINS. (From the Proceedings of the Royal Society.)—On the evening of Wednesday, May 31, I obtained a photograph of the spectrum of this comet, with an exposure of one hour and a quarter. A spectrum of α Ursæ Majoris was taken through the other half of the slit, for comparison.

The photograph shows a strong continuous spectrum extending from about F to a little beyond H. In this continuous spectrum I am not able to distinguish the Fraunhofer lines. In this comet, therefore, at this time, the original light, giving a continuous spectrum, must have been much stronger relatively to the sunlight reflected than was the case in the comet of last year. It should be stated that the greater faintness of the present comet made it necessary to use a more open slit, which would cause the Fraunhofer lines to be less distinct; but the lines G, H and K are to be clearly seen in the star's spectrum taken under the same conditions.

Eye observations by several observers on the visible spectrum of the comet had already shown that this comet, for the first time since spectrum analysis was applied to the light of these bodies in 1864, gives a spectrum which differs essentially from the hydrocarbon type to which all the comets previously examined spectroscopically (about twenty) belong.

In the visible spectrum bright lines, presumably of the vapor of sodium, and some other bright lines and bright groups of lines, have been seen. The hydrocarbon bands in this part of the spectrum have been suspected to be present by some observers.

The photographic spectrum differs greatly from that of the comet of last year.* I am not able to see the cyanogen group in the ultra-violet beginning at wave-length 3883, nor are the other two groups between G and *h* and between *h* and H to be detected.

The continuous spectrum which extends from below F to a litte distance beyond H contains at least five brighter spaces, which are doubtless groups of bright lines, though it is not possible in the photograph to resolve them into lines. These places of greater brightness can be traced beyond the border of the continuous spectrum on the side which corresponds to the coma of the comet on the side next the sun. The light from this part of the comet gave a very much fainter continuous spectrum, for on the photographic plate it appears to be almost wholly resolved by the prism into these bright groups. One or two fainter groups are suspected to be present, but they are too indistinct to admit of measurement.

The five stronger bright groups are too faint at the commencement and ending of each group to permit of more than a measurement of the estimated brightest part of each bright space.

The positions of these brightest parts are:

λ 4769, λ 4634, λ 4507, λ 4412, λ 4253.

Professor A. Herschel and Dr. von Konkoly pointed out long ago that the spectra of periodic meteors belonging to different swarms of meteors differ from each other, and the meteorites which come down to us differ greatly in their chemical constitution. It is not surprising to find the matter of the nucleus of this comet to exhibit a chemical difference from that of other comets.

4. *Publications of the Washburn Observatory of the University of Wisconsin.* 8vo. Vol. i. Madison, 1882. Edward S. Holden, Director.—This volume contains the description of the Observatory buildings and instruments; a catalogne of 195 stars observed at Detroit by Mr. Schæberle, and reduced at the Washburn Observatory; a list of 27 new nebulæ; a list of 60 new double stars discovered by Mr. Holden; a list of 88 new double stars discovered by Mr. Burnham at the Observatory; measures by Mr. Burnham of 152 selected double stars; observations of 84 red stars and a list of 27 new red stars; observations of the great comet of 1881. The assumed position of the meridian circle of the Observatory is:

North latitude, 43° 4′ 36″·64. Longitude, 89° 24′ 28″·31.

5. *Washington Observations for* 1878. Appendix II.—The longitude of the meridian circle of the John C. Green School of Science, at Princeton, N. J., was determined by H. M. Paul of the U. S. N. Observatory, and Professor Young; the result being that it is 0^h 9^m 34^s·538 east of the central dome of the U. S. N. Observatory at Washington, D. C.

* Proc. Roy. Soc., vol. xxxiii, p. 1.

IV. Miscellaneous Scientific Intelligence.

1. *A new method of measuring Heights by means of the Barometer;* by G. K. Gilbert. (U. S. Geological Survey, J. W. Powell, Director. Extract from the Annual Report for 1880–81).—Mr. Gilbert has made a very important contribution to the subject of practical hypsometry, having developed a new method of measuring differences of altitude by the barometer, which though somewhat limited in its application, gives under favorable conditions results which are decidedly more accurate than those obtained by the methods now in use. The following notice will make clear the principles upon which the new method is based, while for the thorough discussion of the subject reference must be made to the original memoir which leaves little to be desired in this respect. Mr. Gilbert devotes the opening thirty pages of his memoir to a general discussion of the problem of determining differences of altitude by means of the barometer, describing the principal methods now employed, and the various disturbing conditions of temperature, humidity and so on, with the devices for the elimination of errors due to them. This discussion brings out very fully and clearly the unavoidable difficulties with which ordinary hypsometric methods are beset, and prepares the way for the presentation of the new method proposed.

This method is briefly, as follows. Two *base stations* are chosen, whose known difference in vertical height ("*vertical base line*," determined by the spirit-level) is as great, and whose horizontal distance is as small, as practicable; and at these, frequent observations of the barometer are made during the day. Also similar observations are taken at the third station whose altitude is to be determined. No observations to determine the temperature or humidity are required. The readings, corrected for index error and temperature of the mercury, are collected in groups of three, coincident for the two base stations and the new station. From these the approximate height (A') of the new station, and that of the base line (B') are calculated as usual, but without the ordinary corrections, that is, assuming that the air is dry and at a uniform temperature of 32° F. Then if the known true height of the base line is B, the true height (A) of the new station is given by

$$\frac{B'}{B}=\frac{A'}{A} \qquad (1)$$

For, the weight (W) of the air column between the two base stations, determined by the barometer, is equal to the product of the mean density (d) of the column, multiplied by the height (B) and by a constant factor (E)

$$W=d\,B\,E \qquad (2)$$

Also, as B' is the approximate height of the same column, on the assumption that its mean density (d') is that which would exist if the air were dry and at 32° F.

$$W = d'B'E \tag{3}$$

And from (2) and (3) $\frac{B'}{B} = \frac{d}{d'}$.

The ratio of the approximate height (B') to the true height (B) of the base line is therefore a measure of the temporary condition of the column of the base line with respect to density. Similarly the corresponding ratio of the approximate height (A') to the true height (A) of the new station measures the same condition as regards density, for the column between the new station and the lower base station, and hence follows equation (1).

In equation (1) it is assumed that the temporary condition of the two air columns named is identical, or in other words that the temporary accidents of temperature and moisture affect both columns alike. Practically the comparison of the computed and true heights of the base line gives a coefficient expressive of the temporary local variation of density, and this is applied in the simultaneous determination of the height of the other partially coincident air column.

Equation (1) above is readily transformed so as to be useful in practice. If L, U, N, represent the altitudes of the lower and upper base stations and the new station respectively (where it is assumed that $L < N < U$) and if l, u, n represent respectively the synchronous readings of the barometer at the corresponding stations, then the approximate heights of the base line, and of the new station above the lower base station respectively will be expressed, in accordance with the familiar logarithmic law, by

$$C\,(\log l - \log u) \text{ and } C\,(\log l - \log n)$$

where C is a constant. Substituting these values in equation (1) we obtain

$$a = B\frac{\log l - \log n}{\log l - \log u}.$$

This expression would give the required height, if the distribution of aqueous vapor were uniform and the air column were uniform in temperature. As this is not true, however, a thermic correction must be introduced allowing for the effect of temperature and aqueous vapor, and this is obtained as follows: The mean thermic density of the air column, between the new station and lower base station, is assumed to be equal to that of the stratum midway between the two, the altitude of which is $\frac{N+L}{2}$. Similarly the mean thermic density of the column between the two base stations is assumed equal to that of a stratum whose height is $\frac{U+L}{2}$. The vertical space between these two midway strata is

$$\frac{U+L}{2} - \frac{N+L}{2} = \frac{U-N}{2} = \frac{B-A}{2}.$$

The difference between the two mean densities will be found by multiplying the number of units in this vertical space by the thermic density for each unit of vertical space. The rate of thermic increase being assumed to be uniform from the ground upward, it may be supposed that at some height (call it $\frac{D}{2}$) its total amount becomes equal to the density at the ground, and becomes unity when expressed in terms of the initial density. The thermic increase of density for each unit of vertical space is then expressed by $1 \div \frac{D}{2}$ or $\frac{2}{D}$, and the expression for the difference between the mean thermic densities becomes

$$\frac{B-A}{2} \times \frac{2}{D} = \frac{B-A}{D}.$$

This denotes the fraction by which the thermic increase of density affects the relative densities of B and A; it also expresses the fraction by which the deduced altitude A is affected by the thermic variation of density. The correction is therefore

$$\frac{A\,(B-A)}{D}.$$

The original assumption of uniformity of temperature and humidity made the density too great, and consequently the height too small. Hence the full formula should read

$$A = B\frac{\log l - \log n}{\log l - \log u} + \frac{A(B-A)}{D}.$$

This formula may be readily modified to correspond to the case where the relative heights of the three stations ($L < N < U$) is not that assumed above.

The constant D in the above equation must be determined experimentally. As stated, $\frac{2}{D}$ is the increment of thermic density for an ascent of a unit of space, and $\frac{D}{2}$ is the vertical distance at which the total increment is unity. D is therefore to be expressed in the same linear units as A and B and is a function of the vertical distribution of heat and moisture in the atmosphere. It represents consequently a perpetually fluctuating quantity for which only the average value can be obtained. The author proposes to ascertain its value by applying the formula to the computation of altitudes already known, and then deducing the value of D which will give the best average result. This method was applied to the case of observations taken by the California Geological Survey at Sacramento, Colfax and Summit, extending over a series of nearly three years; also to observations given by Rühlmann for three stations on the Miesing taken during a week in August, 1857. It was found that a wide variation in the magnitude of the increment existed, both for different hours of the day and for different seasons of the year. The average value accepted is 490,000 feet (or 149,349 meters), so that the formula reads

$$A \text{ (in feet)} = B \frac{\log l - \log n}{\log l - \log u} + \frac{A(B-A)}{490,000}.$$

The variation in the force of gravity is neglected on the ground that its variation affects the air column to be measured and the standard column (base line) in nearly equal degrees, so that its influence is approximately eliminated.

Mr. Gilbert has made an extended series of comparative tests between the new method and those now in general use, for the discussion of which reference must be made to the original memoir. In general, they show that the new method gives results of decidedly more accuracy than the others, sufficient to justify its substitution for them in cases where the conditions required (of two base stations properly situated) can be realized, and where the extra expense of a second station is not too serious an element.

The author, having established the value of the method proposed, goes on to consider possible improvements in the formula, involving a more accurate determination of the constant D, a provision for diurnal and annual periodicity and various other related points. He also discusses the limitations to the application of the new method; these are obviously considerable, but it is believed that it will probably prove applicable to the greater part of the work done in the country during the years immediately to come, in cases where the more accurate method by the use of the theodolite and allied instruments is out of the question. For the practical application of the formula a table is given, from which the value of the thermic term $\frac{A(B-A)}{490,000}$, can be immediately obtained. An ingenious graphic table is also added to take the place of the other, which allows the determination of the same value without the labor of a double interpolation, otherwise often necessary.

2. *Professional Papers of the Signal Service.* No. 4. Report of the Tornadoes of May 29 and 30, 1879, in Kansas, Nebraska, Missouri and Iowa; by J. P. FINLAY. No. 7. On the Character of Six Hundred Tornadoes; by J. P. FINLAY.

The first of these papers is a monograph of 116 pages, and contains 29 maps and numerous other illustrations of thirteen tornadoes that occurred on the days and in the States named. The second is a catalogue of six hundred tornadoes that have occurred in the United States since 1794. By far the larger portion are, however, comprised in the last decade. Classified by months, these tornadoes occurred as follows:

January,	7.	April,	97.	July,	90.	October,	15.
February,	21.	May,	81.	August,	47.	November,	22.
March,	37.	June,	112.	September,	50.	December,	9.

The paper is accompanied by suggestions of methods of investigation and a statement of peculiarities of tornado clouds and suggestions for avoiding their violence. The numbers occurring in different States are tabulated, and a chart illustrating the frequency of tornadoes is constructed therefrom.

These papers will probably be more useful for the collections of facts contained in them than for the conclusions which the collector has himself deduced. Thus, in constructing the chart of frequency in different localities, the numbers for different States and Territories seem to be used without any correction for the size of the States, the period during which the observations can be presumed to have been made, or the facilities for securing reports of tornadoes that have occurred. The map is specially shaded to represent the two tornadoes of Vermont and the one of Rhode Island against the thirty-five of New York State, and the one tornado of the Indian Territory and one of Arizona against the sixty-two of Kansas.

3. *The Elements of Forestry*, designed to afford information concerning the planting and care of Forest Trees for ornament or profit, and giving suggestions upon the creation and care of woodlands, with the view of securing the greatest benefit for the longest time, particularly adapted to the wants and conditions of the United States, by Franklin B. Hough, Ph.D., Chief of Forestry Division, U. S. Dept. of Agriculture, Member of the American Philosophical Society, etc. 382 pp. 8vo. Cincinnati, 1882. (Robert Clarke & Co.)

The Geological Record for 1878, edited by Wm. Whitaker and W. H. Dalton. 496 pp. 8vo. London. 1882. (Taylor & Francis.)

The Scientific evidences of Organic Evolution, by G. J. Romanes, F.R.S. Nature Series. 88 pp. 12mo. London. 1882. (Macmillan & Co.)

Synopsis of the Classification of the Animal Kingdom, by H. Alleyne Nicholson, Prof. Nat. Hist. Aberdeen. 130 pp. 8vo, with many illustrations. Edinburgh and London. 1882. (Wm. Blackwood & Sons.) A very convenient synopsis for the student, well illustrated.

Report of an examination of the Upper Columbia River and the Territory in its vicinity in September and October, 1881, to determine its navigability and adaptability to steamboat transportation. Made by direction of the Commanding General of the Dept. of the Columbia, by Lieut. T. W. Symons, Corps of Engineers U. S. A., Chief Engineer of the Dept. of the Columbia. 134 pp. large 8vo, with 26 maps. Washington. 1882. Senate document No. 186.

Annual Report upon the Surveys of the Northern and Northwestern Lakes, in charge of C. B. Comstock, Major of Engineers, Brevet Brigadier-General U. S. A. Appendix TT of the Annual Report of the Chief of Engineers for 1881. Washington.

Practical Microscopy, by George E. Davis. 335 pp. 8vo, with a colored plate. London, 1882 (David Bogue).

Lehrbuch der Vergleichenden Anatomie der Wirbelthiere auf Grundlage der Entwicklungsgeschichte bearbeitet von Dr. Robert Wiedersheim, Professor in Friburg, I. B. Erster Theil. 476 pp. 8vo. Jena. 1882. (Gustav Fischer.)

Acephalés: Etudes locales et comparatives. Extrait du Système Silurien du Centre de la Bohême. vol. vi. By Joachim Barrande. 536 pp. 8vo. with 10 plates. 1881. Paris, Rue de l'Odéon. No. 22.

Mémoires sur les Terrains Crétacé et Tertiaires, préparés par feu André Dumont, pour servir à la description de la Carte Géologique de la Belgique, édités par M. Mourlon. Tome iv. Terrains Tertiaires, 3me. Partie. Bruxelles. 1882.

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[THIRD SERIES.]

ART. XLIV.—*Terraces and Beaches about Lake Ontario;* by J. W. SPENCER, B.A.Sc., Ph.D., F.G.S., State University of Missouri, Columbia, Mo. (Late Vice-President of King's College, Windsor, Nova Scotia). With Plates VI and VII.

[Read before the Montreal Meeting of the American Association for the Advancement of Science.]

THE extreme western end of Lake Ontario is separated by Burlington Beach from the open waters of the lake, and forms Burlington Bay, having a length of about five miles, and a width of four miles at the eastern end, from which place it gradually narrows to less than half a mile, at the western end. This triangular bay is bounded on two sides by the Niagara escarpment rising from four to five hundred feet above the lake. At a short distance westward of the bay, the two faces of the escarpment suddenly approach to within about two miles of each other, and thence extend parallel to each other for several miles, having formed the boundaries of a grand ancient river valley, through which the waters of the Lake Erie basin flowed,—receiving, as a tributary, the Grand River, which drained the principal portion of the high lands of the peninsula of western Ontario,—in Pre-glacial times. This ancient valley is deeply filled with drift deposits, as described in a former paper read before the Association. Interglacial and modern streams have excavated deep valleys in the soft drift deposits producing a very broken country throughout the whole Dundas valley, as represented on Plate VI. Along the sides of the escarpments, and in some of the hillocks, fragments of ancient beaches and terraces remain.

The eastern portion of the Dundas valley is occupied by a marsh, which is separated from Burlington Bay by "Burlington Heights"—a ridge which rises abruptly from the waters (of the same level) on both sides, to a height of from 108 to 116 feet, with the breadth on the summit of only a few hundred feet. Burlington Beach, which separates the bay from the lake is the counterpart of the "Heights" and rises eight feet above the water. It is not usually more than a quarter of a mile wide. Burlington Bay is excavated out of Erie clay and is 78 feet at its greatest depth.

After this topographical description, let us now consider the elevation of the beaches and terraces, and their composition. (See Plates VI and VII.)

1. The lowest beach is that forming the present lake margin and rising to a height of eight or ten feet above its surface, of which Burlington Beach is a portion. It is composed wholly of sand and pebbles (mostly flattened) derived from the ruins of various rocks of the Hudson River formation, with a few small crystalline pebbles. The pebbles are often full of characteristic Hudson River fossils. Sometimes the rounded slabs measure more than a foot in length, though usually much less. At the western end of the lake the present beach does not contain any pebbles of the Niagara formation. The nearest exposures of the component rocks are more than twenty miles away to the northward.

2. The next terrace is 70 (to 80) feet above the lake, and consists of sand,—or, in the Dundas valley, where it forms a conspicuous flat terrace, it is composed of thin-bedded loose arenaceous clay, with some fine gravel along the margin. This terrace in the Dundas valley is the remnant of the deposits of Saugeen clay.

3. The most conspicuous of all the terraces is that at 116 feet above the lake, of which "Burlington Heights" is a portion. Its composition is precisely of the nature of Burlington Beach, and on a succeeding page, the structure will be more fully noticed in studying its origin, along with that of Burlington Beach.

4. The upper portion of an isolated conical hill, rising to 180 feet on the southern side of Dundas, is composed of stratified fine gravel, probably of the Hudson River formation, but with large stones and semi-angular slabs (sometimes a foot and a half long) composed of Niagara dolomites and other rocks of that formation.

5. On the northern side of the town of Dundas there is an old beach with the sand and fine gravel exposed from 224 to 261 feet above the lake.

6. Higher up, on the side of the escarpment north of the town (at the mouth of Glen Spencer), and not distant from the last beach, there are still the fragmentary remains of stratified gravel and sand rising to 335 feet above the lake. This deposit probably reached higher at a former time, but has been removed from the steep side of the so-called "mountain." It is composed of a mixture of Niagara and Hudson River pebbles and sand, with a few crystalline pebbles. Farther up the Dundas valley and near Ancaster, this same beach is represented in fragments on some of the hills. But there they are composed more largely of fine materials of Hudson River age, with only slabs of Niagara rocks (being farther removed from the escarpment).

7. Westward of Ancaster village, and near the watershed between the present Dundas valley (at an estimated height of 440 feet above the lake), there is another beach composed largely of Hudson River pebbles, and showing much oblique bedding, dipping at 23 degrees to the southeastward. Farther southeastward we again find an old beach at the same elevation adjacent to the Grand River.

8. On top of the Niagara escarpment, just north of the village of Waterdown, there is a beach of very fine gravel at a height of about 500 feet above Lake Ontario.

From the study of the beaches in the Dundas valley there appears to have been simply a gradual recession of the water with comparatively few sudden changes of level—the most sudden being between the deposit of the terrace at 116 feet above, and that at the present lake level.

Between Toronto and Lake Simcoe, Mr. Thomas Roy, in 1837, measured beaches at 110, 210, 282, 310, 346, 402, 422, 502, 558, 626, 682, 734, 764 feet respectively above Lake Ontario. In addition to these gravel beaches, others at 600 feet, and, on descending toward Georgian Bay (along the Northern Railway) at 520, 388 and 354 feet, have been measured. Along the Toronto, Grey and Bruce Railway, which extends in a direction north of west from Toronto to the highest portions of the peninsula of Ontario, and crossing the "Artemesia Gravel" ridges, there are a number of conspicuous beds of sand and gravel, which follow contour lines more or less closely. The elevations of some of the most conspicuous of these deposits were furnished by the kindness of Edmund Wragge, Esq., Chief Engineer of the Railway. They are at 160, 280, 370, 710, 990, 1120, 1340 feet respectively above Lake Ontario. After passing the summit of the road, at 1462 feet above the lake, there are extensive gravel beds at 1310 feet, and from 1000 to 697 feet above the same datum, along the main line, and along the western branch at 1299, 1130, 1050, 870, 850 and 830 feet above Lake Ontario. Near Owen Sound there are others at 546, 496 and 466 feet above Lake Ontario.

Along the Great Western Railway, adjacent to the valley of St. David's (near the Niagara River), there are stratified sands and gravels (of Hudson River epoch) from 383 to 250 feet above the lake.

In New York State, eastward of Lockport, the lake ridges rise from 158 to 190 feet above the lake (Hall). On the south-eastern margin of the lake basin there are old beaches at 400 feet, and at the north end of Skaneateles Lake, at about 625 feet above Lake Ontario, there are still others. But the collected records of the New York terraces are too fragmentary for general comparison.

In the appended table the reader will be immediately impressed with the relationship existing between the beaches at the various elevations which surround the lake, and the continuity of the slow recession of the waters. The higher beaches, of course, refer to the time when the waters of all the Great Lakes were united in one body. In Michigan there are beaches at 1350 feet above Lake Ontario. Near Petits Écrits, Lake Superior, beaches at 398, 408, 458, 592, 627, 635 and 699 feet above Lake Ontario were measured by the Geological Survey of Canada.

Again to the southwestward of Lake Erie, Messrs. Gilbert and Winchell measured beaches or ridges at 65–90, 165, 195, 220, 350–408, 386–490 feet above Lake Erie.

The belt of the Artemesia gravel may approximately be represented by the contour line of 1250 feet above the sea, but extending southward of this line to somewhat beyond the contour of 950 feet. It is thus described by Dr. Bell: "This great belt of gravel has a general parallelism with the Niagara escarpment and follows the highest ground of the peninsula. The materials composing it consist principally of the ruins of the Guelph formation, on which the greater part lies, except toward the southern extremity, where the Niagara formation is largely represented. Pebbles of Laurentian and Huronian rocks are everywhere mixed with the others, and sometimes form a considerable proportion, while rounded fragments from the harder beds of the Hudson River formation occur locally in some abundance." (These last rocks are derived from lower levels.) "The gravel is all well rounded and generally coarse. It often constitutes what might properly be called 'cobble stones,' being loose and free from any admixture of clay; and it is distinctly stratified. Well worn boulders of Guelph, Laurentian and Huronian rocks are disseminated through the whole mass." In a few places this gravel overlies blue Erie clay. From the eastern side of the Artemesia gravel ridges, there extends a long comparatively narrow ridge for about 100 miles to near the Trent River, known as "Oak Ridge." Its most conspicuous portion may be represented by the contour line of 650 feet above Lake Ontario, although the highest portion rises to 893 feet. Its height is from 200 to 300 feet above the broad

TABLE OF ELEVATIONS OF TERRACES, BEACHES AND RIDGES.

Elevations in feet above Mean Tide.

At Western end of Lake Ontario (Spencer).	Between Toronto and Lake Simcoe (Roy).	Along Northern Railway.	Along Toronto, Grey & Bruce Railway (Wragge).	Near Owen Sound (Bell).	Petits Écrits, Lake Superior (Geology of Canada.)	In New York State.	At Western end of Lake Erie (Geology of Ohio).	Along the St. Lawrence (Dawson).
			1709*	----	1700†			
			1587					
			1557					
			1546					
			1377					
			1367					
			1297					
			1247					
1140‡	----	----	1117					
			1077	----	----	----	{ 1063 to	
	1011	----	----	----	----	----	} 959	
	981	----	957	----	----	----	{ 981 to	
	929	----	944	----	946	----	} 923	
					882	----	----	900
	873	----	----	----	874	872	----	
		847	848§	----	839‖			
	805	----	----	793	----	----	793	
		767	----	----	----	----	768	
747	749	737	----	745	----	----	738	748
687 (?)	----	----	----	713	705			
	669							
	649	----	----	----	655	----	{ 663 to	660
633¶	----	635	----	----	645	647	} 638	
		601	617	----	----	583(?)		
582	593							
	557							
	529	----	527					
508 to }	----	----	----	----	----	----	----	505
471 }	----	498**	----	----	----	----	----	479
	457	----	----	----	----	----	----	448
427	----	----	----	----	----	{ 437 to		
	407	----	401	----	----	} 432		
363	----	----	----	----	----	405	----	378
		342††						
327	----	----	----	----	----	----	----	325
255 to }								
247 }								

* Summit of land.

† On Highlands of Michigan.

‡ Along Toronto, Grey & Bruce Railway.

§ Along W., G. & B. Railway.

‖ Beach, also of the elevation on Mackinac Island.

¶ Adjacent to St. David's Valley.

** Along Whitby Br. of Midland Railway.

†† Along Midland Railway.

rock-bottomed trough which extends from the Georgian Bay to the eastern portion of Lake Ontario. The descending portion of this ridge may be represented by a contour of 250 feet above Lake Ontario, to which it approaches at Scarboro Heights. The composition of the whole thickness to lake level (more than 300 feet) is here shown and consists mostly of stratified sand and clay, with two intercalated beds of boulder-bearing clay.

There is a resemblance between the Artemesia ridges and the so-called Kettle Moraines of Wisconsin, Coteau des Prairies and Coteau de Missouri. There is a general parallelism between these ridges. The Artemesia gravel reaches 1700 feet above the sea—a height as great as portions of Coteau des Prairies.

From the structure of both the "Artemesia Gravel" and "Oak Ridge," there is no evidence of their being of morainic character. The deposits of the Artemesia gravel are simply around the high rocky floor of this portion of the country, and mark the recession of the waters in more or less perfect contour lines, with most of the material of local origin.

Whatever barriers may have separated the lake region from the sea, there seems no doubt that the whole area was submerged beneath the sea level to at least 1700 feet, for no glacial lake could account for the high level beaches. From the character of the deposits there appears to have been but little floating ice—perhaps not much more than the ice-fringes of the present day. The highlands south of the lakes do not rise to any such height as to permit a small amount of floating ice to barricade them to the height of several hundred feet.

As the continent was rising, the waters of this inland lake had many channels communicating with the exterior sea, across Ohio and New York, besides that by way of the St. Lawrence. However, local oscillations probably played an important part, but to what extent cannot yet be well determined.

Below 1200 feet above sea level of to-day, the principal old outlets are by the valley of Cayuga Lake, at 1015 feet; by Seneca Lake valley, at 865 feet; by the Mohawk River, at 434 feet, and by the present St. Lawrence River, at 247 feet above mean tide. In Ohio, Dr. Newberry enumerates various other outlets at 936, 968, 909, 910 and 940 feet above present ocean level.

There is a remarkable connection between these old outlets and the beaches which rise a few feet above them, in that they are conspicuous and are most widespread.

Many of the transported bowlders of crystalline rocks may have been carried by the floating ice of the great lake of the time; but the explanation of the Hudson River pebbles and slabs, which are observed in the old beaches, higher than these original sources, can be best accounted for by the theory that they were carried upward by the coast-ice during the time when the continent was undergoing subsidence, and were rearranged by the waves and shore ice of a later period.

