THE TAMARACK MINE CROSS-SECTION

AND THE

KEWEENAWAN LODES.

THE KEWEENAWAN ABOVE THE CALUMET AND HECLA CONGLOMERATE,

ESPECIALLY BASED ON THE RECORDS OF THE CAPTAINS OF THE TAMARACK MINE SHAFTS AND SAMPLES AND RECORDS PRESERVED BY THE ENGINEERS, R. M. EDWARDS AND W. E. PARNALL, JR.

It will be noticed that I have made some changes in the belts, from those given in previous publications and reports, in some cases throwing together several belts, only one being the true amygdaloid, the others either zones or alterations or slips. As to the practical importance of this, it may be noted that a thick flow is liable to be more persistent and farther traceable than a thin, and that its grain, lustre mottling, etc., is liable to be coarser at the center, and so it is important to recognize these big belts. The lustre mottling is due to the augite crystalline patches. In the normal ophite they are 1 mm. across within ten feet of the bottom of the flow, and then increase toward the center a millimeter for every 15 feet or so. Moreover the belts of faulting and alteration are probably of importance in the stratigraphy of the range and the concentration of copper.

The samples preserved by the mining captains are generally taken from the top of each belt as they observed them, and therefore do not show the true coarseness of the intermediate belt of trap. One object of presenting this section at this time is to show the importance of the grain, and how different mining men may differ in interpretation of records, which are not fundamentally so very different, and how easy it is to confuse the typical amygdaloid with porphyritic melaphyre or trap, and altered melaphyre or sand amygdaloid. If specimens were taken of the coarsest mottling in every belt of trap it would be possible to detect faults, and to know more certainly the size of the flows, than when samples of the trap belts are taken close underneath the amygdaloid, as is usually the case, if kept at all.

The examination of the specimens has often been only with the eye or hand lens, but quite a number of sections have been made. Relative to the systematic classification, I would refer to the Isle Royale report, in which the same series of rocks are treated. Referring to the more recent works of Cross, Iddings, Pirrson, and Washington, it is apparent that the series of Keweenawan flows are mainly dosalic, yet nearly salfemic, and perfelic, that in sub rang they are presodic, but in rang, they may run in the same flow from alkalicalcic at top to docalcic at bottom, e. g., from andose to hessose; generally they are hessose, but practically on the line between hessose and auvergnose. The same variation is noted in comparing different flows and is constantly associated with differences of texture so that I have called the former porphyritic melaphyre or porphyrite (compare augite andesite, andose and camptonose) and the latter ophite melaphyre or ophite, compare tholeyite and hessose and auvergnose.

Pumpelly's terms, ashbed diabase and lustre mottled melaphyre are nearly equivalent.

One term I use that they do not, that needs explanation. A glomeroporphyrite is a rock in which the crystallization at the time the feldspar phenocrysts were formed, went so far that these latter are more or less aggregated and bunched together. It is mainly found in the alkalicalcic flows, I think.

Tamarack shaft No. 5, went through 41 feet of peat and 5 feet of gravelly hardpan (till), before striking bed rock, began Aug. 7, 1895,—Jan. 1, 1896, 140 feet.

On the lower side of the shaft they average 11 feet lower than the figures given. See note book 99, p. 88, Portage Lake Mining Gazette, March 24, 1901, also Lake Superior Mining Institute, Vol. VII, p. 50.

1. Amygdaloid (T5b1, on N. W. side); amygdaloidal trap (T5b2); and amygdaloid (T5b3, 20 to 27) at center of shaft. Total thickness, 8+6+13 =27+ (21.2).[1]

Compare belt 22 at the Copper Falls drift, and the Isle Royale drill hole IX, 482-493.

2. Conglomerate (T5b4, 27 to 57 at center, 46 at eastern end). Thickness, 30; total 45.3 feet (23.8).

I. R. XI. 493-499 and belt 23 at the Copper Falls adit.

3. Amygdaloid (T5b5, 46-139, on the upper, 68-161 on the lower side) and trap (T5b6, 139-185).

Thickness, 139 (110) feet; total (155.2) feet.

Light colored zeolitic amygdaloid, and a dark chloritic porphyrite sp. 17674-5.