Let us now return to the lower water margins of Lake Ontario, represented by "Burlington Heights" and "Burlington Beach," which are almost wholly composed of Hudson River pebbles. The former of these ridges is 116 feet and the latter eight feet above the lake. Both of these beaches, of the same materials, skirt much of the western shores of Lake Ontario.

Their component pebbles and sand appear to have been entirely transported by the action of shore-ice and waves. At the commencement of the deposit of the beach at 116 feet above the present water, the Dundas valley formed one continuous basin with the lake bed. But at that time, as now, only the extensions of Lake Ontario forming bays were frozen over in winter. The Dundas valley, being a confined arm, was frozen over, and the pebble-laden ice, from the more exposed coast, was drifted by the winds and currents, and packed across the front of the ice-sheet, covering the waters in this arm of the lake, at 116 feet above their present level; and with annual dissolution of the ice, the small amounts of material transported during the winters began to deposit the barrier, which was in course of time destined to produce "Burlington Heights"—the beach of that day. The location of the "Heights" was in no way produced by the unimportant streams flowing down the Dundas valley, as is apparent, for the Pre-glacial and Inter-glacial drainage of the western peninsula of Ontario was turned into Lake Erie before the Terrace Epoch. The false and inclined bedding of the "Heights" is always toward the lake (the material sometimes consisting of fine beds of sand, and sometimes of clean large gravel) showing that the stratifying forces proceeded from the side of the lake. In addition to the transportation of the material by ice, the action of the waves in no small degree assisted in the production of this old beach.

The present "Burlington Beach" is simply a reproduction of the "Heights" since the time when the lake receded to its present level. Burlington Bay is frozen over every winter, but the lake is seldom frozen to a greater extent than enough to produce fringes. Yearly much ice shod with pebbles is drifted against the western shores of the lake by the action of storms and waves. In this way much of the western end of the lake, although almost against the foot of the Niagara escarpment, has had its shores made up of pebbles and sands of Hudson River formation. A small portion of the shore material may have been derived from the ruin of former beaches at higher levels.

In conclusion, it may be said that the country covered with "Artemesia Gravel" gives no evidence of any morainic origin of the deposits, but rising from the great subsidence of the Terrace Epoch, it was first an exposed island, and afterward it formed a more extended margin, as the waters were contracting to within their present basins.

When the ancient beaches and terraces in the whole region of the Great Lakes shall have been carefully measured and studied with reference to their original extension, then there may be some accurate data for the determination of the relative amounts of local and general oscillations of the continent, for we see that the above fragmentary lists of elevations show a close relation between the different beaches, which would doubtless be further borne out, were the measurements more complete, and made with a view of arriving at true scientific results.

ART. XLV.—*Apparent Attractions and Repulsions of Small Floating Bodies*; by JOHN LECONTE.

ALTHOUGH the apparent attractions and repulsions of small floating bodies is one of the most familiar phenomena, and one of the earliest to which the physical theory of capillarity was applied, yet it remains a perplexing puzzle to a large number of intelligent students. This arises from the fact that the popular explanations given in many standard works on elementary physics do not bear a critical examination and are, consequently, anything but satisfactory to the student who endeavors to secure a clear physical conception of the cause of these motions.

This class of phenomena seems to have been first explained by the celebrated Mariotte about 1655; but more particularly by the great geometer Monge,* who distinctly and correctly referred them to the action of the surface film of the liquid, as modified by the presence of the partially immersed solid bodies. In more modern times, the improved theory of capillary action of Young† and Laplace,‡ as modified by the refined physico-mathematical investigations of Gauss,§ and of Poisson,‖ refers all capillary phenomena not only to the reciprocal attractions between the liquid and the solid, but also to the existence of a tense superficial film at the free surface of every

* "Mémoires de l'Acad. de Sciences" for 1787, p. 506 et seq.

† "Phil. Trans." for 1805, p. 65 et seq. On the "Cohesion of Liquids."

‡ "Mécanique Céleste," tome iv. "Supplément au Livre x," "Sur L'Action Capillaire." (1806.)—Also, "Supplément à la Théorie de L'Action Capillaire." (1807.)

§ "Principia Generalia Theoriæ Figuræ Fluidorum in Statu Æquilibrii." Göttingen, 1830.

‖ "Nouvelle Théorie de L'Action Capillaire." Paris, 1831.

liquid, which gives origin to a tensile elastic reaction resulting in the development of a force tending to elevate or depress the liquid according as its terminal surface adjacent to the solid is concave or convex. The actual existence of such an elastic contractile film at the bounding surfaces of liquids is abundantly verified by numerous conclusive experiments with films of soapy water, as well as by the whole class of striking phenomena rendered prominent by the admirable researches of Plateau,* and the equally satisfactory investigations of Dupré† and of Quincke.‡

Even according to the more exact mathematical theories of capillarity of Laplace and of Poisson, the explanation of this class of phenomena is not altogether free from ambiguity. Thus, in Laplace's investigation, as the pressure of the atmosphere appears as a prominent element in producing the motions of such floating bodies, the student is naturally perplexed when he is confronted by the somewhat awkward fact, that capillary phenomena are entirely independent of the pressure to which the apparatus is exposed; as was long ago proved by the experiments in vacuo executed by the members of the "Academia del Cimento" of Florence. It is proper to add, however, that a critical examination of the explanation given by Laplace as well as by Poisson,§ very clearly indicates, that, when the effective forces are considered, the pressure of the atmosphere is practically eliminated from their equations;—so that finally the forces actually in operation, which produce the tendency of such bodies to approach or to recede from one another, are due exclusively to molecular actions.

Nevertheless inasmuch as Laplace's explanation contains the pressure of the atmosphere as a term, while at the same time it makes the effective force equivalent to a modification of hydrostatic pressure, which is negative or positive according as the surface of the liquid adjacent to the solid bodies is concave or convex; it is by no means surprising that the idea of atmospheric pressure should have been associated with these phenomena. Hence, we find that many first-class physicists, such as Lamé, Desains, Jamin, Everett,‖ and others, introduce the

* "Statique Experimentale et Théorique des Liquides."

† "Théorie Mécanique de la Chaleur," chapitre ix. "Capillarité," p. 206, et seq. Paris, 1869.

‡ "Phil. Mag.," IV, vol. xxxviii, p. 81, and vol. xli, pp. 245, 370, 454; V, vol. v, pp. 321, 415, and vol. vii, p. 301.

§ Laplace "Mécanique Céleste," tome iv. "Supplément au livre x."—Article 11, p. 41 et seq.—Poisson, op. cit. supra, articles 81–85, pp. 162–173.

‖ Lamé, "Cours de Physique," 2d Ed., Paris, 1840, tome i, p. 188 et seq. Article 143.—Desains, "Traité De Physique." Paris, 1857, tome i, pp. 603–606.—Jamin. "Cours De Physique," 3d Ed., Paris, 1871, tome i, pp. 229–230.—Everett. Translation of Deschanel's "Traité Élémentaire de Physique." N. Y., 1880. Part I, p. 136. Article 97, D.—Péclet in his "Traité De Physique," (4th Ed., Paris, 1847, tome i, p. 158, Article 224), leaves out the pressure of the atmosphere, and ascribes the motions exclusively to negative and positive hydrostatic pressures.

pressure of the atmosphere as a fundamental element into their explanations of these motions. Indeed, Laplace himself seems to have been impressed with the apparent conflict between theory and experiment: for, after giving the result in relation to the case of two solids moistened by the liquid (in which the hydrostatic pressure between them has a negative value), he significantly adds: "Dans le vide, les deux plans tendraient encore à se rapprocher; l'adhérence du plan au fluide, produisant alors le même effect que la pressure de l'atmosphere."*

Doubtless, the view, which ascribes these apparent attractions and repulsions to the modifications of hydrostatic pressure due to the action of capillary forces, is a philosophical one and capable of being put into a mathematical form; yet, when the physical cause of the disturbance of hydrostatic equilibrium is kept in the back ground, the student is greatly embarrassed and perplexed in obtaining clear conceptions of negative and positive pressures, complicated as they are with considerations relating to the pressure of the atmosphere; especially when he is assured, that the last-indicated pressure must be inoperative, from the experimental fact, that the phenomena take place in vacuo. Moreover, from this point of view, he is liable to lose sight of the real physical cause of all capillary phenomena, viz:—the reaction of the tense superficial film of the liquid,—the true and efficient cause of the disturbance of hydrostatic pressure. It seems to me, that by referring the motions of such bodies directly to the action of this tensile superficial film, a fundamental principle in the physical theory of capillarity is secured in the mind of the student; while the resulting disturbances of hydrostatic equilibrium are not primary facts, but secondary consequences of the more fundamental cause.

The general explanation, which I am about to offer of the "Apparent Attractions and Repulsions of small Floating Bodies," is so simple and obvious a deduction from the fundamental Laws of Capillary Action, as expounded by Laplace and Poisson, that it is difficult to bring myself to believe, that it has hitherto escaped the attention of physicists. Nevertheless, I have not, thus far, been able to find it in any of the treatises on physics.

In order to render my explanation more clear, it will be necessary to present the commonly-received popular explanations of these phenomena, and to indicate their defects.

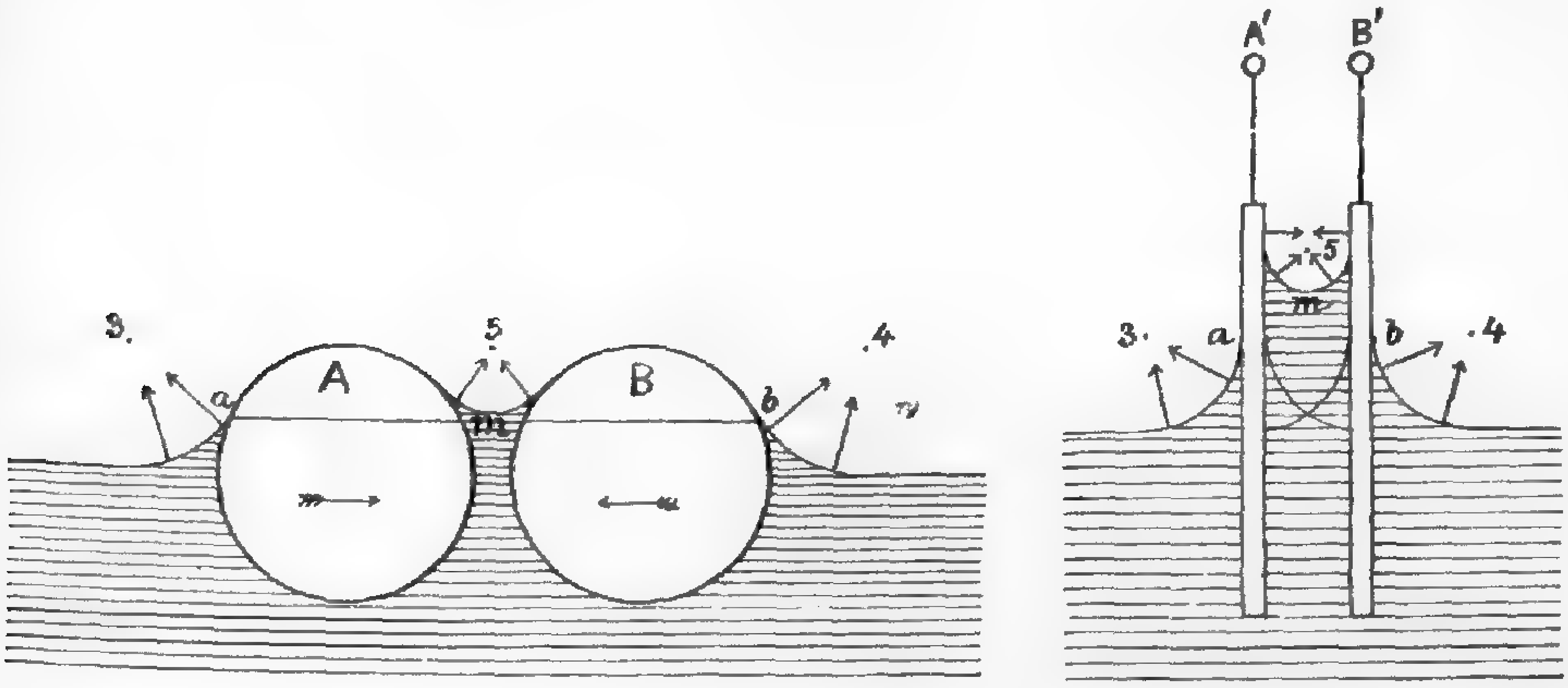
Two methods of experimental illustration may be adopted, viz: 1st. By floating in water two small bodies whose surfaces have been so prepared as to be moistened or non-moistened by liquid; and 2d. By plunging vertically into water or into mercury, two parallel plates of clean glass suspended by threads.

* "Mécanique Céleste," "Supplément au Livre X," article 11, p. 44.

ORDINARY POPULAR EXPLANATIONS.

CASE 1. *When both bodies are moistened.* In this case (fig. 1, A, B, and A′ B′), when the two bodies are brought so near that their intervening concave meniscuses join each other, the bodies are drawn together by the weight of the column of the

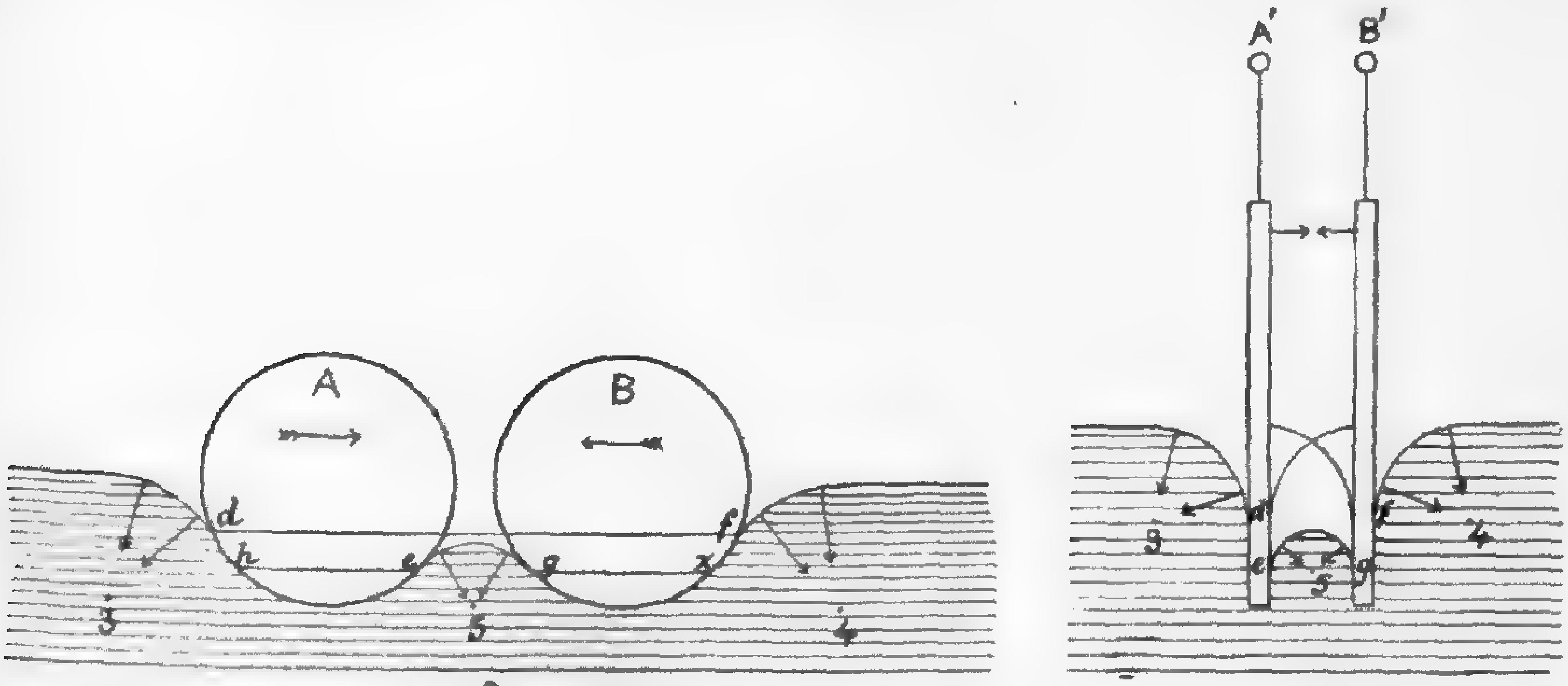
1.



liquid *m*, elevated above the level *a b*, acting like a loaded cord secured to each of the bodies.

CASE 2. *When both bodies are not moistened.* In this case (fig. 2, A, B, and A′ B′), when the two bodies are brought so near that the intervening convex meniscuses unite, *e* and *g* are more depressed than *d* and *f*; consequently the two bodies are pushed toward each other, by the greater exterior hydrostatic pressure exercised by the portions *dh* and *fx*.

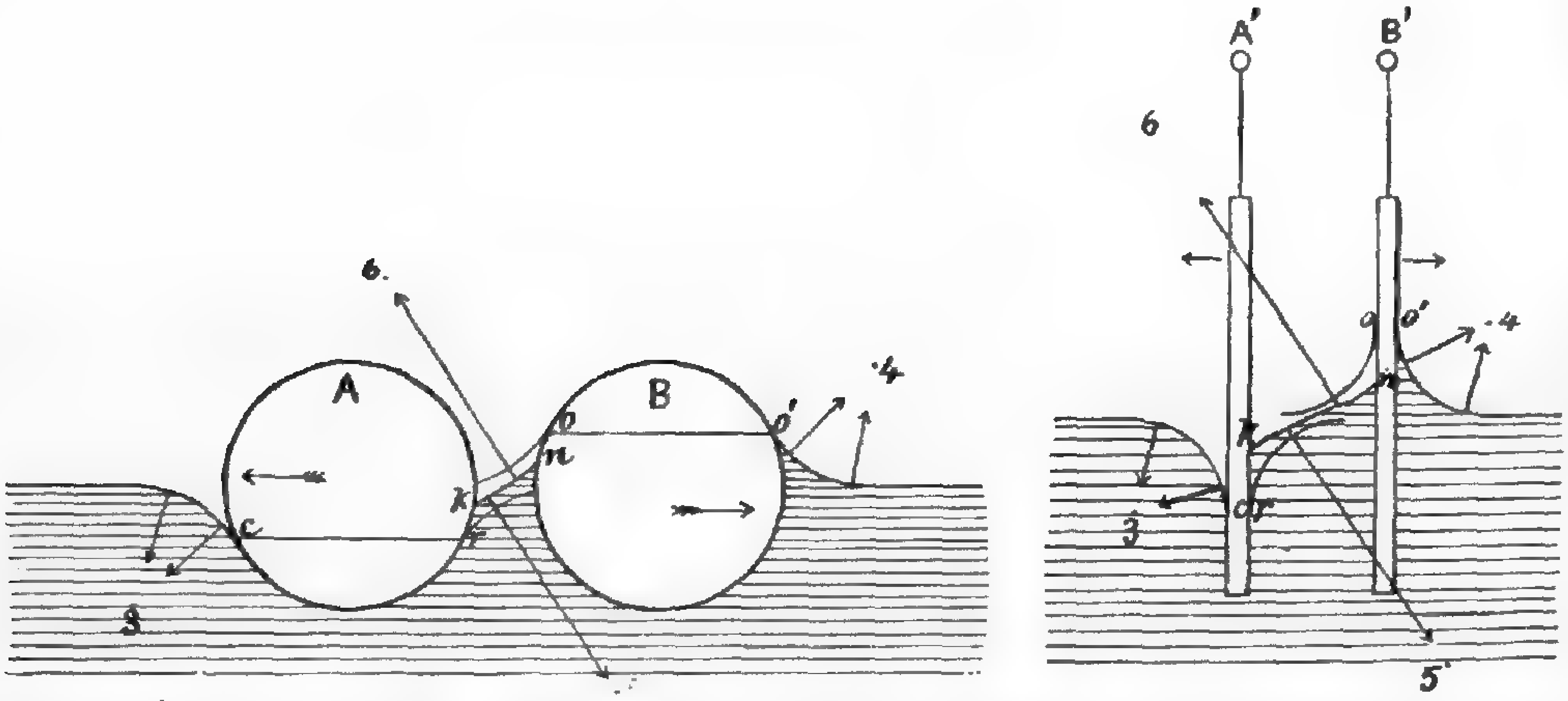
2.



CASE 3. *When one body is moistened and the other is not moistened.* In this case (fig. 3, A, B, and A′ B′), if the moistened body B or B′, were alone, the concave meniscus would be elevated to *o*; in like manner, if the non-moistened body A or A,′ were alone, the convex meniscus would be depressed to *r*. Now, if the two bodies are brought so near that their meniscuses join each other, the intervening liquid surface will take

an intermediate position *nk*. Hence, the point *n* will be below the point *o*; and the point *k* will be above the point *r*. It is therefore assumed, that the moistened body B or B′, will be drawn away from A or A′, by the excess of the weight of the

3.



exterior above the interior meniscus, due to the difference of height *o n* or *o′ n′*: In like manner, the non-moistened body A or A′, will be pushed away from B or B′, by the excess of interior hydrostatic pressure due to the difference of level *kr*. Hence, there is apparent mutual repulsion.

Defects of the foregoing explanations.—Leaving out of consideration those physicists who have adopted, more or less completely, the mathematical methods of Laplace and of Poisson, the foregoing seem to be the generally-received popular explanations of this class of capillary phenomena. They are those given by Brewster, Daguin, Silliman, Snell, and other writers on elementary physics; and are essentially identical with the explanations originally proposed by Monge.* The most cursory examination will serve to show their unsatisfactoriness.

In the first place, each case requires a special explanation: there is no common physical principle coördinating the three cases under consideration. Thus, in case 1, the weight of the intervening elevated column of liquid draws the bodies together, without reference to the modification of hydrostatic pressure due to the elevation. On the other hand, in case 2, the bodies are pushed together by the excess of the exterior hydrostatic pressures. Finally, in case 3, it will be noticed,

* Brewster, "Encyc. Britannica," 8th ed., article "Hydrodynamics," chap. III, "On Capillary Attraction and the Cohesion of Liquids."—Daguin. "Traité Elémentaire de Pysique," 3d Ed., Paris, 1867, tome i, article 226, pp. 209–210.—Silliman. "Principles of Physics," 2d Ed., revised and re-written, Philad., 1861, article 242, pp. 195–196.—Snell's Olmsted's "Nat. Phil.," 2d Revised Ed.. N. Y., 1870. article 229, pp. 150–151. Also, Kimball's 3d Revised Ed., N. Y., 1882, article 202, p. 135.—Monge, "Mém. de l'Acad.," cit. ante. Of the above, Daguin gives the most explicit and clear statement of these explanations.

that the excess of hydrostatic pressure due to the difference of height equivalent to *o n* or *o′ n′*, is made a pulling force, urging B or B′ to the right; while the excess of hydrostatic pressure due to the difference height equivalent to *kr*, is made a pushing force urging A or A′ to the left. Now, why this difference in the direction of action of the excess of hydrostatic pressures? Why not regard the excess of pressure on the right of B or B′, (equivalent *o n* or *o′ n′*), as a pushing force urging B or B′ towards A or A′?—a result which is evidently at variance with experiments.

In the second place, it is very clear, that the laws of hydrostatics are so seriously modified by the action of capillary forces (the disturbances of level being in fact due to them), that it is very questionable whether hydrostatic pressure can be properly or safely invoked to explain these phenomena without the restrictions imposed by the introduction of the negative and positive molecular pressures, which constitute such important factors in the physico-mathematical analyses of these questions.

PROPOSED GENERAL EXPLANATION.

In the following explanation of the "Apparent Attractions and Repulsions of Small Floating Bodies," I have referred this class of the phenomena to two fundamental principles of capillarity which are abundantly verified by observation and experiment, viz: 1st. That in every case, whether of moistened or non-moistened bodies, there exists an adhesion between the solid and the liquid; and 2d. That the capillary forces are, in any given case, inversely proportional to the radii of curvature of the meniscuses, and their resultants are directed toward the centers of concavity. It seems to me that these two fundamental and well-established principles of capillary action, will explain the whole class of phenomena, in a much more consistent and satisfactory manner.

Case 1. Fig. 1. Before the two bodies are brought near each other, the concave meniscus around each of them having the same radius of curvature on all sides, each of the floating bodies is in equilibrium under its action. But when brought so near that their meniscuses join each other, the radius of curvature of the united intervening concave meniscus at *m*, (fig. 1), is less than that of the exterior concave meniscuses at *a* and *b*, and its superior tension acts upon both bodies toward a common center of concavity at 5. Hence, by virtue of the smaller radius of curvature of the intervening tense film, the interior forces prevail, and the two bodies are drawn together.

Case 2. Fig. 2. The same explanation applies to this case. The common or united intervening convex meniscus being attached to the bodies at *e* and *g* (fig. 2), has a smaller radius of curvature than the exterior convex meniscuses at *d* and *f*. Hence, in this case, likewise, by virtue of the smaller radius of curvature of the intervening contractile elastic film, the interior forces necessarily prevail, and the two bodies are drawn together.

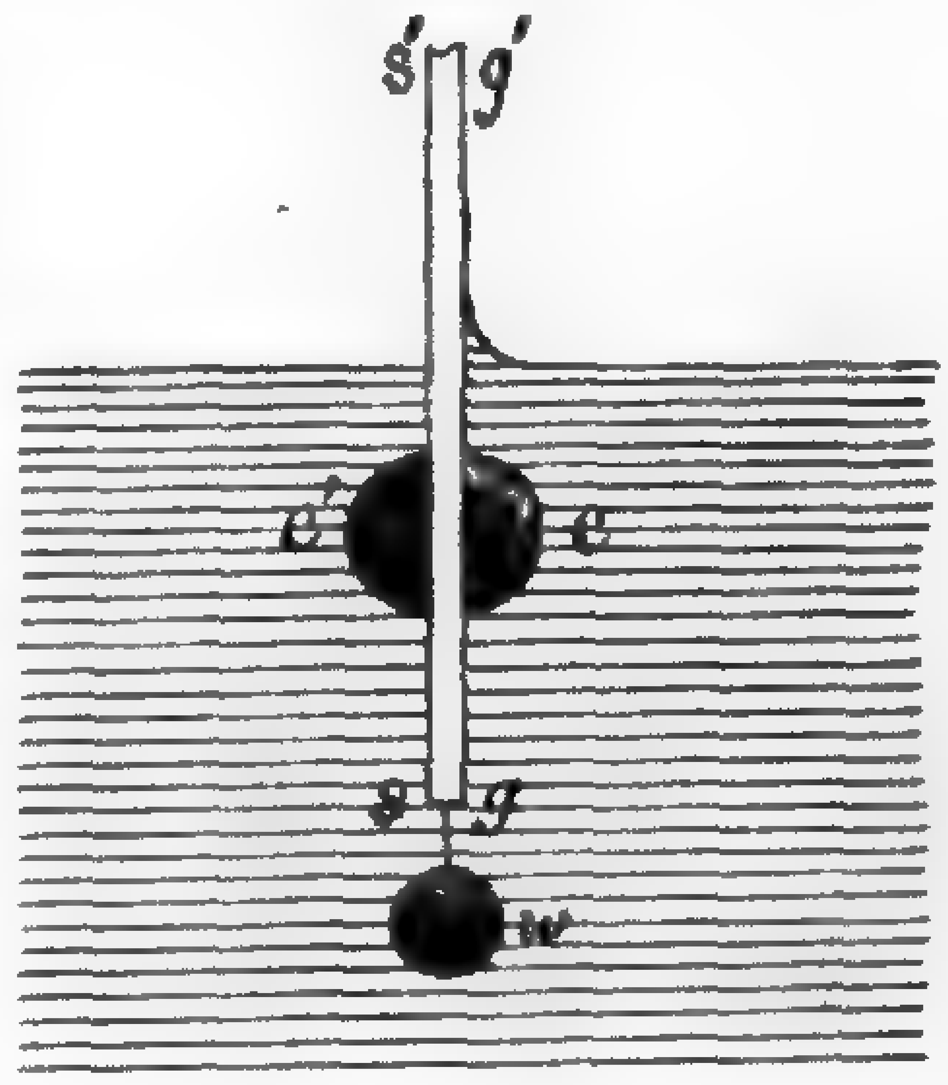
CASE 3. In this case (fig. 3), it is evident, that as the centers of concavity of the interfering meniscuses are in opposite directions, the common or united meniscus formed by their union, as *k n*, must have a radius of curvature greater than that of either of the exterior meniscuses at *c* and *o′*. Hence, by virtue of the smaller radius of curvature of the exterior tense elastic films at *c* and *o′*, the exterior capillary forces must prevail, and the two bodies are drawn apart, by the superior tensile reactions directed toward the centers of concavity at 3 and at 4, (fig. 3).

It will be noticed that in the preceding explanations of this class of capillary phenomena, I have referred the apparent attractions and repulsions exclusively to the elastic reactions of the tense surface film, whose form is modified by the proximity of the partly immersed solid bodies. For the reasons previously assigned, I have left out of consideration the modifications of hydrostatic pressure, which are, after all, really due to these elastic reactions. To those physicists who prefer the mathematical methods of Laplace and of Poisson, my explanations may seem to be less complete and exhaustive; but in such general explanations, it is of primary importance to keep steadily before the student the fundamental physical principle which constitutes the *fons et origo* of these phenomena.

There is, however, an objection to the explanation which refers this class of capillary phenomena to the contraction of the tensile film of liquid adjacent to the sides of the partly immersed solids, which it is proper to notice. Since the capillary force thus developed is inversely proportional to the radius of curvature and directed toward the center of concavity; it has been urged, that when an isolated vertical plate that has its two parallel faces of different substances is partly immersed in the liquid, under such conditions that the radii of curvature of the meniscuses on the opposite faces are unequal,—there should result a difference of pressure; so that such an isolated body floating on an indefinite surface of a liquid, would, under the mutual action of the fluid and solid, take on a horizontal and perpetual motion of translation. There are obvious mechanical difficulties in the way of the admission of such a result; for, as suggested by Poisson, in such a movement, the center of gravity of the entire system is not displaced. Laplace seemed to think that there would be some difference of pressure in such cases, but that it would be so small that it might be neglected.* It is evident that, however small it might be, a motion of translation would be the consequence, and this it seems difficult to admit. Dr. Thomas Young, in a letter to Poisson, insists upon this as a most serious objection to Laplace's Theory of Capillarity.† On the contrary, Poisson shows that his own modified theory does not lead to this mechanical difficulty; for it indicates that under the foregoing conditions, the horizontal pressures on the opposite faces exactly counterbalance each other, so that the floating solid can have no motion of translation.‡ In like manner, Dupré in his admirable researches on "Molecular Actions," investigates this anomalous deduction from Laplace's theory, indicating the incompleteness of the latter, and showing, that Poisson is correct in the conclusion that the horizontal molecular forces exactly balance one another.§

Notwithstanding the *à priori* mechanical impossibility of an isolated floating body taking on a motion of translation under the conditions above designated, I made the following arrangements with the view of experimentally testing the question. A plate of well-cleaned glass (fig. 4), $g\,g'$, and a plate of polished steel, ss', were cemented together, so as to constitute a single compound plate of these substances. This was floated in a vertical position, by securing masses of cork, c and c', to the two faces, and attaching a leaden sinker (w), of the proper weight, to the lower extremity of the plates. If such a composite plate is plunged vertically into alcohol contained in a large vessel, a concave meniscus will be formed by the ascending liquid on the glass face, while on the steel face no meniscus will be formed, and the adjacent surface of the alcohol will be horizontal. Now, Dr. Young insisted that, according to Laplace's theory, the horizontal molecular pressures on the opposite faces being unequal, the composite plate should be drawn in the direction of the center of concavity of the meniscus on the glass face, and thus cause the entire system to take on a motion of translation toward the right. The arrangement represented in fig. 4 was so sensitive that it was difficult to avoid the influence of slight currents of air; nevertheless, there were no indications of the action of unbalanced forces on

4.



* "Supplément a la Théorie de l'Action Capillaire," p. 43.

† Poisson, op. cit. ante. Article 128, p. 265.

‡ Poisson, op. cit. ante. Articles 85 et 96, pp. 172 et 194.

§ Dupré, op. cit. ante. Chap. ix, p. 396–400.

the floating apparatus. Hence, the idea that such a system would take on a horizontal and perpetual motion under the action of molecular forces, is not only inconsistent with fundamental mechanical principles, but is contradicted by direct experiment: for, no motion takes place in such a composite vertical plate, when partly immersed and floating in the liquid.*

Moreover, it seems to me, that according to any theory of capillarity which is based upon the action of a tense elastic superficial film, it is clear, that the tensile reaction of the bounding film, which envelops such a floating composite plate, must necessarily be exactly the same in all parts of its perimeter; so that, it is impossible for the forces due to capillary actions, to disturb the equilibrium of such a body while floating in the liquid, so long as its component plates are maintained at a fixed distance apart. It is obvious, that the tensile reaction can only tend to press the plates together; it cannot produce a motion of translation. It is almost needless to add that in the cases previously considered where the floating solids were separated and movable, the conditions of equilibrium were disturbed by the modifications of the interfering meniscuses due to their proximity; and these conditions of equilibrium could only be realized by mutual contact, or by recession beyond the reach of disturbing influences.

It is, likewise, evident, that in cases 1 and 2 the interfering and modified united bounding films tend, in each case, to assume a minimum perimeter, which is only secured when the two bodies are brought in contact. In the composite plate above considered, this condition is instantly realized upon partial immersion in the liquid. This principle explains why it is practically so much more difficult to experimentally verify case 3, than cases 1 and 2. For in case 3 when the floating bodies are brought so near to one another that the interfering meniscuses form a common enveloping film, the principle of minimum bounding perimeter prevails, and the verification of apparent repulsion fails; for the two bodies are drawn together as in cases 1 and 2. The fact that in such cases, floating bodies apparently repel one another at a certain distance, but on nearer approach, apparently attract, is noticed both by Laplace and by Poisson, as a deduction from their respective theories of capillarity, and was experimentally verified by the Abbé Haüy and others.

Finally, it may be proper to add, that the reaction of the surface tension of liquids always tends to reduce the surface to

* It is scarcely necessary to add that the irregular and perplexing capillary motions due to the difference in the surface tensions of different liquids or of the same liquid in different states, are here excluded from consideration. The curious motions of small isolated masses of camphor, when floating on the surface of warm water, come under this category. These phenomena have been carefully studied by Tomlinson and others.

the smallest area which can be enclosed by its actual boundary. This fundamental principle of the tensile reaction tending to reduce the bounding area or bounding perimeter to a minimum affords a very simple and elegant explanation of the whole class of phenomena under consideration.* As already intimated, cases 1 and 2 evidently come under this principle; for the common bounding perimeter produced by the union of the meniscuses, in tending by virtue of its elastic reaction to become a minimum, draws the two floating bodies together. The same is true of case 3, provided the floating bodies are brought in such proximity that a common bounding perimeter is produced by the interfering meniscuses. But when the proximity is not sufficient to secure this condition, the disturbance of equilibrium due to this interference results, as we have seen, in the recession of the floating bodies. For in the latter case the first effect of the interfering meniscuses (as previously shown) is to augment the radius of curvature at the intersecting portions; this is evidently equivalent to a tendency to increase the bounding perimeter of the meniscuses enveloping each of the bodies; so that the minimum principle operates to separate them.

Hence the two fundamental principles of capillarity, 1st, that the elastic reaction is inversely proportional to the radius of curvature of the meniscus, and 2d, that the same contractile reaction tends to reduce the perimeter to the smallest which can be inclosed by its actual boundary, are coördinated, and alike concur in furnishing complete explanations of this class of phenomena, without the necessity of invoking the agency of atmospheric pressure or the modifications of hydrostatic pressure due to the operation of these molecular forces.

Berkeley, California, October 10, 1882.

ART. XLVI.—*High Terraces of the Rivers of Eastern Connecticut;* by Professor B. F. KOONS, Storrs Agricultural School, Mansfield, Ct.

IN the observations here reported I have attempted to supplement the work done by Professor Dana on the high terraces of the Thames River of Eastern Connecticut. The results of his research upon this stream were published in this Journal, vol. x, p. 429, 1875. The heights as there given (I refer the points to the mouth of the river instead of, as Professor Dana did, to Norwich) are:

* This principle is very elegantly deduced by the great geometer Gauss, by the application of the principle of mutual velocities. He shows that the condition of capillary equilibrium is that the expression for the force function shall be a minimum. (Vide op. cit. ante.)

5·5	miles	above	the mouth	of the river,	....	50 ft.
8·	"	"	"	"	....	68 "
10·5	"	"	"	"	....	75 "
13·5	"	"	"	"	....	88 "
15·	"	"	"	"	....	108 "
16·	"	"	"	"	(at Norwich),	110 "

The Thames River is formed at Norwich by the union of the small stream Yantic from the northwest and the much larger river Shetucket from the northeast. The latter stream is about twenty miles long and has its origin at Willimantic, where it is formed by the union of the Natchaug from the northeast and the Willimantic River from the northwest.

As pointed out by Professor Dana there was an ice dam at Norwich during the melting of the glacier of the Champlain period. Taking up the work where he left off, I, accompanied by Arthur Hubbard, one of my pupils, have attempted to make out the heights of the high terraces on the Shetucket and its tributaries, above modern flood plain, and also, at those points where the New London Northern Railroad follows the river, the height above mean tide at New London.

By the kindness of Mr. G. W. Bentley, General Superintendent of the railroad, such parts of the surveys of the road as would assist me in securing the latter measurements were placed at my disposal. Likewise the surveys of the New York & New England Railroad assisted me to one measurement on the Natchaug.

As a result of my investigations I found that the heights on the Shetucket are:

(1)	2·	miles above Norwich,	94·5 ft.	Above mean tide at N. London,	---- ft.
(2)	3·5	" "	81· "	" " "	---- "
(3)	6·5	" "	84· "	" " "	---- "
(4)	9·5	" "	75· "	" " "	---- "
(5)	10·75	" "	69· "	" " "	---- "
(6)	13·	" "	60· "	" " "	---- "
(7)	13·5	" "	107·5 "	" " "	---- "
(8)	15·	" "	107· "	" " "	246· "
(9)	16·75	" "	98·5 "	" " "	249·5 "

On the Natchaug:

(10)	In the city of Willimantic,	86 ft.	Above mean tide at N. London,	250·2 ft.
(11)	2·5 miles above Willimantic,	69 "	" " "	---- "
(12)	5· " "	50 "	" " "	---- "
(13)	6· " "	46 "	" " "	---- "

On the Hope River, a tributary of the Natchaug:

(14) ·5 mile above its mouth,...58 ft. Above mean tide at N. London, ---- ft.

On the Willimantic River:

(15)	7 miles above Willimantic,	86 ft.	Above mean tide at New London,	354 ft.
(16)	8 " "	84 "	" " "	364 "
(17)	10 " "	60 "	" " "	375 "

At stations one and two the terraces are well defined on both sides, and extend far up and down the stream, also, considerable distance back from it, indicating that the floods had great width at this point. As indicated by the heights at these two stations I expected a gradual decrease in the elevation of the terraces as I ascended the river from Norwich, but found that at station three, on the west side of the stream, in the village of Occum, the height is 84 feet, but upon investigation found the cause of this increase of height above station two to be the narrows in the river, a mile below the village, where the stream breaks through a line of hills, and doubtless during the flood times, as now, had a narrow channel and rapids between the rocks rising abruptly on both sides of the stream.

At stations four, five and six the floods again spread very widely, and formed what might more properly be called a lake than a stream, for the terrace outline can be traced far back from the present stream, and in an almost unbroken line well up to station seven, where the river again makes its way through a line of hills. At this point bold cliffs project well into the stream, and the evidences are very clear that this was the location of another ice-dam; for, at the head of the narrow gorge, which is about one-half mile long, there is a terrace formation 107·5 feet high, and located close to the stream.

Had the passage through these hills remained unobstructed during the flood period, the great force with which the vast volume of water would have gone into these narrows would have been such as to sweep everything before them, and no deposit could possibly have been made at this point. Also the nature of these deposits, the coarse and irregular condition of the stones and bowlders, seems to indicate that only floating ice could have placed them there. Likewise, a kettle-hole, some 25 feet deep, is found within this deposit, and it appears as though a mass of floating ice became stranded at one side of the entrance to the gorge, was subsequently buried by the stones, sand and gravel, brought down upon the floating ice, and finally melted leaving this depression. The deposits a mile above this are very fine, composed principally of clay and sand, while at station eight, a mile and a half above, they are considerably coarser, and at station nine coarser still. If an obstruction existed within the pass, then the waters above would be checked in their flow and would drop their coarse material far up stream and their finer lower down, and the floating ice would carry its material into the pack at the head of the pass; and this is just the condition we have here, and that too without the aid of any considerable side streams to produce it.

All these facts, together with the great difference in the height of the terraces above and below the narrows, seem to indicate that this was the location of an ice-dam.

Station eight is on the east side of the river, and one-half mile below South Windham, and here again, and also at station nine and those above on the Natchaug, the floods were generally very widely spread, forming great areas of level plains which extend far back from the streams, even to Mansfield Center, four miles north of the city of Willimantic.

Unlike the region just mentioned, the Willimantic River lies in a very narrow valley with the lines of hills on either side close to the stream, so that the waters swept everything out of the valley, and nothing but doubtful remains of high terrace-deposits are found till we get to Eagleville, seven miles above its mouth, and at but few points above this were we able to determine the height of the floods.

Agricultural School, Mansfield, Conn., Oct. 7th, 1882.

ART. XLVII.—*Note on the former Southward Discharge of Lake Winnipeg*; by J. D. DANA.

THE most remarkable of the changes that are known to have occurred in the water-courses of North America is that in the discharge of Lake Winnipeg from a former southward course by the Minnesota Channel and Mississippi to its modern discharge into Hudson's Bay, first announced and sustained by General G. K. Warren, in a report of 1867 published in the Report of the U. S Engineers for the year 1868 (pp. 307–314), after levelings along these rivers, by order of the government, in 1866 and 1867. The question was more fully illustrated by General Warren in "an Essay concerning important physical features exhibited in the Valley of the Minnesota River and upon their signification," submitted to the Chief of Engineers in 1874 and published in the Report for 1875 (pp. 385–402); and afterward, further discussed by him in his paper on the Bridging of the Upper Mississippi, in the Report for 1878 (pp. 909 to 926) with a reproduction of some of the maps of the essay of 1874. The last of the above-mentioned papers, excepting its closing details as to sections across the valleys, is reproduced in this Journal on pages 417–431, vol. xvi, 1878, along with its eight maps and plates.

In the first of his papers, that of January, 1867, General Warren, after mentioning the evidences that "Lake Winnipeg was once continuous southward over the central portion of the Red River of the North, and had its outlet down the Minnesota, and not down the Nelson to Hudson's Bay" (p. 307), considers the origin of the former hydrographical conditions. He speaks of the possibility of an ice-barrier on the north in the Glacial era; but he sets this idea aside, and argues for an actual change of land-level, and makes the southward discharge to have ended in consequence of a depression of land to the south, accompanying (as added in his paper of 1875) a rise to the north; and instancing, as examples of a corresponding change of level, the former *southward* discharge of Michigan Lake through the Illinois River, and of Winnebago Lake through the Wisconsin River. A map of the large Winnipeg Lake—larger he observes than Lake Superior and Michigan together, and having the Saskatchewan River as the head stream—accompanied the written report sent to the Department, but it was not published. The same view is presented at more length in the paper of 1874 (Report for 1875), along with a wider discussion of the facts, and a review of the writings of previous travelers who had recognized the lake-like features of the region.

The idea of the southward discharge of Lake Winnipeg was presented again in 1875 by Mr. George M. Dawson, in his excellent Report on the Geology of the region in the vicinity of the 49th Parallel, with a recognition of General Warren's paper, but with the statement that the inference was an independent one. In explanation, he says (pp. 253, 254) that "by the flow of a large volume of water in this direction, the excavation of the basins of the Winnipeg group of lakes and the great valley of the Red River itself can be explained; the river cutting downward and westward on the sloping surface of the Laurentian rocks, at the expense of the Cretaceous strata, and later of the limestones of the Devonian and Silurian; the blocking up of the southern exit and changed direction of flow being a phenomenon only similar to that which is known to have taken place with the Great Lakes of the St. Lawrence."

The ice-barrier hypothesis has been sustained, in place of that of a change of level, by Professor N. H. Winchell in his Minnesota Report for 1877, who there observes, in his explanation, that the lake, having first appeared at the south or Minnesota end, "grew toward the north as fast as the retreating ice-sheet made way for it." In the Minnesota Report for 1879, the same view is urged, with more detail, by Mr. Warren Upham.

A decision between these two conflicting explanations is of great importance to a right understanding of Quaternary events as well as of fundamental principles in terrestrial dynamics; and I therefore review here the more prominent facts, taking them mostly from General Warren's papers and the Report of Mr. Dawson.

1. The Red River of the North, rising in Lake Traverse, flows northward along the west side of Minnesota for 225 miles, crosses then the 49th parallel, and continues on the same course

for 90 miles to Lake Winnipeg; the distance from Lake Traverse to Lake Winnipeg being 315 miles.

2. The Minnesota, rising to the westward of Lake Traverse, enters its valley within two miles of it and flows south, through Big Stone Lake, to the Mississippi at Minneapolis.

3. The valley of Red River, after narrowing much, is still 46 miles wide on the 49th parallel, and, for a long distance south of this parallel, it has an average width of 30 miles (Gen. Warren's map and G. M. Dawson's statement); toward Lake Traverse it narrows rapidly, is a mile wide along this lake, the sides rising abruptly from the borders of the lake; beyond this lake, southward, it continues on, one to two miles wide, as the valley of the Minnesota River; and, where it joins the Mississippi, the valley has four times the width of the Mississippi valley above the junction (Gen. Warren).

4. All now agree that the wide part of the valley which stretches northward from Lake Traverse is lake-bottom prairie, that it was adopted by the Red River, not made by it (Dawson); and that the part south of this lake, is, as General Warren first showed, the deserted highway of the outflowing river and lake.

5. The Red River lake-bottom valley is bordered much of the way by abrupt sides rising 100 to 200 feet to the top of a terrace-plain or plateau; and, similarly, the Minnesota channel has sides usually 100 to 150 feet in height.

6. Heights above the sea-level:

(B. C. means Boundary Commission Report.)

	1. Lake-bottom prairie.	2. Bordering plateau.
Near 45° 30′ N., between Big Stone Lake and Lake Traverse (5 miles apart),	970	1,120
Near 47° N., at Fargo and Moorhead,	900	1,050 (?)
On the 49th parallel near Pembina and St. Vincent,*	784 (B.C.)	East side 989 West side 994
Toward Lake Winnipeg	740	810
Height of Lake Winnipeg (about the mouth of Red River, a great marsh), 710 feet.		

The heights on Minnesota River are (Winchell's Report):

Surface of bordering plateau near Big Stone Lake,	1,125
At Mankato, 145 miles south,	975
At Shakopee, 50 miles northeast,	925
At junction with the Mississippi,	800 to 820

* The height of the Lake of the Woods is 1048 feet (B. C.); of the divide between it and the near-by head of Roseau River, a westward-flowing tributary of Red River along the 49th-parallel region, about 1078 feet (Dawson); edge of plateau where it looks down on the lake-bottom about Pembina, 90 feet less (B. C.), and hence about 988 feet; Pembina Mountain, on the west side, 210 feet above the lake-bottom prairie, and hence 784 + 210 = 994 feet above the sea-level. Red River as it flows in its channel is 20 to 60 feet below the surface of the lake-bottom prairie; at Pembina, about 50 feet (Warren).

7. The *slope* of the lake-bottom prairie is *northward*, toward Lake Winnipeg; and, from the 49th parallel, according to Dawson, it is nearly six inches per mile; the mean slope from Moorhead in Minnesota, 150 miles south of the 49th parallel, is little less than one foot per mile.

The slope of the bordering plateau *northward* from Lake Traverse to Lake Winnipeg, 315 miles, is about one foot per mile; for 1,125−810=315.

The slope of the bordering plateau along the Minnesota from Big Stone Lake to Mankato (145 m.) is *southward* and about one foot per mile; for 1,125−975=150.

8. The material of the lake-bottom, where examined by Mr. Dawson, is mostly yellowish clayey earth or lœss, containing calcareous matter enough to effervesce freely with acids; the upper portion is rarely so coarse as to be called sand, though sometimes an arenaceous clayey material; that of the border is also somewhat arenaceous. The depth of this lake-bottom deposit is generally 40 feet or more over the central portions, bu it thins toward the sides. This point is illustrated in the pla e facing p. 248 in Dawson's Report. He represents the lœss as overlying stratified drift and bowlder clay. The surface of the prairie rises somewhat toward the sides; but whether the depression is more than would result from the drying (and consequent contraction) of so much wet loam after the disappearance of the lake, is not ascertained. It is rare to find anything like pebbly areas or pebbles over it.

9. The outline of the lake-bottom prairie has the appearance of being, so far as it extends, the outline of the great Winnipeg Lake, and is so recognized by Warren, Dawson and others.

10. The material of the bordering high plateau along both the Red River portion and the Minnesota is coarse gravel and sand; much of it unstratified till, much, more or less stratified; and the upper surface is often pebbly or stony, with occasional bowlders.

Roseau River, for 25 miles east of the western edge of the plateau, says Dawson (p. 214), has cut deeply into the plateau formation so as to have high bluff sides; and the sections show alternating beds of clay, sand and gravel characterized by "current bedding;" one of them having stratified arenaceous clay below, then coarse gravel, then sand, and then gravel as the top beneath the soil; another "typical one" consisting of hard-compacted clay below, partly stratified, then a thin pebbly bed, then sand, then the upper gravel. These are given by Mr. Dawson as examples of the constitution of what he calls the "Drift Plateau of Eastern Manitoba and Northern Minnesota." He says of the great "High-level Plateau" that it is frequently irregular in detail, covered with banks and ridges of sand and gravel of the nature of "kames," but, on the whole, remarkably uniform; on the 49th parallel it rises gently eastward toward the Lake of the Woods, 90 feet in the 77 miles. On the upper part of the Minnesota the deposits are largely the Glacial drift (General Warren, and Professor Winchell), with also portions that are bedded.

Conclusion.—Taking the accounts of the region from which we have cited to be correct, we have the deduction forced upon us that Winnipeg Lake did not lose its discharge into Hudson's Bay and become the great lake with southward discharge, because of a barrier of ice or of any other kind. For if so, if there had been no great change of slope over the region, the shores of the *great* lake should be approximately horizontal, to its outlet at Lake Traverse, and if horizontal, they would have a height in the vicinity of the present Winnipeg of 260 feet above the lake, supposing the waters just up to the Lake Traverse level, and 300 feet if the water at this place of discharge was merely 40 feet deep. Instead of this condition, *the observed shore line has nearly the present general slope of the surface;* and, further, *the slope of the lake-bottom prairie is not much different from that of the bordering plateau on either side.*

We have thence the conclusion, since the present outline of the lake-deposits or lœss, whatever the present slope, was approximately the shore-line and once horizontal, that there has been a great change in the level of the land, as General Warren urged. The idea of a change in the position of the earth's center of gravity sufficient to change the slope of the surface a foot a mile, or half a foot, cannot be reasonably entertained.

We may infer also, from the near correspondence between the northward slope of the lake-bottom prairie and that of the bordering plateaus, that the prairie and plateaus were affected alike by the conditions as to level. And we may deduce from the regularity of the slope, that the conditions as to level affected equally the region from Lake Traverse to Lake Winnipeg, and beyond doubt also to a much greater undetermined distance northward.

This conclusion bears so profoundly on questions as to the condition of the earth's interior, and the origin of changes of level over the earth's surface, that it is greatly to be desired that further investigations should place the facts beyond all doubt.

Admitting that the facts are correctly given, they appear to point to the following succession of events:

The fact that the lake deposits are underlaid by unstratified drift, shows that before the era of the great lake the glacier had moved southwestward over the region, and deposition of moraine material had taken place. The high-level prairie either side of the lake region and of the Minnesota valley is made largely of this unstratified drift; but the generally level surface in the part toward the lake region and valley, and the stratification in much of the material, are evidence that the flood from the melting glacier covered and levelled it, and stratified its bedded deposits; the coarseness of these deposits, and the large size of the valley of discharge, that the flood waters had great velocity; the height of the prairie, that they stood 100 to 150 feet above the present level of the region including Lake Traverse, instead of the 40 feet at the divide above supposed. This time of maximum flood and of rather violent fluvial conditions was followed by the era of the Great Lake, that is, of quiet waters and lacustrine deposits, with slow discharge over the Lake Traverse region: which may have been brought about in part by diminished supply of waters from the melting ice and precipitation, but more, with little doubt, by a diminution in the slope of the general surface, which was a part of the great change of slope that went on, as explained by General Warren, until the land was reduced to its present pitch and the streams to their modern courses.

The application of a new name, Lake Agassiz, to the flooded Lake Winnipeg, proposed by Mr. Upham because of its alleged relation to the retreating ice-sheet, tends to obscure the great historical facts in the case. All desire to honor Professor Agassiz, and no one more so than the writer; and still the name that most deserves honor in connection with the developments in Central North America is that of General G. K. Warren. But rather than use either, it is better to let the accepted name, Lake Winnipeg, be the name for past, as it is for present, time.

ART. XLVIII.—*Note on the Alleged Change in the Resistance of Carbon due to Change of Pressure*; by SILVANUS P. THOMPSON, Professor of Experimental Physics in University College, Bristol.

IN the July number of this Journal, Professor T. C. Mendenhall has described some experiments upon the change of resistance in a disk of prepared lamp-black, such as is used in Edison's tasimeter. At the close of his communication Professor Mendenhall ventures, "without knowing anything about the nature of these experiments," to call in question the researches made by Professor W. F. Barrett, by Mr. Herbert Tomlinson, and by the present writer, in which they had each independently arrived at the conclusion that this alleged effect was due not to any change in the specific resistance of carbon, but to better external contact between the piece or pieces of carbon and the conductors in contact with them. It may be added that an identical conclusion was arrived at in 1879 by Professors Naccari and Pagliani; and that a similar result was found a little later by Mr. Conrad W. Cooke. In short, with the exception of Professor Mendenhall, all who have investigated the point are agreed in their verdict.