4. Conglomerate (T5b7, 185 to 195 feet). Thickness 10 (7.9) feet; total (163.1) feet.

Mainly feldspathic pebbles, but some basic. Rieder says it is a scoriaceous conglomerate of the ashbed type, and may include the amygdaloid top to the sheet below, which is of the feldspathic "ashbed diabase" type that has a rough, broken "aa" surface, which is characteristic of the "ashbeds." Sp. 17656. Probably Marvine's conglomerate No. 35 of his Eagle River section, Nos. 25 and 26 of the Copper Falls adit, and the Island mine conglomerate. I. R. X. 170-193.

5. Trap (T5b8, 195 to 340 feet).

Thickness, 145 (115) feet.

Fine grained porphyrite of the Tobin porphyrite type, feldspar abundant, though the porphyritic texture is not conspicuous. "Ashbed diabase." Sp. 17657.

Compare on Isle Royale, X. 193-306=113 (110) feet thick, and of the same petrographic character.

U. M. the augite is in idiomorphic granules. The feldspar extinctions indicate Ab_1 An_1.

The olivine has been largely changed to iron oxide.

[1]Distances actually measured, usually vertical, are given without parentheses, actual thickness and distances reduced to distance perpendicular to the beds by multiplying by cos 37½° = .795 are given in parentheses as in Vol. VI. Reference as to a given belt in different shafts are indicated by b. Thus T 5b1 means belt No. 1 in the mining section of Tamarack No. 5. TJ1b 20 means the twentieth belt recorded in No. 1 shaft of the Tamarack Junior Mine, now an Osceola property.

6. Amygdaloid (T5b9, 340-395) and trap (T5b10, 395-627).

Thickness, 55 (43)+232 (183.1)—(227).

Total (505) feet.

Porphyritic melaphyre verging toward ophite. This probably includes more than one sheet of porphyrite, but it may be one thick flow which is at the bottom more augitic,—a feldspathic ophite. Sp. 17658, 17659, from T5b9 and Sp. 17660 (ophite), 17661, 17662 from T5b10. This is equivalent to T4b1, T4b2, 347 and T3b1 to T3b3, 122. Sp. 16401 (ophitic).

Compare also I. R. X., 335-415 analyzed and studied for grain variation. The magma of this flow seems to have been of such a character that a more and less augitic portion readily separated.

U. M. 17658, shows iddingsite very abundant, the amygdules are of chlorite and calcite.

U. M. 16402, shows labradorite in large patches of augite; olivine just altered and with a strong pleochroism between yellow and green, remarkably abundant and embedded in augite.

7. Amygdaloid (T5b11, 627-667).

Thickness, 40 (31.7).

Total (537) feet.

Sp. 17663 to 17667. These specimens show signs of fault slips, clasolitic seams of sediment, crushed amygdaloid, etc.

These indicate that there has been much motion in this belt which may be thus in part cut out. It might even represent the fragments of several flows. It is beter shown in T3 and T4,—T3, 122-178, Sp. 16403, 16404 and T4, 347-409, 44.5 to 49.3 feet. It is probable, therefore, that 16 feet or more are here cut out by a fault.

U. M. 16403, is an ophitic melaphyre, but with amygdules, and much smaller feldspar than 16402.

8. Conglomerate (T5b12, 667-692).

Thickness 25 (19.8).

Total (557) feet.

Sp. 17668 to 17670. This is equivalent to T3b4, 178-181, and T4b5, 409-413, 16504. Possibly the slide above here has in T3 and T4 cut out of the conglomerate and amygdaloid below instead of the overlying trap.

This is the "Hancock West" conglomerate, Marvines No. 17, the Ashbed slide, I. R. X., 413 to 426, No. 44 of the Eagle River section. This horizon is characterized by a large bed above, in which, near the bottom, the augitic magma has so accumulated as to give some lustre mottling and make it an ophite (See Vol. VI., part 1, p. 64.), while beneath is a hard feldspathic sheet with a clean conchoidal fracture.

9. Trap (T5b13, 692-711).

Thickness—19 (15).

Total (572) feet.

Amygdaloid not noted in T3 or T4 in which beds 13 and 14 may have been wanting, or planed off by slide?

Compact porphyritic melaphyre with small green feldspar phenocrysts.

Equivalent to T4b6, 413 to 476, Sp. 16405, and T3b5, 191 to 243, with a thickness of 63 (50) or 52 (41) feet.

10. Amygdaloid (T5b14, 711 to 734), Sp. 17672, and trap, T5b15, 734 to 784, Sp. 17673, 17674.

Thickness, 73 (57).