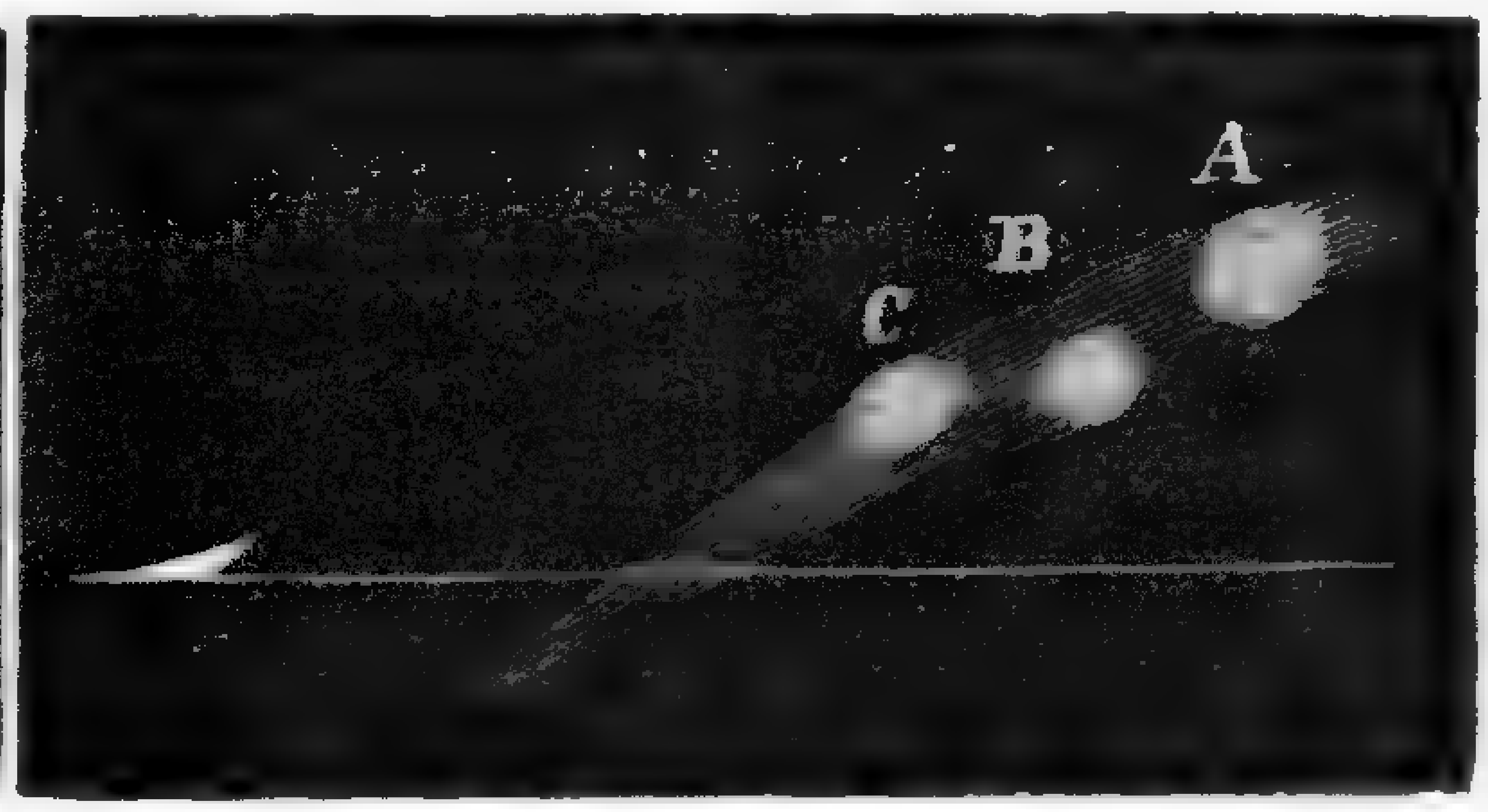
As Professor Mendenhall expressly disclaims all acquaintance with the experiments upon which previous observers founded their conclusions, it is not extraordinary that he fails to appreciate the vital point in experimenting. His carbon disk lay in its usual place in the tasimeter, of which, however, the upper works had been removed for the purpose of his experiments, in which pressure was applied through a slender brass rod placed in a vertical position upon the center of "the upper contact piece." What this upper contact-piece was he does not say. No information is given of the nature of the contacts above and below. No attempt to distinguish between the resistance at the contacts and the resistance of the carbon disk was made; nor does the memoir show that any care was taken to ensure either perfection or constancy of contact. Under these circumstances it is difficult to see what grounds these experiments afford Professor Mendenhall for expressing opinions upon the question at issue. In the crucial experiment of Professor Barrett, which was made with one of Edison's own buttons of prepared lamp-black, there was a perfect contact maintained during the variations of pressure by covering both surfaces of the button with mercury; and in some of the other cases amalgamated copper contacts, and electroplated contacts have been employed. I venture to predict that if Professor Mendenhall will repeat his experiment, ensuring at the outset by one or other of these precautions that the disk of carbon shall have uniform and constant contacts during the experiment, he will find a very different result from that which he has announced. The very interesting observation which he has made that the influence of *time* makes itself felt when pressure is applied but not when pressure is removed, furnishes another argument in favor of the views held by the majority of experimenters on this question.

Another point worthy of note is this. Observers have more than once suspected that in carbon there is the peculiarity that the resistance—the true resistance of carbon itself—varies under different electromotive forces. The point is certainly worth investigating. Professor Mendenhall does not state what electromotive force was employed in his investigations.

ART. XLIX.—*Figure of the Nucleus of the bright Comet of* 1882 (Gould); by EDWARD S. HOLDEN.

ALTHOUGH this comet presented a beautiful spectacle, when seen with the naked eye, I have been disappointed at the small amount of work which I have been able to do in the way of accurate observation. I give herewith the only two good sketches which I have been able to make. The aperture employed was 15 inches and the power was 145 diameters.

1882, Oct. 13.



1882, Oct. 17.

1882, October 13. (See the figure.) The nucleus is curved as in the drawing. It consists of three masses. I am sure of a break at *a*; tolerably sure of the break at *b*, and I suspect a break at *c*, but I am not certain of it.

1882, October 14. The night is very poor. (In general the appearances of last night are confirmed.) The nucleus is about 1′ long.

1882, October 17. (See the figure.) There are three masses, plainly separated. *B* is farther north than the line *A–C* by 3–4″. There is a dark division between each pair of masses. *B* and *C* are nearly in the parallel. The brush of light from the mass *A* toward the east, comes from the south side of *A*, as it is drawn. From the east end of *A* to the west end of the brush of light, is about 15″.

1882, October 18. The dark space bewteen *A* and *B* is about 10″; it is as wide as *A* itself, and wider than on October 17. *C* is certainly seen as a separate mass; *A* and *B* are bright and stellar in appearance, more so than on October 17. *C* is, however, fainter than then. The dark axis of the tail extends quite up to the coma.

1882, October 19. Cloudy. The nucleus is seen as before. *A* and *B* are seen, as also the dark space between them. *C* is not seen, but this is probably on account of the unsteady air.

I regret that my opportunity did not allow me to make any further sketches of value.

Washburn Observatory, University of Wisconsin,
Madison, November 3, 1882.

ART. L.—*On Eccentricity and Perihelion Longitude of the Earth's Orbit as a cause of change of Climate.* From the Presidential Address before the Geological Society of Dublin, by Rev. SAMUEL HAUGHTON, in February, 1882.

ANOTHER astronomical cause of change in geological climate was proposed by Adhemar, and afterward worked out more fully by Croll, J. Murphy and Wallace.

This is the secular variation in climate depending on the eccentricity and perihelion longitude of the earth's orbit.

The change depending on the position of the perihelion is completed in about 21,000 years; while that depending on the eccentricity requires much more time to pass through its course. In fact, astronomers have proved that the eccentricity of the earth's orbit may have been $\frac{1}{12}$th instead of $\frac{1}{60}$th, as at present; but are unable to say how long ago the maximum eccentricity occurred.

Adhemar, Croll and J. Murphy deduce from this astronomical cause the alternate glaciation of the northern and southern hemispheres every 21,000 years, which glaciation is more or less severe in proportion as the eccentricity during the perihelion period is greater or less. Mr. Croll, however, places the glaciation of a hemisphere in the time when its winter solstice is in aphelion; whereas Mr. J. Murphy places the glaciation of a hemisphere in the time when its winter solstice is in perihelion.

I have given a mathematical demonstration of the form of this secular inequality in climate,* which may be thus expressed without the use of mathematical symbols:—

The mean annual temperature of any place varies as the eccentricity of the earth's orbit, and as the range of temperature from summer to winter jointly.†

Of these two factors of climate, viz: eccentricity and range of temperature, the first is astronomical and the second terrestrial, depending on distribution of land and water, on ocean currents and prevailing winds.

If we suppose the terrestrial factor to be the same, while the eccentricity attains its maximum, the greatest possible change in mean annual temperature for any place on the earth's surface turns out to be less than 5° F.; and in order to produce a sensible effect upon climate, we must suppose that the annual range (terrestrial factor) must vary also by variation in the dis-

* Proceedings of the Royal Society, 19th February, 1881.

† $\Theta_0 \propto \varepsilon\rho$, where Θ_0 = mean annual temperature; ε = eccentricity of earth's orbit; ρ = annual range of temperature at place.

tribution of land and water. This is of course possible; but such a variation must follow its own development, and be quite independent of eccentricity or perihelion.

I shall allow, however, the advocates of this theory permission to make the terrestrial factor what they please (within the limits which the observed facts of climate permit), and then inquire whether the theory can account for geological climates.

1. I take as my first example the present climate of *Discovery Harbor*, Grinnell Land, close to the Miocene Plant-beds:—

July temperature, +37°·2 F.; mean annual temperature, −1°·7 F.; January temperature, −40°·6 F.; annual range, 77°·8 F.

I have elsewhere* shown that the July temperature of Discovery Harbor, during Miocene times, was probably higher than 63°·7 F.; that is to say, 26°·5 F. higher than its present amount. This would require, at the time of maximum eccentricity, an annual range of temperature greater than 120°·7 F.†

The foregoing amounts to a demonstration, that a change in the eccentricity of the earth's orbit from $\frac{1}{60}$th to $\frac{1}{12}$th would not produce in Grinnell Land the summer temperature necessary to ripen its Miocene fruits, unless it were accompanied by such a redistribution of land and water as would raise the annual range of temperature from 77°·8 F. to 120°·7 F.; that is to say, increase the already great range by more than half its present amount.

I have no hesitation in saying that (with the present quantity of sun-heat) this amounts to an impossibility.

The greatest range of annual heat now found in N. America occurs at *Melville Island*, where we have—

July temperature, +42°·35 F.; January temperature, −36°·40 F.; range, 78°·75 F.

The greatest known annual range of temperature occurs (as we might expect) in the northeastern part of Europasia. Observations taken at *Jakutsk* for seventeen years give the following results—

July temperature, +62°·15 F.; January temperature, −43°·82 F.; range, 105°·97 F.

This shows that even a redistribution of land and water, replacing N. America by a continent like Europasia, would still leave the annual range of temperature 16°·73 F. short of

* Lectures on Physical Geography, p. 321.

† For $\frac{\varepsilon\rho}{2}+\frac{\rho}{2} > 63°\cdot7 + 1°\cdot7 > 65°\cdot4$ F.; therefore, when $\varepsilon=\frac{1}{12}$, ρ must be greater than 120°·7 F., and if $\varepsilon=\frac{1}{60}$, ρ must be greater than 128°·7 F.

what the Miocene vegetation of Grinnell Land requires. This is a *Reductio ad absurdum* of the changes of geological climate produced by the secular inequality of the eccentricity and perihelion longitude of the earth's orbit.

Similar arguments may be applied to the other well-known Miocene Plant-beds of the high northern Atlantic latitudes.

2. For a second example, in Miocene times, *Spitzbergen* must have had a July temperature greater than 64°·4 F.* Its present climate is—

July temperature, +37°·2 F.; annual temperature, +16°·5 F.; January temperature, —4°·2 F.; range, 41°·4 F.

It is easy to see that the annual range of temperature in Miocene times in Spitzbergen must have exceeded 88°·4 F.† at the time of maximum eccentricity, in order to account for the fruits ripened there in summer.

This, although not an impossible case, like the former case of Grinnell Land, is yet quite incredible; for we have to imagine a redistribution of land and water such as would more than double the annual range of temperature in Spitzbergen, or raise it from 41°·4 F. to 88°·4 F.

3. The Miocene Plant-beds of *Disco*, on the west coast of Greenland, furnish a third proof that change of eccentricity of the earth's orbit is not sufficient to account for former geological climates. The present climate of Disco is—

July temperature, +44°·1 F.; January temperature, —4°·9 F.; annual temperature, +19°·6 F.; range, 49°·0 F.

The probable Miocene July temperature of Disco was greater than 72°·3 F.‡ From this it follows, that the annual range of temperature at Disco in Miocene times must have exceeded 97°·2 F., when the eccentricity of the earth's orbit was a maximum.§

* Lectures on Physical Geography, p. 332.

† For $\frac{\rho}{2}(1+\varepsilon) > 64°\cdot4 - 16°\cdot5 > 47°\cdot9$ F. This gives, when $\varepsilon = \frac{1}{18}$, $\rho = 88°\cdot4$ F.

‡ Lectures on Physical Geography, p. 340.

§ For $\frac{\rho}{2}(1+\varepsilon) > 72°\cdot3 - 19°\cdot6 > 52°\cdot7$ F.; $\rho(1+\varepsilon) > 105°\cdot4$ F.; and, when $\varepsilon = \frac{1}{18}$, $\rho > 97°\cdot3$ F.

ART. LI.—*On Crystals of Axinite from a locality near Bethlehem, Pennsylvania, with some remarks upon the analogies between the crystalline forms of Axinite and of Datolite*; by B. W. FRAZIER.

THE crystals of axinite described in this paper were found in the heap of débris surrounding an abandoned pit, which had been sunk in exploring for ore on a farm in Northampton County, Pennsylvania, about three miles north of Bethlehem.

The locality was discovered by Professor F. Prime, Jr., of the second Geological Survey of Pennsylvania, and was brought by him to the notice of the late Professor W. T. Rœpper, who determined the mineral to be axinite, and who secured a number of specimens of it. The determination of the mineral as axinite, was made also, independently, by Dr. F. A. Genth, the mineralogist of the Survey. Upon the purchase of Professor Rœpper's collection of minerals by the Lehigh University, the specimens of axinite collected by him from this locality became the property of the University, and have furnished the material for this investigation. The instrument which has been employed in the measurements is a goniometer made on the Babinet system by R. Fuess of Berlin, and imported for the University. A description of this form of goniometer is given by Websky in the Zeitschrift für Krystallographie, vol. iv, p. 545.

The crystals occur in a rock containing crystalline hornblende, apparently mixed intimately with axinite, and traversed by numerous narrow veins of axinite. In some of these veins the axinite is mixed with asbestus. Probably owing to this association the axinite itself sometimes assumes a fibrous structure. Wherever in the veins a free surface is exposed, it is thickly covered with implanted crystals of axinite, irregularly crowded together. Some of the crystals are colorless, others and the crystalline variety which fills the veins have a pale brown color. The color in some cases is chiefly superficial from the presence of a thin, brown incrustation which occurs sometimes in minute globular concretions, sometimes in dendritic forms. The luster of the crystals varies from dull to highly brilliant.

The crystals have the usual sharp, axe-like shape, which originally suggested to Haüy the name of the mineral. The planes occurring in the zone *p*, *l*, *u*,* and especially the planes *p* and *u*, have the greatest development, and these planes are

* Here and elsewhere in this paper the letters used to designate the planes of axinite are those adopted by v. Rath in his monograph on the crystallization of axinite in Pogg. Ann., vol. cxxviii, pp. 20 and 227. For those planes which have been discovered since the date of that paper the letters adopted by their discoverers are used.

usually striated parallel to their mutual intersections, especially in the neighborhood of *l*. Next in importance is the zone *p*, *r*, *m*, the planes *r* and *z* being especially developed. After these the zone *p*, *s*, *x*, is the most prominent.

The crystals are in general small, varying from a fraction of a millimeter to several centimeters in length. The larger crys-

Table I.

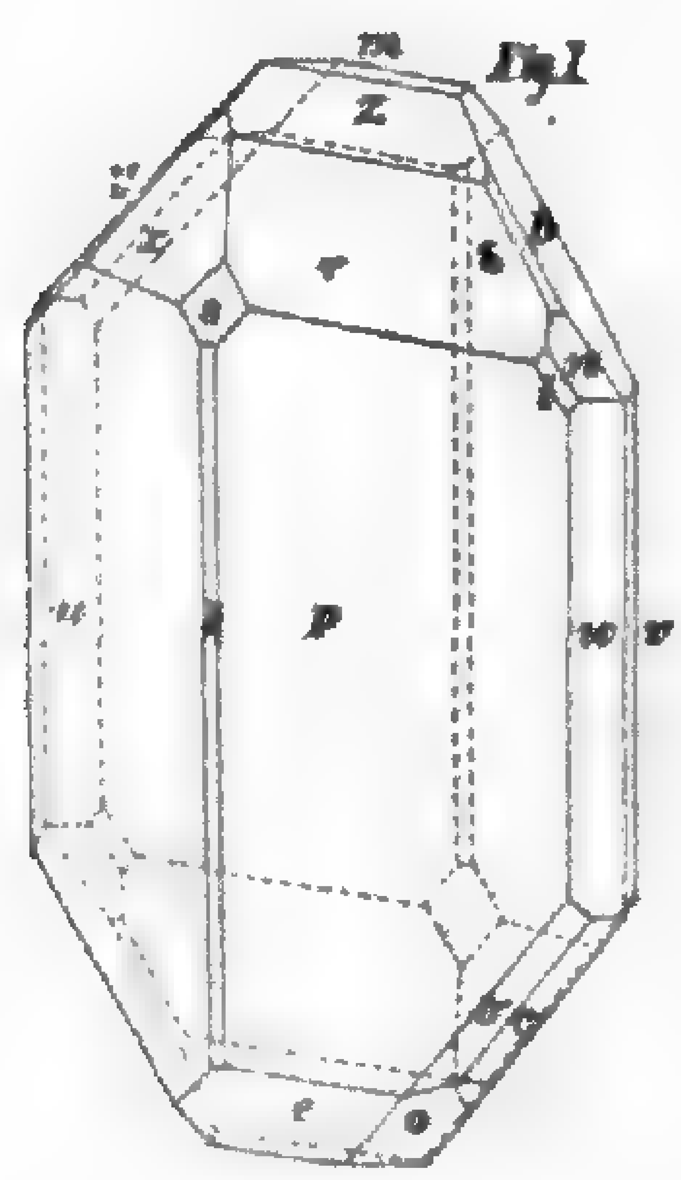
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	Calculated. v. Rath.
w : *p*	60·21¼	--	--	--	--	60·29¾	--	--	60·29
p : *l*	29·2	28·4¾	--	29·5½	--	--	--	--	28·54¾
p : *u*	--	44·34¼	44·52¼	44·19¼	--	--	--	--	44·28¾
l : *u*	15·32¾	16·29¾	--	15·13¾	--	--	--	--	15·34
u : *v*	32·54¾	32·45½	--	--	--	--	32·49	--	32·47
u : *w*	75·	--	--	--	--	--	--	--	75·2¼
p : *r*	45·12¼	--	--	--	--	--	--	--	45·15
r : *z*	18·27¼	--	--	--	--	--	--	--	18·20¾
z : *m*	26·16	--	--	--	--	--	--	--	26·20
p : *m*	89·55	--	--	--	--	--	--	--	89·55¾
m : *e*	44·39	--	--	--	--	--	--	--	44·45
b : *m*	47·3½	--	--	--	--	--	--	--	47·12¾
m : *v*	82·6	--	--	--	--	--	--	--	82·9¾
y : *v*	--	40·51	--	--	--	--	--	--	40·52¼
p : *s*	33·21¼	--	--	--	--	--	--	--	33·18
s : *x*	16·9	--	16·7¼	16·1	--	--	--	--	16·7
p : *x*	49·30¼	49·26½	--	--	--	--	--	--	49·25
x : *y*	29·46¾	29·47½	--	--	--	--	--	--	29·46¾
y : *c*	--	36·9¾	--	--	--	--	--	--	36·12¼
x : *c*	--	65·57¼	65·56½	--	--	--	--	65·59 65·55	65·59
c : *σ*	--	23·17½	23·19¾	--	--	--	--	--	23·27
σ : $\bar{p}$	--	41·16¼	41·15¼	--	--	--	--	--	41·9½
c : $\bar{p}$	--	64·33¾	64·35	--	--	--	2	64·31 64·36½	64·36
$\bar{\bar{p}}$: *n*	--	--	112·30¾	--	--	--	--	--	112·33¾
n : *d*	--	--	22·17	--	--	--	22·16	--	22·19
n : *p*	--	--	--	--	--	--	67·25¼	--	67·26¼
u : *s*	27·58¾	--	27·56½	27·52¾	--	--	--	--	27·57
s : *r*	36·31¼	--	36·29¾	36·17	--	--	--	--	36·24½
u : *r*	--	--	64·26¼	--	--	--	--	-	64·21½
r : *b*	--	--	--	68·12¾	--	--	--	--	68·24
u : *o*	--	--	--	--	85·42¾	--	85·40¾	--	85·38
o : *e*	--	--	--	--	39·11½	--	39·10½	--	39·13
u : *y*	--	49·39¾	--	--	49·49 49·41	--	49·44¼	--	49·40
v : *x*	--	45·54¾	--	--	--	--	--	--	45·53
x : *r*	--	40 57	--	--	--	--	--	--	40·46¾
u : *x*	--	--	-	--	30·40½	--	--	30·29¾	30·33
x : *m*	--	--	--	--	65·2¼	--	--	--	65·0¾
r : *o*	--	--	--	--	--	69·53 69·35¼ 69·27¼	--	--	69·47½
o : *σ*	.	--	--	--	--	35·58¼	--	--	35·51¾
x : *l*	--	--	--	--	--	--	--	32·29¾	32·30
b : *e*	53·19½	--	--	--	--	--	--	--	53·18½
x : *o*	--	--	--	--	61·49	--	--	--	61·51
d : *r*	--	--	32·30½	--	--	--	--	--	32·30½

tals have usually dull, uneven surfaces, and are not fitted for accurate measurements. Some of the smaller ones, however, have smooth, brilliant planes, and admit of quite accurate measurements. The crystals are implanted in such a manner that the planes surrounding only one extremity of the axis of zone, *p*, *l*, *u*, are developed. Adopting v. Rath's suggestion, we will consider the crystal upright when it is held so that, *x* being above *s*, *u* lies to the right of *s*. Most of the crystals examined were in a reversed position.

The same irregularities noticed by previous observers in the crystals of axinite, have been observed in these also. The planes are frequently curved, giving several reflected images of the signal, occasionally they deviate slightly from the zones in which they should lie; and the results of measurement of angles between planes giving sharp, clear reflections, and apparently fulfilling all conditions of regularity, differ in some cases considerably from the results of calculation, the differences far exceeding the probable errors of observation.

In some of the cases where there were several reflections from a plane the angle as measured by the brightest only is recorded in the subjoined table. In other cases of multiple reflection, where the decision was doubtful, all the measurements are given.

The following planes were observed on the crystals which were examined, viz: *p*, *l*, *u*, *v*, *w*; *r*, *z*, *m*, *e*; *s*, *x*, *y*, *c*, *σ*; *d*, *n*, *b*; *δ*; *o*; *φ*. In table I the results of some of the measurements are given. Only those angles are recorded which were measured between planes admitting of tolerably accurate measurement.



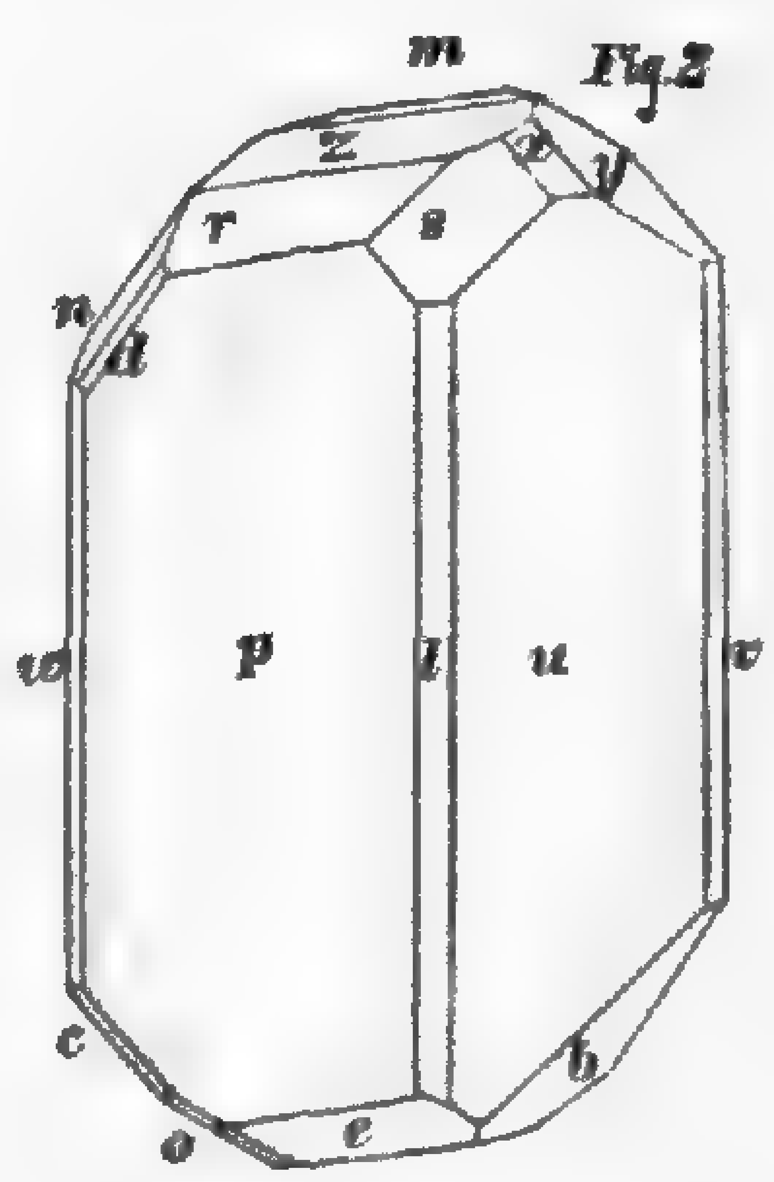


Fig. 1 represents a crystal in the reversed position, which seems to be the prevailing one in crystals from this locality. Fig. 2 represents a crystal in an upright position. Both crystals are drawn with the axis of the zone *p*, *l*, *u*, as vertical

Table II.

	In position corresponding to that chosen by Dana for Datolite.	Miller.	Naumann. Dana.	DesCloizeaux.		Schrauf.		v. Rath.	
p	100	010	$1\bar{1}0$	*m*	$1\bar{1}0$	*c*	001	$\bar{2}01$	*p*
v	010	100	010	*g'*	010	M	110	131	*v*
m	001	001	001	*c'*	$\bar{1}12$	*m*	$1\bar{1}0$	$1\bar{3}1$	*m*
h	320	130	$3\bar{1}0$	${}^{2}h$	$3\bar{1}0$		113	$\bar{7}\bar{3}2$	*h*
l	110	120	100	*h'*	100		112	$\bar{5}\bar{3}1$	*l*
β	560	350	510	$h^{\frac{3}{2}}$	510		335	$\bar{1}\bar{3}.\bar{9}.2$	*β*
h^2	340	230	310	h^2	310	H	223	$\bar{8}\bar{6}1$	h^2
a	230	340	210	h^3	210		334	$\bar{1}\bar{1}.\bar{9}.1$	*a*
$h^{\frac{9}{2}}$	11.18.0	9.11.0	11.7.0	$h^{\frac{9}{2}}$	11.7.0	*k*	9.9.11	$\bar{3}\bar{1}.\bar{2}\bar{7}.2$	$h^{\frac{9}{2}}$
u	120	110	110	*t*	110		111	110	*u*
w	$1\bar{2}0$	$1\bar{1}0$	$1\bar{3}0$	${}^{2}g$	$1\bar{3}0$		$\bar{1}\bar{1}1$	$\bar{1}32$	*w*
μ	$0\bar{8}1$	$\bar{2}01$	$0\bar{4}1$		$\bar{1}\bar{3}2$		130	191	*μ*
y	041	101	021	*γ*	$\bar{1}32$	*a*	100	101	*y*
b	$0\bar{4}1$	$\bar{1}01$	$0\bar{2}1$	*b'*	$\bar{1}\bar{1}2$		010	010	*b*
f	021	(*t*)102	011	*β*	$\bar{1}22$		$3\bar{1}0$	$1\bar{1}1$	*f*
g	043	103	023		$\bar{3}56$		$2\bar{1}0$	$2\bar{3}2$	*g*
φ	601	031	$3\bar{3}1$	$d^{\frac{1}{2}}$	$1\bar{1}1$		$1\bar{1}3$	$\bar{7}32$	*φ*
π	401	021	$2\bar{2}1$	*d'*	$1\bar{1}2$		$1\bar{1}2$	$\bar{5}31$	*π*
r	201	011	$1\bar{1}1$	*p*	001		$1\bar{1}1$	$1\bar{1}0$	*r*
e	$\bar{2}01$	$0\bar{1}1$	$\bar{1}11$	$c^{\frac{1}{2}}$	$\bar{1}11$		$\bar{1}11$	$\bar{1}\bar{3}2$	*e*
L	805	045	$4\bar{4}5$	c^5	$\bar{1}.1.10$		$5\bar{5}4$	$13.\bar{1}\bar{5}.1$	L
z	101	012	$1\bar{1}2$	c^2	$\bar{1}14$		$2\bar{2}1$	$4\bar{6}1$	*z*
s	441	121	201	*f'*	112		101	100	*s*
d	$4\bar{4}1$	$\bar{1}21$	$2\bar{4}1$		$1\bar{3}2$		$0\bar{1}1$	$\bar{2}31$	*d*
σ	$\bar{4}41$	$1\bar{2}1$	$\bar{2}41$		$\bar{3}52$		$\bar{1}01$	$\bar{1}02$	*σ*
t	$6\bar{8}1$	$\bar{2}31$	$3\bar{7}1$		$1\bar{3}1$		$\bar{1}\bar{3}3$	$\bar{5}94$	*t*
ρ	$\bar{6}81$	$2\bar{3}1$	$\bar{3}71$		$\bar{2}41$		$\bar{3}\bar{1}3$	$\bar{1}12$	*ρ*
k	481	$\bar{2}21$	$2\bar{6}1$		$1\bar{5}2$	*κ*	$\bar{1}\bar{3}2$	$\bar{1}31$	*k*
x	241	111	111	*i'*	011		201	401	*x*
n	$2\bar{4}1$	$\bar{1}11$	$1\bar{3}1$	*e'*	$0\bar{1}1$		$0\bar{2}1$	$\bar{2}61$	*n*
c	$\bar{2}41$	$1\bar{1}1$	$\bar{1}31$	*z*	$\bar{1}21$	Y	$\bar{2}01$	001	*c*
δ	$1\bar{2}1$	$\bar{1}12$	$1\bar{3}2$	b^2	$\bar{1}\bar{1}4$		$1\bar{3}1$	$1\bar{3}0$	*δ*
o	$\bar{1}21$	$1\bar{1}2$	$\bar{1}32$	*x*	$\bar{3}54$		$\bar{3}11$	$1\bar{3}4$	*o*
ψ	$\bar{2}43$	$1\bar{1}3$	$\bar{1}33$		$\bar{2}33$		$\bar{4}21$	$2\bar{6}5$	*ψ*
ν	281	211	121	$i^{\frac{1}{2}}$	021		311	532	*ν*
q	$\bar{2}81$	$2\bar{1}1$	$\bar{1}51$	*δ*	$\bar{1}31$		$\bar{3}\bar{1}1$	134	*q*
ζ	$\bar{2}85$	$2\bar{1}5$	$\bar{1}55$		$\bar{3}55$		$\bar{7}31$	332	*ζ*
θ	$1\bar{6}1$	$\bar{3}12$	$1\bar{7}2$		$\bar{1}54$		$\bar{1}51$	$\bar{3}21$	*θ*
i	641	131	$3\bar{1}1$	*o'*	101		203	$\bar{8}01$	*i*
ε	$3\bar{2}1$	$\bar{1}32$	$3\bar{5}2$		$1\bar{3}4$		$1\bar{3}3$	$\bar{7}92$	*ε*
ξ	$12.\bar{4}.3$	$\bar{1}63$	$6\bar{8}3$		$3\bar{5}6$		$1\bar{2}3$	$\bar{7}62$	*ξ*
τ	$16.\bar{4}.3$	$\bar{1}83$	$8.\overline{10}.3$		576		$1\bar{2}4$	$\bar{3}21$	*τ*

Dana's symbols for the planes of Table II (in the position adopted by him and Naumann) are the following, viz:

p, *I*; *v*, $i\text{-}\breve{1}$; *m*, *O*; *h*, $i\text{-}\bar{3}$; *l*, $i\text{-}\bar{1}$; *β*, $i\text{-}\bar{5}'$; h^2, $i\text{-}\bar{3}'$; *a*, $i\text{-}\bar{2}'$; $h^{\frac{9}{2}}$, $i\text{-}\overline{\tfrac{11}{7}}'$; *u*, 1'; *w*, $i\text{-}\breve{3}$; *μ*, $4\text{-}\breve{1}$; *y*, $2\text{-}\breve{1}'$; *b*, $2\text{-}\breve{1}$; *f*, $1\text{-}\breve{1}'$; *g*, $\frac{2}{3}\text{-}\breve{1}'$; *φ*, 3; *π*, 2; *r*, 1; *e*, −1; L, $\frac{5}{4}$; *z*, $\frac{1}{2}$; *s*, $2\text{-}\bar{1}$; *d*, $4\text{-}\breve{2}$; *σ*, $-4\text{-}\breve{2}$; *t*, $7\text{-}\breve{\tfrac{7}{3}}$; *ρ*, $-7\text{-}\breve{\tfrac{7}{3}}$; *k*, $6\text{-}\breve{3}$; *x*, 1'; *n*, $3\text{-}\breve{3}$; *c*, $-3\text{-}\breve{3}$; *δ*, $\frac{3}{2}\text{-}\breve{3}$; *o*, $-\frac{3}{2}\text{-}\breve{3}$; *ψ* $-1\text{-}\breve{3}$; *ν*, $3\text{-}\breve{3}'$; *q*, $-5\text{-}\breve{5}$; *ζ*, $-1\text{-}\breve{5}$; *θ*, $\frac{7}{2}\text{-}\breve{7}$; *i*, $3\text{-}\bar{3}$; *ε*, $\frac{5}{2}\text{-}\breve{\tfrac{5}{3}}$; *ξ*, $\frac{8}{3}\text{-}\breve{\tfrac{4}{3}}$; *τ*, $\frac{10}{3}\text{-}\breve{\tfrac{5}{4}}$.

axis, that of the zone p, m, r, as macrodiagonal axis, and that of the zone y, m, b, as brachydiagonal axis. This position has been chosen to facilitate the comparison with datolite, which will be made in this paper.

New planes were observed on some of the crystals, but unfortunately their nature was not such as to admit of measurements sufficiently accurate for their determination.

In examining these crystals I have been struck with the resemblance between them and crystals of datolite, which I will now endeavor to make manifest. If we take for the crystallographic axes of axinite those adopted in the figures, and choose l for the fundamental, right hemi-prism and z for the upper hemi-macrodome, $1\bar{\imath}$, the other planes will have the parameters given in the first column of table II. In this table all the forms, hitherto published as definitely established, are given with their parameters in this new position, and, for convenience of reference, with their parameters in the positions adopted by Miller, Naumann, DesCloizeaux, Schrauf and v. Rath.

The values for this new position, of the angles between the axes and between the axial planes and of the lengths of the axes, as calculated from the measurements of v. Rath, are the following:

$\bar{b} : \overset{|}{c} = \alpha = 81° 56' 59''$ $\qquad$ $O : \breve{\infty} = A = 82° 09' 48''$

$\breve{a} : \overset{|}{c} = \beta = 91° 51' 28''$ $\qquad$ $O : \bar{\infty} = B = 90° 04' 21''$

$\breve{a} : \bar{b} = \gamma = 102° 52' 14''$ $\qquad$ $\breve{\infty} : \bar{\infty} = C = 102° 44' 18''$

$$\breve{a} : \bar{b} : \overset{|}{c} = 1 : 1{\cdot}56003 : 0{\cdot}48742$$

The corresponding values for datolite, in the position adopted by Dana, are

$\beta = 90° 06'$ $\qquad$ $B = 90° 06'$

$$\breve{a} : \bar{b} : \overset{|}{c} = 1 : 1{\cdot}5712 : 0{\cdot}49695$$

The axis $\breve{a}$ is here the clinodiagonal axis.

There is quite a close correspondence in the axial lengths of the two minerals, but the considerable divergences in two of the axial angles may do much to render it nugatory. A more definite criterion is furnished by a comparison of the angles between similar planes. To facilitate such a comparison I have prepared table III. Under the column headed datolite, the letters and angles are those given by E. S. Dana in his article on the crystallization of datolite in Tschermak's Min. Mitt., 1874, No. 1. As for each hemi-pyramid, prism and clinodome of the monoclinic system there are two corresponding forms in the triclinic, not making the same angles with the axial planes, I have added a second column of angles under axinite in which are carried out the angles for those simple forms of axinite which correspond to simple forms of datolite, and the *averages* of the angles made with an axial plane by the two simple forms of axinite corresponding to but one simple form of datolite.

TABLE III.

	Datolite.		Axinite.		
100 : 010	*a* : *b*	90°	*p* : *v*	77° 16′	77° 16′
100 : 001	*a* : *c*	89 54′	*p* : *m*	89 56	89 56
010 : 001	*b* : *c*	90	*v* : *m*	97 50	97 50
100 : 110	*a* : M	32 28	*p* : *l*	28 54	
100 : $1\bar{1}0$			wanting		
100 : 120	*a* : *o*	51 51	*p* : *u*	44 28	52 28
100 : $1\bar{2}0$			*p* : *w*	60 28	
120 : $1\bar{2}0$	*o* : *o′*	103 42	*u* : *w*	104 58	104 58
001 : 101	*c* : *u*	26 25	*m* : *z*	26 20	26 20
001 : 201	*c* : *x*	44 47	*m* : *r*	44 41	44 41
001 : $\bar{2}01$	*c* : *ξ*	44 53	*m* : *e*	44 45	44 45
001 : 021	*c* : *g*	32 19	*m* : *f*	34 49	
001 : $0\bar{2}1$			wanting		
001 : 041	*c* : *m*	51 41	*m* : *y*	56 58	52 05
001 : $0\bar{4}1$			*m* : *b*	47 13	
041 : $0\bar{4}1$	*m* : *m′*	103 22	*y* : *b*	104 11	104 11
001 : 441	*c* : *n*	66 56	*m* : *s*	72 12	66 28
001 : $4\bar{4}1$			*m* : *d*	60 44	
001 : $\bar{4}41$	*c* : *ν*	67 03	*m* : *σ*	68 36	
001 : $\bar{4}\bar{4}1$			wanting		
100 : 441	*a* : *n*	39 01	*p* : *s*	33 18	39 12
100 : $4\bar{4}1$			*p* : *d*	45 07	
100 : $\bar{4}41$	*a* : *ν*	39 04	*p* : *σ*	41 09	
100 : $\bar{4}\bar{4}1$			wanting		
001 : 241	*c* : Q	58 06	*m* : *x*	65 01	57 45
001 : $2\bar{4}1$			*m* : *n*	50 29	
100 : 241	*a* : Q	58 18	*p* : *x*	49 25	58 25
100 : $2\bar{4}1$			*p* : *n*	67 26	

A comparison of the angles in this second column under axinite with those in the column under datolite will show a close agreement in the angles between similar planes, except only in two of the angles between the axial planes. Axinite thus appears like a distorted datolite, and though the distortion is considerable, it is by no means sufficient to obliterate the resemblance between them. A peculiarity common to both minerals is worthy of notice. The zones *a*, *x*, *c*, *ξ* of datolite, and *p*, *r*, *m*, *e* of axinite have each four planes, the poles of which are separated by arcs of nearly 45°, and the other planes of the crystals seem to be grouped around the respective axes of these zones with an approach to tetragonal symmetry. All of the planes required by this degree of symmetry may not be present, but those which do occur have approximately the positions which such a law of symmetry would assign to them.

Table III would lead one to infer that there must be some similarity in habit between axinite and datolite. Further comparison will confirm this conclusion. In an examination of the published descriptions of crystals of axinite from various localities I have found twenty forms, viz: *p*, *v*, *m*, *l*, *u*, *w*, *y*, *b*, *f*, *g*, *r*, *e*, *z*, *s*, *d*, *x*, *n*, *c*, *δ*, *o*, mentioned as occurring in three or more localities. Of these all but one (*c*) correspond to forms occurring in datolite, and fifteen of them correspond to forms common to the crystals of datolite from all of the four localities given by Dana in his article, cited above. Of the forty-two simple forms yet discovered in axinite, twenty-eight correspond to forms occurring in datolite. Conversely all of the eleven simple forms of datolite mentioned as common to all the localities given (equivalent to sixteen simple forms of axinite) are represented, partly or wholly, by corresponding forms of axinite, and ten of these forms of datolite are represented by frequently occurring planes of axinite. As datolite crystals are far richer in planes than those of axinite, there must be many forms in the former mineral which are not represented by corresponding forms of the latter. From what has been adduced, however, it is clear that, so far as regards the commonly occurring forms of the two minerals, there is a close correspondence between them in habit as well as in angles.

Calamine is another mineral showing analogies in its crystals to those of datolite. The similarity between the crystalline forms of these two minerals seems to have been observed by Miller. This I infer from his having chosen positions for both minerals which would bring out the resemblance between them, and from his having placed datolite in his edition of Phillips' Mineralogy immediately after smithsonite, by which name he calls Brongniart's calamine. I am not aware of any express statement of such a resemblance by him or any other mineralogist. The similarity will be made sufficiently plain by a comparison of the following angles between corresponding planes of the two minerals, taken from the work just quoted—

	Calamine.	Datolite.	
010 : 011	58° 20′	57° 43′	010 : 021
001 : 101	25° 46½′	26° 34′	001 : 101
100 : 110	51° 56½′	51° 38′	100 : 120
001 : 211	48° 54′	49° 47′	001 : 221
100 : 411	31° 19′	30° 36′	100 : 421

Miller's fundamental pyramid, $\bar{1}$ (111), for datolite is Dana's clino-pyramid $2\grave{2}$ (121). The fourth column gives the parameters of the planes in question, if referred to Dana's fundamental form for datolite.

The lengths of the axes for calamine in a position and with a fundamental form similar to those adopted by Dana for datolite are—

$$\breve{a} : \bar{b} : \grave{c} = 1 : 1{\cdot}5564 : 0{\cdot}47657.$$

There does not seem to be as great a similarity in habit between calamine and datolite as there is between axinite and datolite.

With regard to the chemical composition of these minerals, a quite evident analogy appears to exist between the formulas of calamine and of datolite.

From an experiment of Herr Fock in Groth's laboratory it appears that calamine contains no water of crystallization, as it remained unchanged at a temperature of 340° C., and yielded water only at a red heat. Groth therefore classes it among the basic silicates with a quantivalent ratio of 3 : 2.* The empirical formula of calamine is $H_2Zn_2SiO_5$. That of datolite is $HBCaSiO_5$ with the same quantivalent ratio.

With regard to axinite the analogy is by no means so clear. Rammelsberg's formula for it is $\acute{R}_2\acute{\acute{R}}_6\text{R}_3Si_8O_{32}$. This would make it a unisilicate. It appears to me unlikely, however, that the close resemblance in crystallization between axinite and datolite is a mere accidental coincidence. The balance of probability is in favor of the conclusion that this morphological resemblance is due to some similarity (however obscure at present) in chemical composition.

I would not be understood as proposing the adoption of a new position for the crystals of axinite. The position and fundamental form similar to those adopted by Dana for datolite have been employed in this paper simply to bring out more clearly the resemblance to datolite. This resemblance is, however, quite evident in Miller's position also, and, as far as axinite alone is concerned, this latter position is, I think, decidedly the best yet proposed. It combines the following advantages. The axes of two of the most prominent zones of the crystal coincide with two of the crystallographic axes, to which also are parallel the most common striations of its planes. The three pinacoids, the two fundamental hemi-prisms, three of the fundamental tetarto-pyramids, the hemi-macrodomes, $1\text{-}\bar{\imath}$ and $-1\text{-}\bar{\imath}$, and the hemi-brachydomes, $1\text{-}\breve{\imath}'$ and $1\text{-}\breve{\imath}$, are all represented by commonly occurring planes. The parameters of the planes in general are simpler than when referred to any other fundamental form and axial system, not excepting those of Schrauf. There is no great departure from a right angle in any of the angles between the axes. Finally it brings into evidence the resemblance to

* Tabellarische Uebersicht der Mineralien, 2d ed., p. 84.

datolite. When it is definitely known what are the minerals composing the datolite group, and after a careful survey of the crystalline forms of all the members of that group, it may be advisable to sacrifice some of these advantages, for the sake of bringing axinite into line with the others. Until such an occasion arises, the general adoption of Miller's position is, in my opinion, to be recommended by the considerations just given. In drawing crystals of axinite in Miller's position it will be well to make his brachy-diagonal axial plane the plane of projection, as has been done in the accompanying figures. An inspection of the figures will show that this position is not ill adapted for the representation of the commonly occurring planes, and for conveying a clear idea of the general shape of the crystal.

Lehigh University, Bethlehem, Pa., November 4th, 1882.

ART. LII.—*Notice of the remarkable Marine Fauna occupying the outer banks off the Southern Coast of New England, No.* 8; by A. E. VERRILL. (Brief Contributions to Zoology from the Museum of Yale College: No. LIV.)

[Published by permission of Professor S. F. Baird, U. S. Commissioner of Fish and Fisheries.]

Nature and origin of the sediments. Occurrence of fossiliferous Limestone-nodules.

A LIST of most of the stations occupied this season by the U. S. Fish Commission steamer "Fish Hawk" has been given in a previous article. After that article was in type, another trip was made to the Gulf Stream slope by the Fish Hawk. A list of these additional stations is now given, together with those occupied by the "Josie Reeves," while fishing for the "tile-fish." In the lists the general character of the bottom is indicated, as well as the depth and temperature.

A detailed description of the materials covering the bottom, in this region, cannot be given, at this time, but certain facts, observed by us, are of sufficient geological interest to justify a brief notice. At several localities, but especially at stations 1121, 1122 and 1124, in 234, 351 and 640 fathoms, respectively, we dredged fragments and nodular masses, or concretions, of a peculiar calcareous rock, evidently of deep-sea origin, and doubtless formed at or near the places where it was obtained. These specimens varied in size from a few inches in diameter up to one irregular nodular or concretionary mass, taken at station 1124, in 640 fathoms, which was 29 inches long, 14 broad, and 6 thick, with all parts well rounded. This probably weighed 60 pounds or more. The masses differ much in appearance, color, texture, and fineness of grain, but they are all composed of grains of siliceous sand, often very fine, cemented by more or less abundant calcareous matter. In some, the grains of sand are large enough to be easily seen by the naked eye, and small quartz pebbles often occur in them, but in others the sand-grains are so fine that a microscopic examination is needed to distinguish them. These fine-grained varieties of the rock are often exceedingly compact, heavy, hard and tough, usually grayish or greenish in color. They usually weather brown, from the presence of iron (probably as carbonate). The sand consists mainly of rounded grains of quartz, with some feldspar, mica, garnet and magnetite. It is like the loose sand dredged from the bottom in the same region. The calcareous cementing material seems to have been derived mainly from the shells of foraminifera abundantly disseminated through the sand, just as we find the recent foraminifera, in the same region. In some cases I was able to identify distinct casts of foraminifera, in the rock. In some pieces of the rock distinct fossil shells were found, apparently of recent species (*Astarte*, etc.). The larger masses appear to have been, originally, concretions in a softer deposit, which has been more or less worn away, leaving the hard nodules so exposed that the trawl could pick them up. The age of these rocks may, however, be as great as the pleistocene, or even the pliocene, so far as the evidence goes. Moreover, it is probable that they belong to a part of the same formation as the masses of fossiliferous sandy limestone and calcareous sandstone, often brought up by the Gloucester fishermen, from deep water, on all the fishing banks, from George's to the Grand Bank, as I have formerly recorded in this Journal. No rocks of this kind are found on the dry land of this coast.

Throughout the Gulf-stream slope examined by us, the bottom, in 70 to 300 fathoms, 60 to 120 miles from the shore, is composed mainly of very fine sand, largely quartz, with grains of feldspar, mica, magnetite, etc.; with it there is always a considerable percentage of shells of foraminifera, and other calcareous organisms, and also spherical, rod-like, and stellate, sand-covered rhizopods, often in large quantities. In the deeper localities there is usually more or less genuine mud, or clay, but this is often almost entirely absent, even in 300 to 500 fathoms. The sand, however, is often so fine as to resemble mud, and is frequently so reported, when the preliminary soundings are made and recorded. In many instances, even in our deepest dredgings (over 700 fathoms), and throughout the belt examined, we have taken numerous pebbles and small rounded boulders, of all sizes, up to several pounds in weight, consisting of granite, syenite, mica-schist, etc. These are sometimes abundant and covered with *Actiniæ*, etc. Probably these have been recently floated out to this region, while frozen into the shore-ice, in winter and spring, from our shores and rivers, and dropped in this region, where the ice melts rapidly under the influence of the warmer Gulf-stream water. Possibly much of the sand, especially the coarser portions, may have been transported by the same agency. Another way, generally overlooked, in which fine beach-sand may be transported long distances, is by reason of its floating on the surface of the water after it has been exposed to the air on the beaches and dried. The rising tide always carries off a certain amount of fine dry sand floating in this way. In our fine towing-nets we always take more or less fine siliceous sand, which evidently was floating on the surface, even at considerable distances from the shore.

The prevalence of fine sand, along the Gulf-stream slope, in this region, and the remarkable absence of actual mud or clay deposits indicate that there is here, at the bottom, sufficient current to prevent, for the most part, the deposition of fine argillaceous sediments over the upper portion of the slope, in 65 to 150 fathoms. Such materials are probably carried along till they eventually sink into the greater depths nearer the base of the slope, or beyond, in the ocean basin itself, where the currents are less active. It is probable that such a movement of the water may be partly due to tidal currents, as well as to the actual northward flow of the Gulf Stream, which is here slow, even at the surface.* It is not probable, however, that the bottom currents are strong enough to move even the fine sand, after it has once actually reached the bottom; nor is it strong enough to prevent the general deposition of oceanic foraminifera, pteropods, etc. I have, above, suggested that the loose nodules of limestone may have been derived from softer rocks or unconsolidated materials by the removal or wearing away of the latter. The existence of actual currents sufficiently powerful to directly effect such erosion is hardly supposable. I believe, however, that such a result may be due directly to the habits of certain fishes and crustacea that so abound on these bottoms. Many fishes, like the "hake" (*Phycis*), of which two species are common here, have the habit of rooting in the mud, like pigs, for their food, which consists largely of Annelida and other

* Our observations fully demonstrate that the western edge of the Gulf Stream is nearer the coast than it has hitherto been located on the charts. In summer, as is well known, it is nearer the coast than in winter, but this doubtless applies strictly to the *surface-water*. Our researches show that the warm-belt, in 65 to 125 fathoms, is inhabited by a peculiar southern fauna, that could not exist there if the Gulf Stream did not flow along this area, *at the bottom*, both in winter and summer. But it is evident that what many of these species require is not a very *high*, but a *nearly uniform* temperature. Such an equable temperature cannot exist in this region except under the direct and constant influence of the Gulf Stream.

mud-dwelling creatures. Other fishes, those with sharp tails especially, burrow actively into the mud or sand, tail first, and in all probability *Macrurus*, abundant in this region, has this habit. Several species of eels and eel-like fishes are very abundant on these bottoms. These are all burrowers. The "slime-eel" or hag (*Myxine glutinosa*) was also taken in large numbers, both in the trawl and in traps. Many crabs and allied forms are active burrowers. Such creatures, by stirring up the bottom-sediments continually, would give the currents a chance to carry away the finer and lighter materials, leaving the coarser behind.

In many localities, in the region under consideration, there are great quantities of dead shells, both broken and entire. A small proportion of the bivalves have been drilled by carnivorous gastropods, but there are large numbers that show no injury whatever. There is no doubt, in my mind, but that these have, for the most part, served as food for the star-fishes, so abundant on these grounds, and from which I have often taken entire shells, of many kinds, including pteropods. Many fishes, like the cod, haddock, hake, etc., have the habit of swallowing shells entire, and after digesting the contents, they disgorge the uninjured shells, and such fishes abound here. The broken shells have probably been preyed upon by the crabs and other crustacea, having claws strong enough to crack the shells. The large species of *Cancer* and *Geryon*, and the larger Paguroids, abundant in this region, have strength sufficient to break most of the bivalve shells. Although I have often seen such crustacea break open bivalves for food, I am well aware that they also feed on other things.* Many fishes that feed on mollusca break the shells before swallowing them, so that both fishes and crabs have doubtless helped to accumulate the broken shells that are very often scattered abundantly over the bottom, both in deep and in shallow water. Such accumulations of shells would soon become far more extensive if they were not attacked by boring sponges and annelids. Certain common sponges belonging to the genus *Cliona* very rapidly perforate the hardest shells, in every direction, making irregular galleries, and finally utterly destroying them. In our shallower waters the most destructive species is *C. sulphurea* (Desor), which burrows in shells and limestone when young, but later grows into large, rounded, sulphur-yellow masses,

* I have observed that, when in aquaria, many different species of the larger crustacea, such as the crabs, *Libinia emarginata*, *Cancer irroratus*, *Panopeus Sayi*, *Carcinas mænas*, *Platyonicus occellatus*; the hermit-crabs, *Eupagurus pollicaris*, *E. longicarpus* and *Catapagurus socialis*; the shrimp, *Palæmonetes vulgaris* and *Virbius zostericola*; and *Limulus polyphemus*, are all extravagantly fond of the masses of diatoms and other fine algæ, intermingled with copeopods, etc., which we often collect in our surface-nets. When a mass of such materials is thrown into an aquarium containing these crustacea they seize and devour it with great avidity.

often a foot in diameter. In deep water other species occur. Rarely, we dredge up, on the outer grounds, fragments of wood, but these are generally perforated by the borings of bivalves (usually *Xylophaga dorsalis*) and other creatures, and are evidently thus soon destroyed. Very rarely do we meet with the bones of vertebrates at a distance from the coast. Although these waters swarm with vast schools of fishes, while sharks, and a large sea-porpoise or dolphin (*Delphinus*, sp.) occur in large numbers, we have, very rarely indeed, dredged up any of their bones, or, in fact, remains of any other vertebrate animals. In a few instances we have dredged a single example of a shark's tooth, and occasionally the hard otoliths of fishes. It is certain that not merely the flesh, but most of the bones, also, of all vertebrates that die in this region are very speedily devoured by the various animals that inhabit the bottom. Echini are very fond of fish-bones, which they rapidly consume. Relics of man and his works are of extremely rare occurrence, at a distance from the coast, or outside of harbors, with the exception of the clinkers and fragments of coal thrown overboard from steamers with the ashes. As our dredgings are in the track of European steamers, such materials are not rare. A few years ago even these would not have occurred. A rock forming on this sea-bottom would, therefore, contain little evidence of the existence of man, or even of the existence of the commonest fishes and cetaceans inhabiting the same waters.