A porphyritic melaphyre of the type I have called Tobin porphyrite. The amygdaloid has some fine red sediment mixed in, and is of the ash-bed type, and in it there was some water encountered. The trap is a tough grey trap, not as dark as the more augitic varieties, which made sinking very slow. The drill cores in this type on Isle Royale were long. This should be good road metal.

U. M. 17673, augite granules idiomorphic, olivine scanty, feldspar symmetrical extinctions often 4°.

11. Amygdaloid (T5b16, 784 to 808), and trap (T5b17, 808 to 920), Sp. 17675.

Thickness, 136 (108) feet.

Total, 737 feet.

Another Tobin porphyrite, with an amygdaloid like the flow above and a similar hard, fine-grained porphyritic trap which made slow sinking, and bears the strongest resemblance to the beds at bottom of drill hole IX and the top of VIII, on Isle Royale.

12. Amygdaloid (T5b18, 920-927), Sp. 17676, and trap, (T5b19, 927 to 1041), Sp. 17677, 17678.

Thickness, 121 (96) feet.

Total, 833 feet.

Porphyrite.

Amygdaloid like the ones above, somewhat more laumonitic in T5, and a thin green porcelain like decomposition seam was noticed in the trap (datolite?).

The trap is a coarse, feldspathic glomeroporphyrite, the feldspar phenocrysts being gathered together in bunches that show that the crystallization had advanced pretty well before the last motion.

This is the lowest of this series of feldspathic melaphyres, its base being 276 feet below the Hancock West conglomerate.

In T4 we find that T4b9, 627 to 642, Sp. 16409, A. B., is classed as a thick belt of amygdaloid, 93 feet thick, and next underneath comes a well marked dark lustre mottled ophite, with olivine, Sp. 16410, and the bottom of this belt is given as 262 feet below the Hancock West conglomerate.

It is pretty clear that the bunches of feldspar phenocrysts have caused this whole flow to be classed as amygdaloid in T4 and T3.

T3b8, 389-499, Sp. 16474, also corresponds in part, but more or less of the bottom of T3b8 and T4b9 may be the amygdaloid of the underlying flow.

U. M. 16409A, is a much decomposed glomeroporphyrite, while B shows low angled feldspar, scanty idiomorphic augite, conspicuous olivine. 16410 shows scanty augite, abundant altered olivine, labradorite $Ab_2 An_3$, but with zonar varying extinction.

[13. 14. 15. 16.

Amygdaloid (T5b20, 1041 to 1194 feet), Sp. 17679, 17680, 17681 (122) feet, is undoubtedly a composite belt really containing one or more flows, as the records of the shafts T3 and T4 show. Together with the trap, T5b21, 1194-1212 (14)—which is a dark, typical ophite, and another composite belt, T5b22, 1212-1368, Sp. 17683 to 17684, (124) total, (260) feet, which is described as "amygdaloid with bunches of trap in it, and has at the bottom blue clayey flucan," we have the imperfectly described and separated representatives of at least four distinct beds of ophite, recognized in T4 and T3, probably decomposed in T5.]

13. Trap T3b9, 499-539, with possibly part of T3b8), 40 (32), and T4b10, 742-770 (with possibly a part of T4b9) Sp. 16410, 28 (22).

This is a fresh black ophite, with two feet of hard, fine-grained, typical olivinitic trap at the base, above T4b11.

14. Amygdaloid (T3b10, 539-610, and T3b11, 610-651), (89) and T4b11, 770-823, and T4b12, 823-865, Sp. 16411 A-C, (76).

U. M. 16411B, augite mainly gone, quartz, secondary, olivine pseudomorphs conspicuous.

16411C, ophitic melaphyre, but the augite is scanty, the olivine conspicuous, the feldspar in two generations, one old, corroded, the other an andesite.

15. Amygdaloid (T3b12, 651-772, and T3b13, 772-792), (112), and T4b13, 865-963, and T4b14, 693-988, Sp. 16413-4 (98).

A well marked ophite, somewhat disturbed, slickensided and altered.

U. M. the feldspar is labradorite, $Ab_2 An_3$.

16. Amygdaloid (T3b14, 792-881), (71) and T4b15, 988-1086, Sp. 16415 A-B (78).

One or more small flows, disturbed and charged with laumonite.

U. M. the feldspar is labradorite, $Ab_2 An_3$.

17. Conglomerate (T5b23, 1368 to 1391).

Thickness, 23 (17).