Additional Stations occupied in 1882.

Stat.	Locality.		Fathoms.	Bottom.	Date.	Temp'rature.		Hour.
						Bottom.	Surface.	
	Off Martha's Vineyard. Sch. "Josie Reeves."							
	N. Lat.	W. Long.			Sept.			
1145	40° 03′ 00″;	70° 28′ 00″	135	fine sand	20			
1146	40 02 00;	70 41 00	140	fine sand	21			
1147	40 01 00;	70 54 00	125	--------	22			
1148	39 54 00;	71 22 00	110	hard sand, sponges	23			
1149				hard sand, sponges				
	Off Martha's Vineyard. "Fish Hawk."				Oct.			
1150	39° 58′ 00″;	70° 37′ 00″	140	sand	4	47°	62°	6·35 A.M.
1151	39 58 30;	70 37 00	125	sand	4	48	62	7·45 "
1152	39 58 00;	70 35 00	115	sand	4	48	62	8·42 "
1153	39 54 00;	70 37 00	225	sand, mud	4	44	62·5	10·45 "
1154	39 55 31;	70 39 00	193	sand, mud	4		62·5	12·10 P.M.
1155	39 52 00;	70 30 00	554	v'y fine sand, soft m.	4	40	63	4·06 "

NOTE.—In the last article of this series, I referred to the adoption of steel wire rope, since 1880, for dredging on the Fish Hawk, as having greatly expedited our work. This great improvement, first introduced by Lieut. Com. C. D. Sigsbee, on the Coast Survey steamer Blake, in 1877–8, was suggested by Mr. A. Agassiz, who used it during that cruise, and also on subsequent ones on the Blake, when commanded by Lieut. Bartlett. Its introduction and use has been described by Mr. Agassiz in his reports, and also, in detail, by Captain Sigsbee, in his extended work on Deep Sea Sounding and Dredging. Our arrangements, on the Fish Hawk, for reeling in the wire rope were unlike those on the Blake, for we used only one drum, with 1000 fathoms of rope on it. The use of steel wire for sounding goes back to an earlier date than is commonly supposed. It was extensively used by Lieut. J. C. Walsh, U. S. N., on the schooner "Taney," in his survey of the Gulf Stream in 1849 (see Maury's Winds and Currents of the Sea, p. 56, 1851). Important improvements have since then been made in the reels for winding it in, by Sir Wm. Thomson, Captain Sigsbee, and others.

ART. LIII. — *Experiments in Cross-breeding Indian Corn with flowers of the same variety, the seed of which was raised one hundred miles away;* by Professor W. J. BEAL.

IN 1878 I reported some experiments in cross-breeding, made with Indian corn and with beans. The advantage shown by the crossing of corn with corn, the seed of which was grown some miles away, over that not so crossed was as 151 exceeds 100, and in the case of black wax beans it was as 236 exceeds 100.

In 1879 and 1880, a similar experiment was made with Indian corn showing that seed from crossed stock produced corn excelling that raised from uncrossed seed as $109\frac{67}{100}$ exceeds 100, or nearly ten per cent in favor of crossed stock.

In the spring of 1881, I obtained two lots of white flint corn; one from Oakland County, the other from Allegan County, about 100 miles apart. These places are in the same latitude in Michigan. The corn from Oakland had been raised for ten years on one farm; that from Allegan six years in the same neighborhood. In one patch of alternate rows of Oakland and Allegan corn, all of the Allegan corn was castrated by pulling out the tassels before flowering. On former experiments, castration has been found to cause the ears to grow larger than they otherwise would grow. Still, with castration in favor of the Allegan corn, it did not produce ears which were so large or evenly developed as did the corn from Oakland County. The Oakland County seed corn was the better of the two.

Owing to an accident, we failed to raise any pure Allegan seed in 1881. The "crossed corn" in 1882 was only compared with pure Oakland seed raised last year at this place.

In the spring of 1882, on good even soil, three rows of "crossed seed" were planted in rows alternating with three rows of pure Oakland County seed of 1881. By an oversight, each row of each lot was not kept separate. The pure seed in the cob nearly dried, yielded $57\frac{1}{2}$ pounds. The "crossed seed" yielded $69\frac{1}{2}$ pounds. In other words, the crossed stock exceeded the pure stock of the best parent nearly as 121 exceeds 100.

CHARLES DARWIN.

[Biographical notice by Dr. Asa Gray. From the Proceedings of the American Academy of Arts and Sciences, volume xvii, May, 1882.]

CHARLES DARWIN died on the 19th of April last, a few months after the completion of his 73d year; and on the 26th, the mortal remains of the most celebrated man of science of the nineteenth century were laid in Westminster Abbey, near to those of Newton.

He was born at Shrewsbury, Feb. 12, 1809, and was named Charles Robert Darwin. But the middle appellation was omitted from his ordinary signature and from the title-pages of the volumes which, within the last twenty-five years, have given such great renown to an already distinguished name. His grandfather, Dr. Erasmus Darwin, — who died seven years before his distinguished grandson was born,—was one of the most notable and original men of his age; and his father, also a physician, was a person of very marked character and ability. His maternal grandfather was Josiah Wedgwood, who, beginning as an artisan potter, produced the celebrated Wedgwood ware, and became a Fellow of the Royal Society and a man of much scientific mark. The importance of heritability, which is an essential part of Darwinism, would seem to have had a significant illustration in the person of its great expounder. He was educated at the Shrewsbury Grammar School and at Edinburgh University, where, following the example of his grandfather, he studied for two sessions, having the medical profession in view, and where, at the close of the year 1826, he made his first contribution to natural history in two papers (one of them on the ova of Flustra). Soon finding the medical profession not to his liking, he proceeded to the University of Cambridge, entering Christ's College, and took his bachelor's degree in 1831; that of M.A. in 1837, after his return from South America.

It is said that Darwin was a keen fox-hunter in his youth,—not a bad pursuit for the cultivation of the observing powers. There is good authority for the statement—though it has nowhere been made in print—that at Cambridge he was disposed at one time to make the Church his profession, following the example of Buckland and of his teacher, Sedgwick. But in 1831, just as he was taking his bachelor's degree, Captain Fitzroy offered to receive into his own cabin any naturalist who was disposed to accompany him in the Beagle's surveying voyage round the world. Mr. Darwin volunteered his services without salary, with the condition only that he should have the disposal of his own collections. And this expedition of nearly five years—from the latter part of September, 1831, to the close of October, 1836—not only fixed the course and character of the young naturalist's life-work, but opened to his mind its principal problems and suggested the now familiar solution of them. For he brought back with him to England a conviction that the existing species of animals and plants are the modified descendants of earlier forms, and that the internecine struggle for life in which these modifiable forms must have been engaged would scientifically explain the changes. The noteworthy point is that both the conclusion and the explanation were the legitimate outcome of real scientific investigation. It is an equally noteworthy fact, and a characteristic of Darwin's mind, that these pregnant ideas were elaborated for more than twenty years before he gave them to the world. Offering fruit so well ripened upon the bough, commending the conclusions he had so thoroughly matured by the presentation of very various lines of facts, and of reasonings close to the facts, unmixed with figments and *à priori* conceptions, it is not so surprising that his own convictions should at the close of the next twenty years be generally shared by scientific men. It is certainly gratifying that he should have lived to see it, and also have outlived most of the obloquy and dread which the promulgation of these opinions aroused.

Mr. Darwin lived a very quiet and uneventful life. In 1839 he married his cousin, Emma Wedgwood, who with five sons and two daughters survives him; he made his home on the border of the little hamlet of Down, in Kent,—"a plain but comfortable brick house in a few acres of pleasure-ground, a pleasantly old-fashioned air about it, with a sense of peace and silence;" and here, attended by every blessing except that of vigorous health, he lived the secluded but busy life which best suited his chosen pursuits and the simplicity of his character. He was seldom seen even at scientific meetings, and never in general society; but he could welcome his friends and fellow-workers to his own house, where he was the most charming of hosts.

At his home, without distraction and as continuously as his bodily powers would permit, Mr. Darwin gave himself to his work. At least ten of his scientific papers, of greater or less extent, had appeared in the three years between his return to England and his marriage; and in the latter year (1839) he published the book by which he became popularly known, viz: the "Journal of Researches into the Natural History and Geology of the Countries visited during the Voyage of the Beagle," which has been pronounced "the most entertaining book of genuine travels ever written," and it certainly is one of the most instructive. His work on "Coral Reefs" appeared in 1842, but the substance had been communicated to the Geological Society soon after his return to England; his papers on "Volcanic Islands," on the "Distribution of Erratic Boulders and Contemporaneous Unstratified Deposits in South America," on the "Fine Dust which falls on Vessels in the Atlantic Ocean," and some other geological as well as zoological researches, were published previously to 1851. Between that year and 1855 he brought out his most considerable contributions to systematic zoology, his monographs on the Cirripedia and the Fossil Lepadidæ.

We come to the first publication of what is now known as Darwinism. It consists of a sketch of the doctrine of Natural Selection, which was drawn up in the year 1839, and copied and communicated to Messrs. Lyell and Hooker in 1844, being a part of the manuscript of a chapter in his "Origin of Species;" also of a private letter addressed to the writer of this memorial in October, 1857,—the publication of which (in the Journal of the Proceedings of the Linnean Society, Zoological Part, iii, 45–53, issued in the summer of 1858) was caused by the reception by Darwin himself of a letter from Mr. Wallace, inclosing a brief and strikingly similar essay on the same subject, entitled "On the Tendency of Varieties to depart indefinitely from the Original Type." Mr. Darwin's action upon the reception of this rival essay was characteristic. His own work was not yet ready, and the fact that it had been for years in preparation was known only to the persons above mentioned. He proposed to have the paper of Mr. Wallace (who was then in the Moluccas) published at once, in anticipation of his own leisurely preparing volume; and it was only under the solicitation of his friends cognizant of the case that his own early sketch and the corroboratory letter were printed along with it.

The precursory essays of Darwin and Wallace, published in the Proceedings of a scientific society, can hardly have been read except by a narrow circle of naturalists. Most thoughtful investigating naturalists were then in a measure prepared for them. But toward the close of the following year (in the autumn of 1859) appeared the volume "On the Origin of Species by means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life," the first and most notable of that series of duodecimos which have been read and discussed in almost every cultured language, and which within the lifetime of their author have changed the face and in some respect the character of natural history,—indeed have almost as deeply affected many other lines of investigation and thought.

In this Academy, where the rise and progress of Darwinian evolution have been attentively marked and its bearings critically discussed, and at this date, when the derivative origin of animal and vegetable species is the accepted belief of all of us who study them, it would be superfluous to give any explanatory account of these now familiar writings; nor, indeed, would the pages which we are accustomed to consecrate to the memory of our recently deceased Associates allow of it. Let us note in passing that the succeeding volumes of the series may be ranked in two classes, one of which is much more widely known than the other. One class is of those which follow up the argument for the origination of species through descent with modification, or which widen its base and illustrate the *modus operandi* of Natural Selection. Such are the two volumes on "Domesticated Animals and Cultivated Plants," illustrating Variation, Inheritance, Reversion, Interbreeding, &c.; the volume on the "Descent of Man, and Selection in Relation to Sex,"—which extended the hypothesis to its logical limits,—and that "On the Expression of the Emotions in Man and the Lower Animals," published in 1872, which may be regarded as the last of this series. Since then Mr. Darwin appears to have turned from the highest to the lower forms of life, and to have entered upon the laborious cultivation of new and special fields of investigation, which, although prosecuted on the lines of his doctrine and vivified by its ideas, might seem to be only incidentally connected with the general argument. But it will be found that all these lines are convergent. Nor were these altogether new studies. The germ of the three volumes upon the Relation of Insects to Flowers and its far-reaching consequences, is a little paper, published in the year 1858, "On the Agency of Bees in the Fertilization of Papilionaceous Flowers, and on the Crossing of Kidney Beans;" the first edition of the volume on "The various Contrivances by which Orchids are Fertilized by Insects" appeared in 1862, thus forming the second volume of the whole series; and the two volumes "On the Effects of Cross- and Self-Fertilization in the Vegetable Kingdom," and "The Different Forms of Flowers on Plants of the same Species," which, along with the new edition of "The Fertilization of Orchids," were all published in 1876 and 1877, originated in two or three remarkable papers contributed to the Journal of the Linnean Society in 1862 and 1863, but are supplemented by additional and protracted experiments. The volume on "Insectivorous Plants," and the noteworthy conclusions in respect to the fundamental unity, and therefore common source, of vegetable and animal life, grew out of an observation which the author made in the summer of 1860, when he "was surprised by finding how large a number of insects were caught by the leaves of the common Sun-dew (*Drosera rotundifolia*), on a heath in Sussex." Almost everybody had noticed this; and one German botanist (Roth), just a hundred years ago, had observed and described the movement of the leaf in consequence of the capture. But nothing came of it, or of what had been as long known of our *Dionæa*, beyond a vague wonderment, until Mr. Darwin took up the subject for experimental investigation. The precursor of his volume on "The Movements and Habits of Climbing Plants," published in 1875, as well as of the recent and larger volume on "The Power of Movement in Plants," 1880, was an essay published in the Journal of the Linnean Society in 1865; and this was instigated by an accidental but capital observation made by a correspondent, in whose hands it was sterile; but it became wonderfully fertile when touched by Darwin's genius.* His latest volume, on "The Formation of Vegetable Mould through the Action of Worms," is a development, after long years, of a paper which he read before the Geological Society of London in 1837.

These subsidiary volumes are less widely known than those of the other class; but they are of no less interest, and they are very characteristic of the author's genius and methods,—characteristic also of his laboriousness. For the amount of prolonged observation, watchful care, and tedious experiment they have demanded is as remarkable as the skill in devising simple and effectual modes of investigation is admirable. That he should have had the courage to undertake and the patience to carry on new inquiries of this kind after he had reached his threescore and ten years of age, and after he had attained an unparalleled breadth of influence and wealth of fame, speaks much for his energy and for his devotion to knowledge for its own sake. Indeed, having directed the flow of scientific thought into the new channel he had opened, along which the

* Mr. Darwin's quickness in divining the meaning of seemingly unimportant things, is illustrated in his study of *Dionæa.* Noting that the trap upon irritation closes at first imperfectly, leaving some room within and a series of small interstices between the crossed spines, but after a time, if there is prey within, shuts down close, he at once inferred that this was a provision for allowing small insects to escape, and for retaining only those large enough to make the long process of digestion remunerative. To test the surmise, he asked a correspondent to visit the habitat of *Dionæa* at the proper season, and to ascertain by the examination of a large number of the traps in action whether any below a certain considerable size were to be found in them. The result confirmed the inference. A comparatively trivial but characteristic illustration of Darwin's confidence in the principle of utility, and a good example of the truth of the dictum, which was by some thought odd when first made, namely, that Darwin had restored teleology to natural history, from which the study of morphology had dissevered it.

current set quicker and stronger than he could have expected, he seems to have taken up with fresh delight studies which he had marked out in early years, or topics which from time to time had struck his acute attention. To these he gave himself, quite to the last, with all the spirit and curiosity of youth. Evidently all this amount of work was done for the pure love of it; it was all done methodically, with clear and definite aim, without haste, but without intermission.

It would confidently be supposed that in this case genius and industry were seconded by leisure and bodily vigor. Fortunately Darwin's means enabled him to control the disposition of his time. But the voyage of the Beagle, which was so advantageous to science, ruined his health. A sort of chronic sea-sickness, under which all his work abroad was performed, harassed him ever afterwards. The days in which he could give two hours to investigation or writing were counted as good ones, and for much of his life even these were largely outnumbered by days in which nothing could be attempted. Only by great care and the simplest habits was he able to secure even a moderate amount of comfortable existence. But in this respect his later years were the best ones, and therefore the busiest. In them also he had most valuable filial aid. There was nothing to cause much anxiety until his seventy-third birthday had passed, or to excite alarm until the week before his death.

It may without exaggeration be said that no scientific man, certainly no naturalist, ever made an impression at once so deep, so wide, and so immediate. The name of Linnæus might suggest comparison; but readers and pupils of Linnæus over a century ago were to those of Darwin as tens are to thousands, and the scientific as well as the popular interest of the subjects considered were somewhat in the same ratio. Humboldt, who, like Darwin, began with research in travel, and to whom the longest of lives, vigorous health, and the best opportunities were allotted, essayed similar themes in a more ambitious spirit, enjoyed equal or greater renown, but made no deep impression upon the thought of his own day or of ours. As one criterion of celebrity, it may be noted that no other author we know of ever gave rise in his own active lifetime to a special department of bibliography. Dante-literature and Shakespeare-literature are the growth of centuries; but *Darwinismus* had filled shelves and alcoves and teeming catalogues while the unremitting author was still supplying new and ever novel subjects for comment. The technical term which he chose for a designation of his theory, and several of the phrases originated in explanation of it only twenty-five years ago, have already been engrafted into his mother tongue, and even into other languages, and are turned to use in common as well as in philosophical discourse, without sense of strangeness.

Wonderful indeed is the difference between the reception accorded to Darwin and that met with by his predecessor, Lamarck. But a good deal has happened since Lamarck's day; wide fields of evidence were open to Darwin which were wholly unknown to his forerunner; and the time had come when the subject of the origin and connection of living forms could be taken up as a research rather than as a speculation. Philosophizers on evolution have not been rare; but Darwin was not one of them. He was a scientific investigator,—a philosopher, if you please, but one of the type of Galileo. Indeed very much what Galileo was to physical science in his time, Darwin is to biological science in ours. This without reference to the fact that the writings of both conflicted with religious prepossessions; and that the Darwinian theory, legitimately considered, bids fair to be placed in this respect upon the same footing with the Copernican system.

An English poet wrote that he awoke one morning and found himself famous. When this happened to Darwin, it was a genuine surprise. Although he had addressed himself simply to scientific men, and had no thought of arguing his case before a popular tribunal, yet "The Origin of Species" was too readable a book upon too sensitive a topic to escape general perusal; and this, indeed, must in some sort have been anticipated. But the avidity with which the volume was taken up, and the eagerness of popular discussion which ensued, were viewed by the author,—as his letters at the time testify,—with a sense of amused wonder at an unexpected and probably transient notoriety.

The theory he had developed was presented by a working naturalist to his fellows, with confident belief that it would sooner or later win acceptance from the younger and more observant of these. The reason why these moderate expectations were much and so soon exceeded are not far to seek, though they were not then obvious to the world in general. Although mere speculations were mostly discountenanced by the investigating naturalists of that day, yet their work and their thoughts were, consciously or unconsciously, tending in the direction of evolution. Even those who manfully rowed against the current were more or less carried along with it, and some of them unwittingly contributed to its force. Most of them in their practical studies had worked up to, or were nearly approaching, the question of the relation of the past inhabitants of the earth to the present, and of the present to one another, in such wise as to suggest inevitably that, somehow or other, descent with modification was eventually to be the explanation. This was the natural outcome of the line of thought of which Lyell early became the cautious and fair-minded expositor, and with which he reconstructed theoretical geology. If Lyell had known as much at first hand of botany or zoology as he knew of geology, it is probable that his celebrated chapter on the permanence of species in the "Principles" would have been reconsidered before the work had passed to the ninth edition in 1853. He was convinced species went out of existence one by one, through natural causes, and that they came in one by one, bearing the impress of their immediate predecessors; but he saw no way to connect the two through natural operations. Nor, in fact, had any of the evolutionists been able to assign real causes capable of leading on such variations as are of well-known occurrence to wider and specific or generic differences. Just here came Darwin. When upon the spot he had perceived that the animals of the Galapagos must be modified forms derived from the adjacent continent, and he soon after worked out the doctrine of natural selection. This supplied what was wanting for the condensation of opinions and beliefs, and the collocation of rapidly accumulating facts, into a consistent and workable scientific theory, under a principle which unquestionably could directly explain much, and might indirectly explain more.

It is not merely that Darwin originated and applied a new principle. Not to speak of Wallace, his contemporary, who came to it later, his countryman, Dr. Wells, as Mr. Darwin points out, "distinctly recognizes the principle of natural selection, and this is the first recognition which has been indicated; but he applied it only to the races of men, and to certain characters alone." Darwin, like the rest of the world, was unaware of this anticipation until he was preparing the fourth edition of his "Origin of Species," in 1866, when he promptly called attention to it, perhaps magnifying its importance. However this be, Darwin appears to have been first and alone in apprehending and working out the results which necessarily come from the interaction of the surrounding agencies and conditions under which plants and animals exist, including, of course, their actions upon each other. Personifying the *ensemble* of these and the consequences,—namely, the survival only of the fittest in the struggle for life,—under the term of Natural Selection, Mr. Darwin with the instinct of genius divined, and with the ability of a master worked out its pregnant and far-reaching applications. He not only saw its strong points, but he foresaw its limitations, indicated most of the objections in advance of his opponents, weighed them with judicial mind, and where he could not obviate them, seemed never disposed to underrate their force. Although naturally disposed to make the most of his theory, he distinguished between what he could refer to known causes and what thus far is not referrible to them. Consequently, he kept clear of that common confusion of thought which supposes that natural selection originates the variations which it selects. He believed, and he has shown it to be probable, that external conditions *induce* the actions and changes in the living plant or animal which may lead on to the difference between one species and another; but he did not maintain that they *produced* the changes, or were sufficient scientifically to explain them. Unlike most of his contemporaries in this respect, he appears to have been thoroughly penetrated by the idea that the whole physiological action of the plant or animal is a response of the living organism to the action of the surroundings.

The judicial fairness and openness of Darwin's mind, his penetration and sagacity, his wonderful power of eliciting the meaning of things which had escaped questioning by their very commonness, and of discerning the great significance of causes and interactions which had been disregarded on account of their supposed insignificance, his method of reasoning close to the facts and in contact with the solid ground of nature, his aptness in devising fruitful and conclusive experiments, and in prosecuting nice researches with simple but effectual appliances, and the whole rare combination of qualities which made him *facile princeps* in biological investigation,—all these gifts are so conspicuously manifest in his published writings, and are so fully appreciated, that there is no need to celebrate them in an obituary memorial. The writings also display in no small degree the spirit of the man, and to this not a little of their persuasiveness is due. His desire to ascertain the truth, and to present it purely to his readers, is everywhere apparent. Conspicuous, also, is the absence of all trace of controversy and of everything like pretension; and this is remarkable, considering how censure and how praise were heaped upon him without stint. He does not teach didactically, but takes the reader along with him as his companion in observation and in experiment. And in the same spirit, instead of showing pique to an opponent, he seems always to regard him as a helper in his search for the truth. Those privileged to know him well will certify that he was one of the most kindly and charming, unaffected, simple-hearted, and lovable of men.

How far and how long the Darwinian theory will hold good, the future will determine. But in its essential elements, apart from *à priori* philosophizing, with which its author had nothing to do, it is an advance from which it is evidently impossible to recede. As has been said of the theory of the Conservation of Energy, so of this: "The proof of this great generalization, like that of all other generalizations, lies mainly in the fact that the evidence in its favor is continually augmenting, while that against it is continually diminishing, as the progress of science reveals to us more and more of the workings of the universe."

[The outlines of a portion of this memorial, written on the day of Mr. Darwin's funeral, were printed in "The Literary World" of May 6.]

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Reciprocal Solutions of Liquids.*—Alexéeff has studied the reciprocal actions of liquids and has discovered that while their mutual solubility increases with the temperature, yet for certain liquids the solubility decreases up to a certain limit as the temperature rises, and then increases again; so that there exists a minimum of solubility, corresponding to the maximum of solubility in certain solids. Again, when phenol and water are mixed two layers are formed; the lower is a solution of phenol in water, the upper a solution of water in phenol. The solubility of these liquids in each other increases continually until a certain temperature is reached (83° for phenol melting at 36°, 68° for pure phenol); then they mix in all proportions. Aniline and water show the same phenomenon. In general all liquids, which dissolve in each other sensibly at ordinary temperatures, mix completely at a temperature much below their absolute ebullition temperatures. The author shows the similarity between solids and liquids in this regard by sealing different proportions of water and salicylic acid in tubes and heating these to temperatures above 100°. On cooling the limpid liquid, no turbidity appears at 100°. The first trace shows itself at 91°, the contents of each tube separating suddenly into two layers, these becoming turbid independently, as the cooling goes on. The curve which represents the results obtained is quite analogous to that given by aniline, and shows that, between certain limits of temperature, there exists true reciprocal solutions of water and liquid salicylic acid. This marked difference in solubility between the solid and the liquid salicylic acid, the author regards as a case of true physical isomerism and he is occupied with its further investigation.—*Bull. Soc. Ch.*, II, xxxviii, 145, Aug., 1882.

G. F. B.

2. *On Crystallization-experiments, proving Berthollet's law of partition.*—Brügelmann has described the following experiments in crystallization as proof of the law of Berthollet that when two salts are dissolved, the solution contains four salts produced by their mutual reaction. (1) Equal volumes of cold saturated solutions of cobalt chloride, $CoCl_2$, $(H_2O)_6$ and nickel sulphate $NiSO_4$, $(H_2O)_7$ are mixed and allowed to evaporate spontaneously. The crystals obtained contain both metals, but combined with sulphuric acid only. (2) Solutions of copper sulphate and cobalt chloride, mixed together, deposit crystals wine-red in color, consisting principally of sulphates of both metals, but containing admixed chlorides. (3) A copper sulphate solution and one of potassium dichromate, when mixed, deposit first bright green crystals containing both metals principally as sulphates. Then crystals in various intermediate stages, yellow-green, green and blue-green; and finally a dark-brown deliquescent mass, becom-

ing crystalline over sulphuric acid, consisting of both metals combined with chromic acid, essentially.—*Ber. Berl. Chem. Ges.*, xv, 1840, Oct., 1882. G. F. B.

3. *On the Oxidation of Carbonous oxide by Oxygen and Palladium-Hydrogen.*—The fact observed by Baumann, that in presence of oxygen, hydrogen-palladium oxidized carbonous oxide to carbon dioxide, was explained by him by supposing that the hydrogen-palladium split up the oxygen molecule, thus producing active oxygen atoms which effected the oxidation. TRAUBE has propounded another theory of the action which is more rational. He supposes two distinct chemical processes to go on successively. First by the action of oxygen and water on the hydrogen-palladium, hydrogen peroxide is formed. This, in presence of the palladium itself, oxidizes the carbonous oxide to carbon dioxide. Hydrogen peroxide alone does not oxidize carbonous oxide; but in presence of palladium free from hydrogen, it does it readily. Hydrogen-palladium behaves in the same way toward carbonous oxide, therefore, as it is known to do toward potassium iodide.—*Ber. Berl. Chem. Ges.*, xv, 2325, Oct., 1882. G. F. B.

4. *On Silicon Sulphides.*—By passing carbon disulphide over silicon, Colson obtained two compounds to which he attributed respectively the formulas SiS and SiSO. SABATIER has investigated the reaction more in detail and comes to a different conclusion. When hydrogen sulphide is passed over crystallized silicon heated to redness, a lively reaction takes place, the silicon disappears and in the cooler parts of the tube a brownish ring is produced, in the center of which are beautiful white needles of silicon disulphide SiS_2. Beyond this ring the tube is covered with a light powder orange-yellow in color. The brown substance is variable in composition containing from 50 to 59·1 per cent of sulphur. Treated with water, hydrogen sulphide is evolved and a brown residue is left which is soluble in ammonium and potassium hydrate, evolving hydrogen. Hence it is a mixture probably of the disulphide SiS_2 and amorphous silicon; a conclusion confirmed by the fact that by the side of the ring is a crystalline deposit of silicon. The yellow deposit consists of SiS_2 essentially, as it contains 65 per cent of sulphur. But when treated with water, the heat evolved is greater than that given by the disulphide. Hence the author concludes that a lower sulphide is present formed with less heat; perhaps of the formula Si_3S_4.—*Bull. Soc. Ch.*, II, xxxviii, 153, Aug., 1882. G. F. B.

5. *On the Constitution of Bleaching Powder.*—The theories of the constitution of bleaching powder now in vogue are for the most part based upon the fact that calcium is a bivalent metal. Such for example, is represented by Odling's formula Cl.Ca.O.Cl. KRAUT has examined the effect of acting with chlorine gas upon lithium hydrate and has obtained a compound very similar to chloride of lime. The hydrate, with the addition of one or two per cent of water, was submitted to the action of chlorine and

absorbed, in one experiment 63·49 and in another 71·5 per cent of its weight. The reaction is: $(LiOH)_4 + Cl_2 = LiCl + LiOCl + (LiOH)_2 + H_2O$. Analysis of the product confirmed this equation, the active chlorine being 31·17 and 38·06 per cent in the two cases, and the total chlorine 38·38 and 41·22 per cent. Moreover the lithium bleaching powder showed the same behavior with carbon dioxide, as the calcium bleaching powder; i. e., it was decomposed with the evolution of chlorine. Since, however, lithium is a univalent metal, it is clear that its atom cannot unite at the same time with chlorine and the radical of hypochlorous acid. Hence Odling's formula is inapplicable. Moreover, lithium chloride ready formed is present in the lithium bleaching powder. As to the decomposability of bleaching powder by carbon dioxide, the author treated a mixture of calcium chloride and hydrate, in a drying-tube, first with hypochlorous oxide gas alone and then with a mixture of this gas and carbon dioxide. As soon as the latter gas arrived in the tube the color and odor of chlorine were perceived, the chlorine falling from 64·66 per cent to 17·09, after the admission of the CO_2. The carbon dioxide decomposes the hypochlorite and the free hypochlorous oxide in presence of an excess of CO_2, decomposes the metallic chloride: $CaO_2Cl_2 + CO_2 = CaO_2CO + Cl_2O$; and $CaCl_2 + Cl_2O + CO_2 = CaO_2CO + Cl_4$. The conclusion is that bleaching powder is simply a mixture of calcium hypochlorite, calcium chloride and calcium hydrate.—*Lieb. Ann.*, ccxiv, 354, Sept., 1882. G. F. B.

6. *On the Preparation of Lead peroxide.*—Lead peroxide is usually prepared, either by treating minium with nitric or acetic acid, or by precipitating lead acetate with sodium carbonate and passing chlorine gas through the mixture. FEHRMANN has proposed another method, which consists in decomposing a concentrated solution of lead chloride at 50° or 60° C. with a solution of chloride of lime. The latter solution is added until the filtrate shows no brown color on farther addition. The precipitated peroxide is filtered off, well washed, and kept for use. It is an almost black powder and is completely pure. The chloride is preferable to the acetate.—*Ber. Berl. Chem. Ges.*, xv, 1882, Oct., 1882. G. F. B.

7. *On the Azaurolic Acids, a Series of Nitrogenized acids belonging to the Fatty Series.*—By the action of sodium amalgam on ethyl-nitrolic acid, beside the nitrous acid, ammonia and acetic acid formed, VICTOR MEYER had observed in 1874 a small quantity of a beautifully crystallized acid, difficultly soluble in water and precipitable by acids from its solution in alkalies in the form of gold-yellow needles. Recently in conjunction with CONSTAM, this chemist has studied the new body more carefully and finds it to be an azo-compound of the fatty series, the first representative yet discovered of the pure fatty azo-bodies. In consequence of the golden color of this first member of a new series of bodies, the authors have called the series *azaurolic acids*. For the preparation of ethyl-azaurolic acid, two grams ethyl-nitrolic

acid was suspended in 10 c. c. water, cooled with ice, and 45 grams of a ten per cent sodium amalgam gradually added with continuous agitation. The intensely blood-red solution was decanted from the mercury, and decomposed carefully with sulphuric acid. A mass of fine matted yellow needles was precipitated, which were freed from mother-liquor on the filter-pump, and recrystallized from hot alcohol. Fiery orange-red brilliant prisms were thus obtained, which were soluble in hot alcohol, difficultly so in ether and nearly insoluble in water. On analysis they gave the formula $C_2H_4N_2O$. Propyl- and methyl-azaurolic acids were also prepared. By the action of hydrogen chloride, of concentrated ammonia, of sodium-amalgam, and even of heat, upon ethyl-azaurolic acid, a new substance, in colorless brilliant, transparent prismatic crystals is obtained, which fuses at 161°·5 without decomposition and which afforded on analysis the formula $C_4H_7N_3O$. It has the characters of a weak amido-acid and the authors call it *ethyl-leukazon.* The authors discuss its constitution and propose for ethyl-azaurolic acid the formula

$$\left.\begin{matrix}CH_3\\NO\end{matrix}\right\}CH-N=N-CH\left\{\begin{matrix}CH_3\\NO\end{matrix}\right..$$

—*Lieb. Ann.*, ccxiv, 328, Sept., 1882. G. F. B.

8. *On Indophenol and Solid Violet.*—KOECHLIN and WITT have generalized a reaction observed with resorcin by Meldola in 1879, by acting on nitrosodimethylaniline with phenols or naphthols. By oxidizing with potassium dichromate or sodium hypochlorite a mixture of α-naphthol and of amidodimethylaniline, combined with soda, a new coloring matter called indophenol has been produced. It is insoluble in water; but like indigo, it can be reduced. In the reduced state it has great affinity for animal matters and it dyes wool well in a bath. It is fixed on cotton in the reduced state, using a tin mordant. After printing, the cloth is steamed for one or two hours, then run through a bath containing ten grams per liter of potassium dichromate, heated to 50°, washed and soaped. Indophenol yields a dark blue color, more stable than indigo to light and to soap, and much cheaper; but mineral acids destroy it. By reacting with tannin, gallic acid, catechin, upon nitrosodimethylaniline, hot, KOECHLIN has prepared another coloring matter which he calls *gallocyanin* or solid violet, the shade of which varies according to the substance used. It forms beautiful salts, that with aniline being in small green crystals. It dyes silk and wool violet and resists light and all reagents. On cotton it needs chromium as a mordant. The color prepared with gallic acid or tannin dissolves in concentrated sulphuric acid with a blue color; but soap destroys the color of fabrics dyed with it. That made with catechin on the contrary, resists boiling soap and dissolves in sulphuric acid with a bluish green color. These two colors appear to be of great commercial importance, the violet to replace alizarin and the blue, indigo, being cheaper and giving a superior color. They are now prepared on the large scale.—*Bull. Soc. Ch.*, II, xxxviii, 160, Aug., 1882. G. F. B.

9. *On Soluble Alizarin-Blue.*—Alizarin-blue has received but limited application because of its insolubility. BRUNCK has discovered that its compound with bisulphites is easily soluble, and in connection with GRAEBE has examined the character of the combination. The soluble blue is in the form of a reddish-brown powder, showing transparent prisms under the microscope. It can be heated to 150° without change. The shades of color it gives are equal to those produced by the best indigo and it resists light, soap, and chlorine better than indigo. Upon analysis the compound was found to be composed of one molecule of alizarin-blue and two of the bisulphite, $C_{17}H_9NO_4+(HNaSO_3)_2$. —*Ber. Berl. Chem. Ges.*, xv, 1783, Oct., 1882. G. F. B.

10. *On the amount of Carbon Dioxide in the Atmosphere.*—M. EUG. RISLER has recently made some observations to determine the amount of carbon dioxide in the atmosphere, which are interesting in connection with the results of Reiset, and of Müntz and Aubin quoted in the last number of this Journal. The experiments were made in the author's garden at Calèves near Nyon, between the hours of 10 A. M. and 2 P. M. The method employed was that of Pettenkofer, with some slight modifications. A vessel of five or six liters capacity, accurately guaged, is filled with the air to be analyzed by means of an aspirator furnished with a long glass tube. The carbon dioxide in the bottle is absorbed by agitation with a known volume of pure baryta water, previously titered, introduced into it. A few drops of tincture of tumeric is added, and then a solution of titered oxalic acid from a burette, until the baryta water is saturated. The tincture of tumeric allows of determining the point of saturation more exactly than the turmeric paper of M. Pettenkofer. From the quantity of oxalic acid employed to saturate the baryta water the quantity of carbon dioxide corresponding to it is calculated, and from this that which has already been fixed by the baryta is deduced. The mean value obtained was 3·035, the minimum 2·530, the maximum 3·492. The monthly means obtained are as follows:

Volumes in 10,000.

1872.	Monthly mean.	Monthly maximum.	Monthly minimum.
August	2·998	3·492 the 9th.	2·616 the 2d.
September	3·020	3·123 " 12th.	2·530 " 5th.
October	2·953	3·067 " 25th.	2·903 " 20th.
November	3·043	3·204 " 15th.	2·867 " 1st.
December	3·058	3·215 " 11th.	2·919 " 17th.
1873.			
January	3·016	3·094 " 29th.	2·889 " 30th.
February	3·045	3·196 " 28th.	2·820 " 20th.
March	3·088	3·239 " 26th.	2·914 " 20th.
April	3·053	3·261 " 1st.	2·861 " 28th.
May	3·139	3·326 " 3d.	2·880 " 25th.
June	3·062	3·318 " 8th.	2·653 " 22d.
July	2·944	3·128 " 1st.	2·665 " 7th.
General mean	3·035		

—*Bibl. Univ.*, Sept., 1882.

11. *Solubility of Carbon dioxide in water under high pressures.* WROBLEWSKI has constructed an apparatus (C. R. xciv, 954) in which a gas at 0° can be subjected to a pressure of 60 atmospheres in tubes with an interior diameter of 10 to 12^{mm}. With this he has established the following laws as to the solubility of carbon dioxide in water. 1. The temperature remaining constant, the coefficient of saturation, e. g. the quantity of gas (in cubic centimeters at 0° and under a pressure of one atmosphere) dissolved in 1 c.c. water increases less rapidly than the pressure, while approaching a certain limit. 2. The pressure remaining constant, the coefficient increases when the temperature diminishes. For example at 0° the values of the coefficient for different pressures are :—

Pressures (in atmospheres),	1	5	10	15	20	25	30
Coefficient of saturation,	1·797	8·65	16·03	21·95	26·65	30·55	33·74

The author goes on to say that under the conditions realized the gas forms a hydrate. If carbon dioxide at 0° is subjected incontact with water to a sufficient pressure the part not absorbed becomes liquid and two distinct liquids are obtained. If the pressure diminishes the CO_2 volatilizes and returns to its primitive state. But if the CO_2 is compressed almost to the point of liquefaction and if a trace of solid matter is produced in the water or on the walls of the tube, the following phenomenon is observed. Every time the pressure is increased and passes a certain fixed amount ("critical pressure"), the tube becomes covered with an opaque frost-like deposit. When the pressure is diminished it disappears. This critical point at 0° is at 12·3 atmospheres, at 3·°6 at 17·9 atmospheres, and at 6·8° at 26·1 atmospheres. This deposit is found to be a hydrate having the composition $CO_2 + 8\ H_2O$. The formation of this hydrate bears an important relation to the laws of solubility of carbon dioxide given above. —*Journ. de Phys.*, Oct., 1882.

12. *Note on the application of the Spectro-polariscope to Sugar Analysis;* by WALLACE GOOLD LEVISON. [Communicated.]— On May 14th, 1881, I read a note before the Academy of Sciences of New York on the spectro-polariscope, which name I applied for convenience to a portable combination of the two instruments from which it is derived, with an intermediate achromatic lens to project upon the slit plate of the spectroscope an image of the object inserted between the Nicol prisms. It seemed to me that the remarkably well-defined absorption bands afforded with certain minerals, such as selenite and quartz, by the instrument should be available for some practical purpose, and recently a method occurred to me of utilizing them for reading sacharometer determinations; this Mr. John Lœber, of the Brooklyn Sugar Refinery, has demonstrated to be practicable and possibly of considerable importance.

Many persons fail to become expert operators with the sacharometer because incapable of distinguishing changes from the transition tint so nicely as a close reading of the scale requires. Any person can read with at least fair accuracy and with great rapidity as follows:

Adjust a Schiebler sacharometer to zero, and insert before the eye-piece a pocket spectroscope, with the slit horizontal or at right angles to the line bisecting the chromatic field.

Looking then in the spectroscope and focussing both the eye-piece of the sacharometer and that of the spectroscope, two vertically dispersed parallel spectra will be seen separated by a well-defined black line which is the image of the line above mentioned. The spectra will resemble ordinary white-light spectra except that a narrow, deep black absorption band will appear crossing both of them in the neighborhood of the D line.

The least turn of the reading screw will destroy the coincidence of the two absorption bands, one moving upward and the other downward, and a sufficient revolution of the reading screw will cause one to pass out of its spectrum entirely into the ultra red, and the other into the ultra blue, both spectra continuing otherwise practically unchanged.

To determine the percentage of a sample of sugar by this method bring the two absorption bands to coincidence and insert the tube of sugar solution, which will throw the bands out of coincidence precisely as if the screw had been considerably turned. Bring the bands to coincide again by means of the reading screw and the scale will give the percentage required.

When the solution of sugar is introduced multiple spectra may be developed, but no confusion need be thereby caused if the two middle spectra only be observed. By a specially constructed instrument it may be possible to more sharply define the edges of the absorption bands and render their exact coincidence so easy to determine that this method of reading the sacharometer will become universally adopted.

13. *On the Soundless Zones observed in connection with fog-signals.*—Dr. TYNDALL offers an explanation of the facts observed by General Duane in connection with the use of fog-whistles on the coast of Maine, viz: that "the signal often appears to be surrounded by a belt, varying in radius from 1 to 1½ mile, from which the sound appears to be entirely absent; thus, in moving directly from a station the sound is audible for the distance of a mile, is then lost for about the same distance, after which it is again distinctly heard a long time." Dr. Tyndall says:

For a long time past, I have thought that this disappearance of the sound was due to the interference, with the direct waves, of waves reflected from the surface of the sea. This explanation is capable of very accurate experimental illustration. Placing, for instance, a sensitive flame at a distance of three or four feet from a sounding reed, the flame exhibits the usual agitation. Lifting a light plank between the flame and reed, a position is easily attained where the sound, reflected from the plank, increases the flame's agitation. Lifting the plank, cautiously, still higher, a level is attained, reflection from which completely stills the flame.

By slightly raising or lowering the plank, or by its entire removal, the flame is once more agitated. In these experiments a high pitched reed was used, so that it was easy to produce by the motion of the plank the retardation of half a wave-length requisite for interference.

In General Duane's case, a fairly smooth sea would be required for the reflection; while the position of the zone of silence would be determined by the height of the signal on the one hand and the height of the observer on the other above the surface of the sea. The position would also, of course, depend on the pitch of the note of the whistle.—*Proc. Roy. Soc.*, xxxiv, 18.

14. *On the Reversal of the Metallic Lines in over-exposed Photographs of Spectra.*—The effect of over-exposure in reversing a photographed image has been distinctly recognized (Bennett, Abney, Janssen). In regard to this subject Professor W. N. Hartley makes the following remarks:

In illustration of this phenomenon, I may mention a remarkable result I obtained on one occasion when photographing a landscape. I endeavored to secure a picture with detail in a shaded foreground, and a direct view of the setting sun, with mountains in the middle distance, and strongly illuminated as well as dark clouds. In one case I succeeded remarkably well, but in another plate the foreground was good, but the sun was completely reversed. The negative image was clear glass and the sun printed black. What should have been a negative in the strong lights became a positive. Again, by exposing a plate to the cadmium spectrum, the whole of the metallic lines were rendered distinctly, but with a flatness and want of density; the whole of the strong air-lines at the least refrangible end of the spectrum were, however, completely reversed.

Any strong lines may be reversed by over-exposure without materially altering the appearance of the rest of the spectrum. This is particularly the case with the lines of the metals—magnesium, aluminium and indium, but particularly so with magnesium. The reversal takes place in the center of the line, that is to say, where the radiation is most active. Except by the method of comparative exposures, which I have always employed, it would be impossible to say whether a reversal was due to an absorbed ray or an over-exposed plate. M. Cornu has shown that the quadruple group of rays in the magnesium spectrum may become quintuple or sextuple, according to the increased intensity of the spark employed. This is precisely what might happen if one reversal by over-exposure were followed by a second. Such reversals might be looked for if, under the conditions of the stronger spark, the exposure of the plate were not shortened, because the first and third of the four lines are stronger than the other two, and they would therefore be the first and second to suffer reversal. The reversal would split the lines in two, and hence produce the appearance of a sextuple group. In order to ascertain whether this might readily occur in the magnesium spectrum, some observations were made with plates containing several photographs obtained by different periods of exposure. Thus, the first spectrum was the result of ten seconds, the second of half a minute, and others various times extending to half an hour. The quadruple group was not affected in the way observed by M. Cornu, from which fact it would appear that the division of the lines was caused by a reversal which was the result of absorption of the central portion of the ray or rays. In the two photographs obtained by the longest exposures, especially in the last, the triplet b' between K and L became a quadruple group by reason of the most refrangible line being split into two by a reversal, the cause of which was nothing more than over-exposure. In the quadruple group previously mentioned the lines were totally reversed or not at all. This subject of reversal by over-exposure is one well deserving the attention of those who are engaged in the study of solar physics. Comparative exposures should be methodically employed to confirm the accuracy of observations made entirely by the aid of photographic representations of spectra. Especially is this desirable when gelatine or other dry plates containing organic matter are in use.—*Proc. Roy. Soc.*, xxxiv, 85.

15. *Thermal Conductivity of Minerals and Rocks.*—M. THOULET has undertaken a series of experiments having as their object the determination of the thermal conductivity of minerals and the more important rocks. The investigations have a bearing upon certain general problems in regard to the genesis of eruptive rocks, which the author proposes to discuss in subsequent memoirs. The method employed is in this respect novel, that instead of the exact measurement of the temperature at the same instant at points situated at different distances from the source of heat, there is substituted the measurement of the time required for the passage of a certain quantity of heat through a section of known thickness. In his experiments, M. Thoulet calls the *thermal resistance* of a mineral or rock, the time required for the passage of a quantity of heat represented by 34° C., from a constant source of 100° C., through a thickness of $0{\cdot}01^{mm}$; this thermal resistance is obviously inversely proportional to the conductivity of the substance in hand.

As a source of heat a rectangular block of forged iron was taken, having a surface of $0{\cdot}11^{m} \times 0{\cdot}77^{m}$ and $0{\cdot}55^{m}$ in height; its weight was 3·8 kilos. A thermometer extended into the center of the block. The iron rested upon a plate of cast iron placed on an iron tripod; a Bunsen burner was placed below; the whole is enclosed in a case of wood. It was found possible by suitable precautions to maintain the iron block at any required temperature, and to keep it constant at this point during a considerable series of experiments. The substance to be experimented upon was in the form of a parallelopiped, the bases perfectly plane and parallel, with square surfaces of $0{\cdot}03^{m}$, and the thicknesses respectively of about $\cdot015^{m}$, $\cdot010^{m}$ and $\cdot006^{m}$ in the three experiments.

To eliminate the variable effect of the surfaces in contact, the two bases were covered with tin foil, and the four lateral faces were painted over with a layer of white lead, so that they should have the same emissive and absorptive powers. For the fusible materials used to mark the temperature stearine and Carnauba wax were taken, melting at 50° and 84° C. respectively. Two little spheres of each ($\frac{1}{3}^{mm}$) were attached about the center of the smooth surface of the tin foil, making thus four indexes. The block of iron was kept successively at the temperatures 100°, 105°, 110°, 120°, 130°, 140°, 150°, 160°, and the time in seconds was noted when each little sphere melted; various precautions were employed to ensure constancy of results.

The substances experimented upon were glass, iron, anhydrite, and the exact weight, surface and thickness of the block taken was accurately determined in each case; as also the weight and surface of the tin foil and the surface of the white lead. For each body two series of curves were plotted, one of the temperatures and times, the other of the thicknesses and times. The results show that the method employed is capable of giving very accurate determinations and those obtained agree very closely with the values obtained by M. Lagarde on theoretical considerations.—*Ann. Chem. Phys.*, V, xxvi.

II. Geology and Natural History.

1. *Oscillation of Land in the Glacial period.*—In the Geological Magazine for September and October, Mr. T. F. Jamieson discusses the question of the origin of the changes of level in the Glacial and following era. He shows, by reference to facts from Great Britain and Europe, that they cannot be accounted for by any theory, including Croll's, which makes them simply a change in water-level. He states, in opposition to the view sustained recently by Dr. Penck of Munich (Jahrb. Geogr. Ges. München, vii, 1882)—that the local attraction of the ice was sufficient to cause a large submergence of coast regions, and different for different localities, according to the height and position of the ice, —the following facts: that shell-beds near Dublin are 1200 feet above the sea, and "it is difficult to see where the mass of ice or of land could have existed in Ireland to have exerted the requisite attractive force;" that there are "shell beds in Wales at 1350 feet, and no evidence of submergence in the valley of the Thames only 200 miles off; and that there are subsidences of land over the interior of continents that cannot be thus explained. He further adds:

"Colonel Clark, in his recent treatise on Geodesy (1880, p. 96), says that although mathematical calculation shows us that large tracts of country may produce great disturbances of the sea-level, it is at least questionable whether in point of fact they do. The attraction of the Himalayas as deflecting the plumb-line at various places in India has been computed, and it has been found that there is little correspondence between theory and observation, for the attraction of the Himalayas only makes itself perceptible to observation at places quite close to them.

"An examination of the tables given by Mr. Buchan in the Transactions of the Royal Society of Edinburgh, showing the mean height of the barometer in various parts of the world, leads me to think that the supposed influence of the continents and high masses of land in drawing the ocean toward them has been greatly overestimated by the authors to whom Dr. Penck appeals. For these tables certainly lend no countenance to the notion that the sea-level is subject to the great inequalities of levels which he assumes."

Mr. Jamieson adopts the opinion, and argues for it at length, that the subsidence was due to the weight of the superincumbent ice, the effect of which would be slowly produced and slowly and often only partly recovered from.

2 *Bulletin of the American Museum of Natural History* (Central Park, New York), Vol. I, No. 3. *On the Fauna of the Lower Carboniferous limestones of Spergen Hill, Indiana;* by R. P. Whitfield. Pages 39–98, 8vo, and plates 6, 7, 8, 9. Oct. 20, 1882.—The papers that have thus far appeared in the Bulletin of the American Museum are all by the paleontologist of the Museum, Mr. R. P. Whitfield, and this last is the fifth. It is "a revision of the descriptions hitherto published" of the remarkable fossils of Spergen Hill, together with figures of all the species. The paper of Professor James Hall on these minute species (Trans. Albany Institute, vol. iv), was not illustrated by figures. Mr. Whitfield's excellent figures, 180 in all, are drawn from Professor Hall's type-specimens, now the property of the Museum. Professor Hall concluded from the oölitic structure of some of the beds, the profusion of gasteropods, and the worn character of many of the shells, that the water in which the species lived at Spergen Hill was very shallow. Some unfavorable conditions existed, since, as Mr. Whitfield urges, the shells are smallest where the individuals are most abundant, and, as Hall also had stated, many of them grow in other localities (as at Bloomington, in the same State) to a larger size. The beds were referred by Hall (and now by Whitfield) to the Warsaw division of the Sub-carboniferous, although containing some species of the Keokuk, St. Louis and Chester limestones.

Mr. Whitfield's paper in No. 2 of the Museum Bulletin, is on *Lymnæa megasoma* and "the changes in form of its offspring produced by unfavorable conditions of life."

3. *American Palæozoic Fossils*, of S. A. Miller, of Cincinnati, Ohio.—A second edition of Mr. Miller's valuable work, the first of which was issued in 1877 and noticed in volume xiv of this Journal, is promised by the author in January. It will contain a Supplement of about 90 pages in connection with the original work. Its price will be three dollars, post paid.

4. *A new fossil Pseudoscorpion.*—Dr. H. B. Geinitz, of Dresden, has described a new Pseudoscorpion of large size, from the

Coal-measures of Zwickau, in the "Zeitschrift der Deutschen Geologischen Gesellschaft" for 1882. It is named after its discoverer, Professor Kreischer, *Kreischeria Wiedei.* A fine plate accompanies the memoir.

5. *Paleozoic Cockroaches.*—Descriptions and figures of *Etoblattina flabellata*, var. *Stelzneri*, *E. ? carbonaria* and *Oryctoblattina oblonga*, by Dr. J. V. Deichmüller, are contained in Isis (Dresden) of 1882. They are from Weissig, near Pillnitz.

6. *On the Discovery of Samarskite in Canada;* by G. CHR. HOFFMANN. — The locality where this specimen was found is situate just beyond the northwestern limits of the township of Brassard, county of Berthier, province of Quebec, Canada. It consisted of irregular-shaped fragments without the slightest indication of crystalline form. Luster, sub-metallic, shining. Color, brownish-black, almost black; in parts iridescent. Opaque even on the thinnest edges. Brittle. Fracture uneven. Streak, grayish-brown. Hardness, about 6. Fuses between 4 and 4·5. Specific gravity, 4·9478. In the closed tube decrepitates and gives off a little slightly acid water. Readily and completely decomposed by heating with concentrated sulphuric acid. Analysis gave:

Columbic acid } Tantalic acid }	55·41*
Tungstic acid	----
Stannic acid	·10
Yttrium oxide†	14·34
Cerium oxides†	4·78
Uranium oxide (UO_3)	10·75
Manganous oxide	·51
Ferrous oxide	4·83
Lime	5·38
Magnesia	·11
Potash	·39
Soda	·23
Fluorine	trace
Water	2·21
	99·04

A gram of the finely pulverized mineral, decomposed by heating with sulphuric acid, with careful exclusion of air, decolorized an amount of potassium permanganate corresponding to 4·79 per cent ferrous oxide. The water was expelled by ignition and collected in a chloride of calcium tube.