Total, (1110) feet.

This conglomerate was sandy on top, 17685, and then conglomerate 17686. It is the Pewabic West, Marvine's conglomerate No. 16, T3b15, 881-916, T4b16, 1086-1110, Sp. 16416 B-C.

It has the same sandy streak on top also in T4, Sp. 16416.

It is generally red and has some felsitic pebbles, but others more basic, and an abundant calcareous cement.

T5 is 282 feet deeper than T4 and 487 feet deeper than T3.

U. M. fragments are (1) porphyry with micropegmatite ground mass; (2) epidote; (3) albite; (4) spherulitic porphyry (microfelsite), calcitic cement.

18. Amygdaloid (T3b24, 1391-1408), and trap, (T5b25, 1408-1425).

Thickness, 34 (27).

Total, (1137) feet.

T3b16, 916-926, and part of T3b17, 926-984, Sp. 16477, 16478 (53).

T4b17, 1110-1122, T4b18, 1122-1150, Sp. 16417, 16418 (32).

With agates and delessitic amygdules, a fine-grained labradorite porphyrite.

U. M. 16417 shows chloritic amygdules, a marginal form of melaphyre, no olivine.

16418, shows idiomorphic augite prisms.

19. Amygdaloid (T5b26, 1425-1435) and trap, T5b27, 1435-1452.
Thickness, 27 (21.5).
Total, (1159) feet.
No samples seen.

20. Amygdaloid (T5b28, 1452-1462), and trap, (T5b29, 1462-1834), Sp. 16483½, 16485, 16486.
Thickness, 382 (304).
Total, (1463) feet.

"Mixed bed of amygdaloid and trap," a big flow of melaphyre porphyrite, often very feldspathic and glomeroporphyritic, which I think is the one just above the Pewabic and Quincy lode. In T5 it showed some sheet copper on the seams.

The middle specimen is very coarse and feldspathic. There may be more than one flow but the records as kept by the various mining captains do not sharply distinguish the feldspathic and amygdaloidal belts.

T3b18, 984-1014, Sp. 16479, and
T3b19, 1014-1204, Sp. 16480, correspond to this flow and probably also
T3b20, 1224-1267, Sp. 16481, which is only a belt with bunches of feldspar, not amygdaloid.
T3b21, 1267-1315, Sp. 16482, will then also be included.

Salt water was struck in this belt in No. 3, and there may be a slip here.

T3b22, 1315-1342, is probably a belt like T3b20, so that T3b23, 1342-1372, will be the last trap belt of this flow, which makes the thickness as in T5 and T4.

Thickness, 388 (307) feet.
Compare specimens 16483, 16485, 16486.
In the same way in No. 4, we have
T4b19, 1150-1194. Amygdaloid, reddish, with laumonite, Sp. 16420,—a considerable part of this belt probably belongs in the flow above.
T4b20, 1194-1200. Trap, Sp. 16421.
U. M. glomeroporphyritic, with Ab_5 An_3.
T4b21, 1200-1347, apparently a coarse, very feldspathic center of the same belt. The feldspar is often reddish, and big green flecks may be pseudomorphs of olivine.

Probably we should include—
T4b22, 1347-1543 (or 1453). Recorded as amygdaloid, but from the samples, Sp. 16422, much the same as the previous belt, with few amygdules and much red feldspar, U. M. a glomeroporphyrite, with iron oxide growth forms.

Then also we must include
T4b23, 1543-1567, a trap, dark chloritic, greenish but feldspathic, like some belts south of Lake Richey on Isle Royale. U. M. Sp. 16423, is a glomeroporphyrite.
T4b24, 1567-1582, while classed as "amygdaloid" is really a porphyrite with large feldspar phenocrysts, Sp. 16424. Augite is scanty.
T4b25, 1582-1595, classed as a "trap," is really a porphyrite with feldspar phenocrysts up to 1 cm. long. Sp. 16425, slightly ophitic with an andesite feldspar.

Through all these belts no genuine amygdaloid or flow margin can be recognized in the samples saved.

Total, 445 (less 44—for part of the belt T4b19, improperly included (353—35) feet.

The difference in the earlier reports of the mining captains on amygdaloid flows in shafts so near together, shows that they are probably not genuine amygdaloids, but perhaps more altered, more porphyritic or more feldspathic streaks in the one great flow.