7. *Mineralogical Notes by A. Weisbach.*—Weisbach describes crystals of *apatite* from Ehrenfriedersdorf, which besides the pyramid $\frac{1}{2}$ show also another pyramid approximately determined as $\frac{1}{10}$–$\frac{4}{3}$; the terminal angle measured 179° 18′. The same author shows that the supposed new mineral *lautite* of Frenzel (xxii, 155)

* Apparently for the greater part, if not almost entirely, columbic acid.

† The presence or absence of other members of this group was not ascertained.

is a mixture of metallic arsenic with a sulpho-arsenite of copper probably near tennantite. According to an analysis by Iwaya the mineral winklerite (Breithaupt) has the composition (after deducting numerous impurities, amounting to 50 per cent) NiO 25·2, CoO 46·2, O 8·0, H_2O 20·6; the calculated formula is $R_2O_3 + 2H_2O$ or $Co_4Ni\,O_9 + 2\,H_2O$.

A lemon-yellow uranium ochre from Johanngeorgenstadt analyzed by Schulze is called *uranopilite* by Weisbach, and the formula $CaU_{16}Si_2O_{31} + 25\,H_2O$ given for it. The impurity of the material examined makes the composition doubtful.—*J. Min.*, ii, 1882.

8. *Rezbanyite, a supposed new mineral.*—Frenzel has given the named rezbanyite (previously used by Hermann in another sense) for a new sulpho-bismuthite of lead, identified at Rezbanya, Hungary. It is a light lead-gray mineral of metallic luster and black streak. Hardness 2·5–3, specific gravity 6·09–6·38. After deducting 4·64 per cent chalcopyrite, 5 per cent calcite, an analysis gave S 17·85, Bi 59·08, Pb 19·80, Ag 1·89, Cu 1·71, Zn tr. =100·33. For this the formula $4\,PbS + 5\,Bi_2S_3$ is calculated. Other analyses give approximately similar results, but the variation is so great that the composition must be considered still doubtful. The mineral occurs massive intimately mixed with chalcopyrite and calcite, also imbedded in quartz.—*Min. Petr. Mitth.*, 1882, p. 175.

9. *Danburite from Switzerland.*—A third locality has been recently discovered for danburite, viz., on the Scopi, in Graubünden, Switzerland. It is described by C. Hintze as occurring in transparent crystals in habit resembling topaz, like that from Russell, N. Y. The measured angles are almost identical with those obtained on the American mineral; the observed planes are also the same, with the addition of several new ones. The terminations of the crystals differ from those of Russell in habit. In optical relations the crystals of the two localities are nearly the same. It is suggested that the undetermined mineral called hessenbergite (Syst. Min., 5th ed., p. 762) may perhaps be identical with danburite.—*Zeitschr. Kryst.*, vii.

10. *Wurtzite from Montana.*—Mr. Richard Pearce has recently discovered the rare mineral wurtzite at the "Original Butte Mine," Butte, Montana. It occurs in small crystals of the characteristic hexagonal form, together with pyrite and zinc blende.

11. *A Dictionary of Popular Names of the Plants which furnish the Natural and Acquired Wants of Man in all Matters of Domestic and General Economy, their History, Products and Uses.* By John Smith, A.L.S. pp. 457, 8vo. London, 1882. Macmillan & Co.—A handsome and handy volume, one of the fruits of the leisure of the aged ex-curator of the Royal Gardens, Kew, mainly gathered from the MSS. of his son, the late Alexander Smith, who was the curator of the Kew Museum—now so extensive and interesting—from the time of its origination until his health gave way, in 1858. Under the circumstances, it could hardly be expected to be brought wholly up to date, nor that the

additions should always be as critically correct as some of them are curious. But the volume is full of valuable information.

A. G.

12. *Description of new Cephalopoda*; by T. W. Kirk. 8vo, pp. 4, 2 plates. Trans. New Zealand Inst., vol. xiv. 1882.—The species described are *Sepiola Pacifica*, *Architeuthis Verrilli*, and *Steenstrupia Stockii*, all from New Zealand. The last two are figured. They are gigantic species, closely allied to the Newfoundland forms of *Architeuthis*. The *A. Verrilli* had a very stout body and small caudal fin; length of head and body, 9 feet 1 inch; of body, 7½ feet; third pair sessile arms, 10 feet 5 inches; other arms, 9 feet; circumference of body, 9 feet 2 inches; tentacular arms, 25 feet, or about three times the length of the body. It was cast ashore, June 6, 1880. It seems to be a true *Architeuthis*. The "*Steenstrupia*" is a longer and more slender species, with the arms relatively much smaller and shorter. Length of head and body, 11 feet 1 inch; of body, 9 feet 2 inches; sessile arms, 4 feet 3 inches; circumference of body, 7 feet 2 inches. The tentacular arms had lost their clubs. The shell was lanceolote, 11 inches broad, with a small terminal hood; beak as in *Architeuthis*. There are no characters given sufficient to separate this species from *Architeuthis*, to which I should refer it without much hesitation, though the tentacular clubs, if known, might show some differences. At any rate, the name, *Steenstrupia*, cannot be retained, for it was given to a genus of Acalephs many years ago. In form and proportions, *A. Stockii* bears more resemblance to the small squids, *Ommastrephes* and *Loligo* than do the other large species hitherto discovered. The existence of two species of the colossal squids at New Zealand is a discovery of great interest. V.

13. *New England Spiders of the family Therididæ*; by J. H. Emerton. 8vo, pp. 86, with 24 lith. plates. Trans. Conn. Acad. Sci., vol. vi, Oct., 1882.—In this country very little systematic work has been published upon our spiders, since the early papers of Hentz. The excellent monograph, now published by Mr. Emerton, marks, therefore, an era in the literature of this subject. In it 134 species are described and well figured. Of these a large number (85 species) are new. Five new genera are also established. The plates are excellent, and are crowded with figures of structural details, drawn by the author himself, who is well-known as a zoological artist, and reproduced in fac-simile by very superior photo-lithographs. V.

14. *A Monograph of the British Spongiada*, vol. iv; by the late J. S. Bowerbank, edited, with additions, by the Rev. A. M. Norman. 8vo, pp. 267, 17 plates. Ray Society, London, 1882.—This final volume contains descriptions of many recently discovered species; additional information about many previously known; a classified list of all the British species; tables of distribution; a catalogue of works and papers on Sponges; with a memoir of Dr. Bowerbank by C. Tyler. The volume is, therefore, an important one. V.

15. *Lehrbuch der vergleichenden Anatomie der Wirbelthiere;* by ROBERT WIEDERSHEIM. 1er. Theil. Gustav Fischer, Jena, 1882. 8vo, pp. 476; cuts 346.—This volume includes the anatomy of the integument, skeleton, muscular and nervous systems of the several classes of Vertebrata. The subjects are illustrated with considerable fullness, and the descriptions are sufficiently detailed for a text book. The work, so far as completed, appears to be well done, and will prove a useful addition to the list of anatomical text books. V.

16. *Synopsis of the Classification of the Animal Kingdom;* by HENRY ALLEYNE NICHOLSON. 8vo, pp. 131, cuts 106. (W. Blackwood & Sons.) Edinburgh and London, 1882.—In this work a systematic arrangement of the names of the higher divisions are given, including the principal families in most of the groups. No characters or definitions are given, except brief ones for the subkingdoms. A list of a few of the principal works on each class is added. The figures are, for the most part, good, and a few are original. Very few working zoologists will be able to accept this classification, as a whole, but it will prove a useful key to many. In several groups (e. g. the mollusca and the birds), the classification adopted is decidedly antiquated. V.

17. *The Vertebrates of the Adirondack Region;* by C. H. MERRIAM. Chapters 1 and 2, pp. 1 to 106. (Trans. Linnæan Soc., New York. October, 1882.)—This part includes a general introduction, in which an account of the topography, climate, botany and other features are given. The remainder of the work is devoted to the carnivorous mammals. The author has brought together a large amount of useful information concerning the zoological characters and habits of the animals discussed, and has presented his facts in a very readable manner. V.

18. *The Coues Check List of North American Birds;* by ELLIOT COUES. Second edition, large 8vo, pp. 105. Estes & Lauriat, Boston, 1882. — According to the title page, this edition has been "revised to date, and entirely rewritten, under the direction of the author, with a dictionary of the etymology, orthography, and orthoepy of the scientific names, the concordance of previous lists, and a catalogue of his ornithological publications." The total number of species and sub-species, now included, is 888. Of these, 120 are additions since the first edition, in 1874, while ten of those then included are now thrown out. The work is well printed on thick paper and will undoubtedly prove of great use to ornithologists. V.

19. *Catalogue of the Australian Stalk- and Sessile-eyed Crustacea;* by WM. A. HASWELL. 8vo, pp. 349, 4 lith. plates. Australian Museum, Sydney, 1882.—This useful work contains descriptions of all the genera and species known from Australia. The introductory chapter is devoted to an account of the structural characters of the Malacostraca. V.

III. Miscellaneous Scientific Intelligence.

1. *The Gulf Stream from the investigations of the Steamer* Blake; by Commander J. R. Bartlett, U.S.N., Assistant in the Coast and Geodetic Survey. (Bulletin No. 2, of the American Geographical Society).—The very important results brought out in this paper were obtained in connection with the explorations of the Gulf Stream in the Coast Survey Steamer "Blake," and are published by permission of the Superintendent of the Coast Survey. The following are the chief points:

(*a*) *Soundings over the area.* On a line from little Bahama Bank, at Memory Rock, in 4 fathoms, to Florida, a distance of 48 miles, the depth in fathoms, for every 5 miles (nearly), was as follows: 294, 347, 395, 439, 416, 341, 250, 176, 95, 31 fathoms. Other lines of soundings were made to the north, as far as Currituck, N. C., 85 miles north of Cape Hatteras; and it is stated that "wherever lines crossed, exactly the same depth was obtained to a fathom." These lines were thirteen in number, and the details respecting them are given in a table affixed to the memoir.

With reference to the general results, the author remarks: "The work of the season gives very interesting data in regard to the physical features of the bottom of the ocean over which the Gulf Stream flows. Instead of a deep channel in the course of the stream, as reported by Lieutenants Maffit and Craven, and published in the Coast Survey reports by Professor Bache, our later soundings show an extensive and nearly level plateau, extending from a point to the eastward of the Bahama Banks to Cape Hatteras; off Cape Canaveral nearly 200 miles wide, and gradually contracting in width to the northward until reaching Hatteras, where the depth is more than 1,000 fathoms within 30 miles of shore. This plateau has a general depth of 400 fathoms, suddenly dropping off on its eastern edge to over 2,000 fathoms."

"The soundings in the full strength of the current were all taken with the 60-pound shot sinkers, each being detached on reaching bottom. The time allowed for the sinker to reach the bottom was less than one minute to each one hundred fathoms in depth. Most of the soundings on each side of the stream, when not in the current, were taken with a 36-pound lead on the sounding wire, the lead being reeled back each time."

(*b*) *Velocity of the current between Memory Rock and Florida.* —From Memory Rock to the middle of the stream, approximately, the current was from 1·5 to 2·7 miles per hour; from the middle to sighting the light, over 5 miles per hour; and thence, 3, 2 and 1 miles per hour, to the anchorage. In other crossings the same average current was observed; but the strength in the axis of the stream was near the east or west shore according to the direction of the wind. "We found that 3 miles per hour was the general average for the whole stream." "The area of the cross-section is 429,526,240 square feet; and, assuming the mean velocity at 3 miles, the delivery would be 51,028,905,312,000 gallons per hour." "To the northward of the Bahama Banks, and to the eastward of the stream, there was a slight current setting southeast. We found the direction of the current in the stream very much affected by the wind, sometimes inclining it to the east, then to the west.

"In the latter part of June we were hove to, some fifty miles east of the Gulf Stream, off Charleston, when we experienced a current of three knots per hour setting southeast, the wind blowing a gale from southwest. The sudden rise of the plateau off Charleston, together with the meeting of the Arctic current, creates a remarkable disturbance. In July, 1880, I reported finding a current off Charleston some fifty miles or more from the 100-fathom curve, setting southwest. When our trawl was dragging on the bottom the vessel headed northeast, and drifted over two miles an hour southwest. I found this southwest current off Charleston, and between Charleston and Cape Fear every time last summer that I crossed the stream, but I did not find it at any other point.

"A very striking example of the influence of the wind on the current was experienced by us off Cape Lookout. We were in mid-stream, with the current setting well to the northward, when a fresh gale came on from the N.W. The current was turned almost due east, and for twelve and a half hours we had a current of 4·9 knots per hour E. by N. The vessel was heading *west* all this time, under full steam and foresail.

"At such points where we anchored off the coast in from 20 to 60 fathoms, the current cans gave a set to the northward of about 1·7 knots. Near the coast the set of the current depends entirely on the direction of the wind."

(*c*) *Character of the bottom along the area surveyed.*—The following citations relating to this subject are from pages 74, 75.

"On each side of the stream the cylinder brought up ooze, but in the strength of the current the bottom was washed nearly bare, the specimens being small pieces of disintegrated coral rock. This bare portion was very hard, and the sharp edge of the brass cylinder came up indented and defaced. From Jupiter Inlet, with the exception of the bare part mentioned, the specimens were a light-colored ooze, composed of Pteropod shells, with a mixture of coral sand. Off Charleston, where the plateau has less depth than to the southward, the bare section extended the whole width of the stream. The Pteropod ooze extended only to Charleston. To the northward of that point the bottom specimens were Globigerina ooze, of a dark greenish color.

"In the Caribbean Sea and Gulf of Mexico the bottom is always Pteropod ooze. These Pteropods are brought along by the Gulf Stream. Sir Wyville Thomson reported most of the Northern Atlantic bed to be Globigerina ooze, and as far as off the George's Banks the *Blake* always found this latter. The fact of finding this ooze off Hatteras, and its gradual diminution, and at last its total absence to the southward, would tend to show the limit of the Arctic current. The Globigerina were not found anywhere on the plateau to the southward of Charleston. The Gulf Stream has for its western bank the 100-fathom curve. It has a depth of 400 fathoms as far as Charleston, where it is reduced to 300 fathoms; but the Arctic current has for its bank the 1,000-fathom curve, which is quite close to shoal water, from the George's Banks to Hatteras. These specimens of the bottom seem to me to throw very important light on the circulation. From them alone we can state as a fact that the Arctic current does not extend along our coast below Hatteras; but at this point the Arctic current, with its colder and heavier waters, in following its bank the 1,000-fathom curve meets the Gulf Stream and goes under it, following the outside of the plateau toward the equator. In addition, the few temperatures that were obtained at the bottom confirm the same fact."

(*d*) *Sea-temperatures.*—At the anchorage near Memory Rock the surface and bottom temperature was 78° F. On the way across to Florida the surface temperature at 5 miles out was 81½° F.; it rose to 83° over the middle of the stream, and fell to 80° for the last 18 miles. The bottom temperatures, corresponding to the depths above mentioned for every 5 miles (see paragraph *a*), were 56½°, 52°, 45°, 44°, 44°, 44°, 50°, 50°, 57°, 78°.

In order to decide the question as to a division of the Gulf Stream into warm and cold bands (as announced in the Report on the Gulf Stream published by Professor Bache in 1861), the temperature at surface was taken at every mile on all the lines, and also at five fathoms beneath it. On this point Commander Bartlett says:

"The surface temperatures obtained by the *Blake* do not show any bifurcation of the stream before reaching Cape Hatteras. At this point I ran out only a few lines, but there were indications of warm and cold bands." As to the average surface temperature of the stream he states that along the axis it rarely exceeded 83° F. in June and July. On one or two occasions at noon in a calm, the thermometer read as high as 86°, and once, 89°; but, at five fathoms, it did not range above the average of 81½°.

2. *Distribution of Government Scientific publications.*—The following paragraph respecting a copy of Leidy's volume on the "Freshwater Rhizopods of North America," occurs as a foot-note to an article by the English zoologist, Mr. H. J. Carter, in the Annals and Magazine of Natural History for November, 1882:

"A copy of this magnificent 'memoir,' containing forty-eight colored plates of some thousand of figures, evidencing an amount of conscientious labor almost unparalleled, was liberally sent to me through the 'Smithsonian Institution,' at Washington; but of the 'Challenger' Reports I have only received *one* paper, and that, too, from a foreign author, viz: Professor Dr. F. E. Schulze, of Gratz, who kindly sent me one of the 'extra copies' of his contribution on *Eup ectella aspergillum*, although at my own cost and labor I had long since published descriptions and illustrations of all the sponges dredged on board H.M.S. 'Porcupine' from the Atlantic sea-bed in 1869."

3. CAPTAIN C. E. DUTTON'S *Report on the Tertiary History of the Grand Cañon District*, noticed on page 81, is now ready for distribution by the Director of the U. S. Geological Survey. Price $10.50. The statute establishing the Survey requires the printing of 3000 copies of its Memoirs, and the distribution of them only by payment of cash, or by exchange. A new statute, placing 200 copies of each out of the 3,000 in the hands of its author for gratuitous distribution, would be greatly for the good of American Science.

4. *National Academy of Sciences.*—At the meeting of the Academy, held in New York City in November, the following titles of papers were entered for reading:

ELIAS LOOMIS: Mean annual rain-fall.

IRA REMSEN: On white phosphorus; Effect of magnetism on chemical action; On sinapic acid.

J. WILLARD GIBBS: On the general equations of optics, as derived from the electro-magnetic theory of light.

GEORGE F. BARKER: On an improved form of standard Daniell cell.

WOLCOTT GIBBS: On complex inorganic acids.

CHARLES A. YOUNG: On a modified form of solar eye-piece for use with large apertures; On the total solar eclipse of May 6, 1883.

SAMUEL H. SCUDDER: On Triassic (?) insects from the Rocky Mountains.

C. H. F. PETERS: Explanations on presenting a copy of the first ten numbers of the author's celestial charts; Lists of errors in star catalogues; Remarks on the structure of the present comet.

O. N. ROOD: On a method of studying the laws of contrast quantitatively.

G. F. BECKER (by invitation): On the heat of the Comstock lode; Topographical effects of faults and landslides.

C. F. CHANDLER: Preparation of cyanin from chinoline.

THEO. GILL: On the place of the Echeneididæ in the system.

A. GUYOT: On the existence in both hemispheres of a terrestrial dry zone.

T. STERRY HUNT: On so-called eruptive serpentines.

A. M. MAYER: On a spherometer for measuring the radii of curvature of lenses of any diameter; On a graphical method of representing the errors of a screw; On a simple experimental demonstration of Ohm's law.

E. D. COPE: On the fauna of the Puerco Eocene; On the Permian genus Diplocaulus.

J. S. NEWBERRY: On the physical conditions under which coal was formed; On the origin of the carbonaceous matter of bituminous shales.

A. E. VERRILL: Physical and geological character of the sea bottom off our coast, especially beneath the Gulf Stream.

E. C. PICKERING: Coöperation in observing variable stars; The meridian photometer.

A. W. WRIGHT: On a form of kathetometer and comparator.

JAMES HALL: On the microscopic structure of some of the Brachiopoda with reference to their generic relations.

C. S. PEIRCE: On the logic of relatives; On the determination of the figure of the earth by variations of gravity; On Ptolemy's catalogue of stars.

O. C. MARSH: On the supposed human foot-prints recently found in Nevada.

OBITUARY.

Dr. HENRY DRAPER, the eminent experimental physicist, Professor of Chemistry in the University of New York, died on the 20th of November, at the age of forty-five. A biographical notice of Dr. Draper is deferred to another number.

INDEX TO VOLUME XXIV.*

* This Index contains the general heads BOTANY, GEOLOGY, MINERALOGY, OBITUARY, ZOOLOGY, and under each the titles of Articles referring thereto are mentioned.

H

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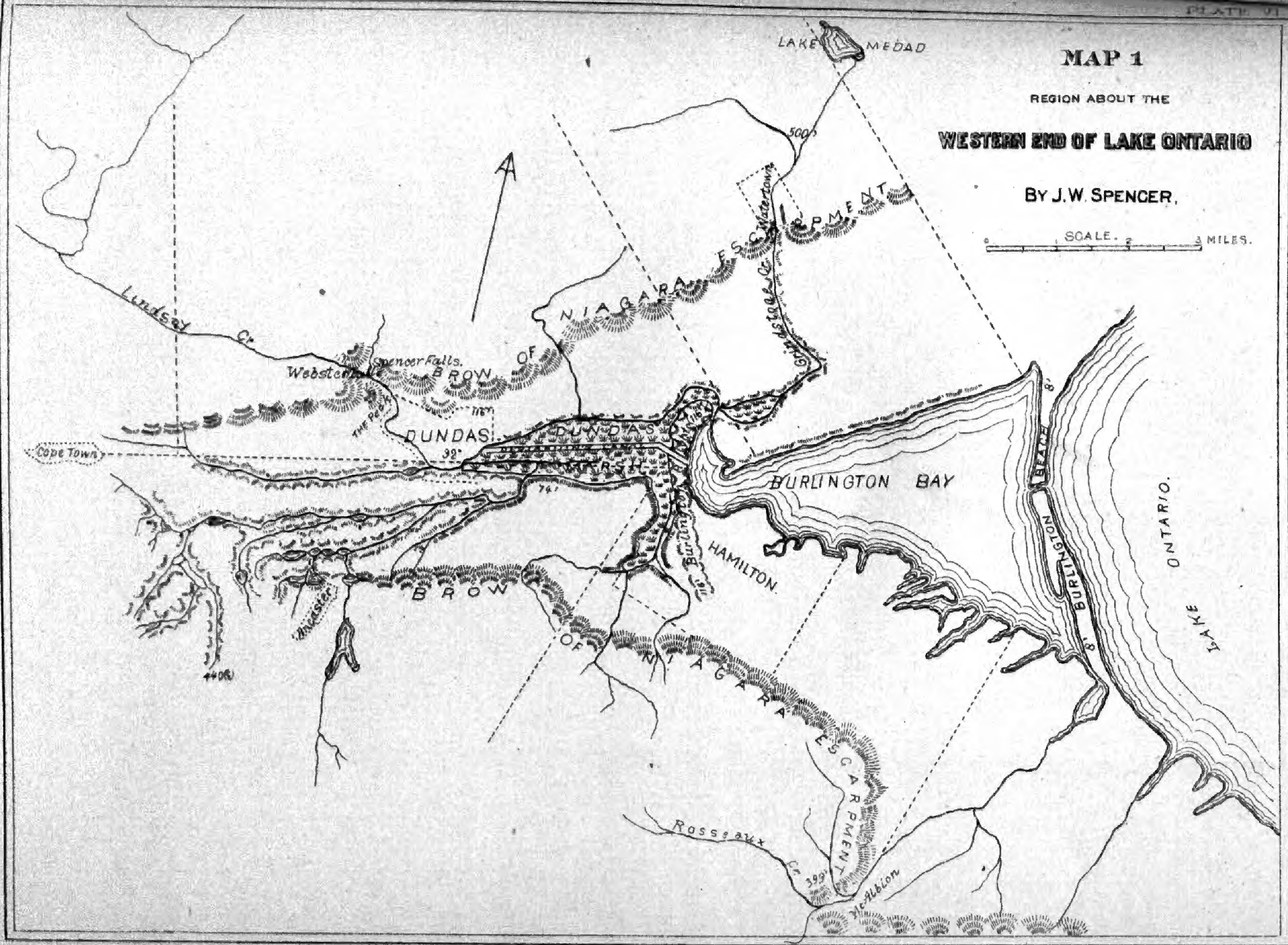
ERRATA.

Page 239, line 18, for Hazen read Hagen.

Page 342, 5th line from foot, for *Amherst College* read *Smith College, Northampton.*

The argument of the ephemeris of the Comet of September, 1882, given on page 301 is Greenwich Mean Time. The brightness of the Comet at the time of the observation of Sept. 19·1 was assumed as its unit.



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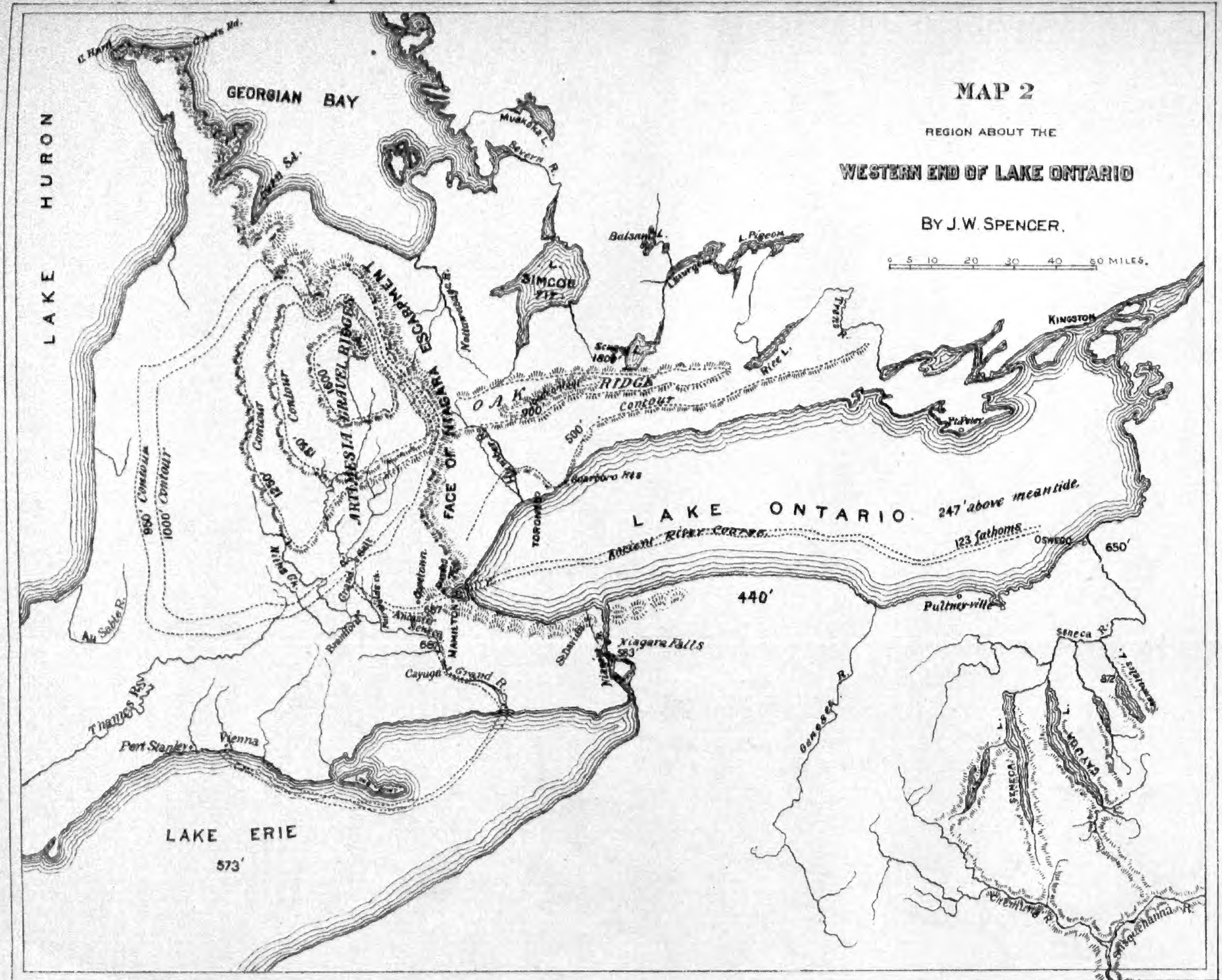

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