21. Amygdaloid (T5b30, 1834-1857), Sp. 16487.
Trap, T5b31, 1857-1916, Sp. 16488.
"Amygdaloid," T5b32, 1916-1924, Sp. 16489.
Trap, T5b33, 1924-2011, Sp. 16490A and 16490.
Total, 183 (140) .... (1603) feet.
Pewabic and Quincy lode?

The amygdaloid at the top is well marked, the bubble cavities being filled with chlorite and calcite, Sp. 16487, and epidote and other crystals, 16426, so that the correlation of T5, 1834=T3, 1372=T4, 1595 is a reliable one within the limits of the amygdaloid belt. The trap becomes pretty close grained with light green feldspar, and green jaspery or datolite seams. T. 5b32 is very feldspathic and decomposed, with reddish feldspar, yellow-green epidote and some dark green chlorite spots. It is one of Pumpelly's pseudamygdaloids, not a real amygdaloid. Sp. 16490, T5b33 is a regular glomeroporphyrite with occasional large feldspar phenocrysts.

T5 reached 2015 feet Jan. 1, 1898.
This corresponds to
Amygdaloid, T3b24, 1372-1435 feet. Sp. 16487.
Trap, T3b25, 1435-1583
211 (168)

Evidently in this shaft the decomposed belt, T5b32=T4b28, was not present, or was not counted as amygdaloid.

It may or may not be one, though Sp. 16427 suggests to me that it is the ophite base of a feldspathic melaphyre.

And this also corresponds to
Amygdaloid, T4b26, 1595-1611. Sp. 16426 (U. M. much altered, yellow epidote).
Trap T4b27, 1611-1652. Sp. 16427 (U. M. much altered, andesitic).
Amygdaloid, T4b28, 1652-1730. Sp. 16428 (U. M. much altered, marginal),
though classed as an amygdaloid, appears to be largely a badly decomposed belt with vein matter, and a little copper and clasolitic sediment.
T4b29, 1730-1806. Sp. 16429.

Total, 211 (168)

T4b27 is a feldspathic ophite like T4b23, and some of the Phelps Island rock of Isle Royale and T4b29, is more coarse with a marked diabasic texture, much plagioclase, and occasional large feldspar phenocrysts, a porphyritic melaphyre.

T4b28 may include an amygdaloid which has acted as a line of weakness and been faulted out or overlooked in T3.

The decomposed and copper-bearing belt, T4b28, 1652-1730, covers the corresponding horizon of T5b32, 1916-1924.

U. M. Sp. 16429, is a doleritic ophite, with low angled feldspars, and chlorite interstices, the chlorite occurring as a rind; zeolite also occurs.

22. Amygdaloid, T5b34, 2011-2037. Sp. 16490½.
Trap T5b35, 2037-2130
119 (95) .... Total (1698)

The Sp. 16490½, is not typical and rather coarse grained, so that if the correlations suggested are right, this might be considered part of the belt below. The specimen of trap has an interesting red aplitic seam of oligoclase, like those often connected with gabbros. It is still feldspathic.

This may correspond to
T3b26, 1583-1613, Amygdaloid,
T3b27, 1613-1635, Trap,
T3b28, 1635-1676, "Amygdaloid," appears to be really a streak of crushed matter along a fault.
T3b29, 1676-1705
122 (97)
and
T4b30, 1806-1891, Amygdaloid, Sp. 16430 (U. M. is a rather feldspathic ophite).
T4b31, 1891-1927, Trap, Sp. 16431, like Sp. 16423, feldspathic.
121 (96)

Sp. 16430, called amygdaloid, proves to be a "pseudamygdaloid," was a much decomposed specimen and very likely may represent parts of T3b26, 27 and 28, especially if the difference in depth (about 222 feet) of corresponding levels of T3 and T4 does not vary much.

Compare TJ2, 417.25—440.75, a belt which carried some copper, with T3b28.

23. Amygdaloid, T5b36, 2130-2169.

24. and trap T5b37, 2169-2278.
Total thickness, 148 (118) .... (1738)

The top is a well marked amygdaloid with thomsonite, and apparently from Sp. 16432, there was a belt of amygdaloid overlooked in the trap. It still belongs in the porphyrite melaphyre type, Pumpelly's ordinary diabase.

This corresponds probably to
T3b30, 1705-1728, "Amygdaloid."
T3b31, 1728-1740, trap.
T3b32, 1740-1785, "Amygdaloid," probably in part at least.
T3b33, 1785-1820.
Thickness 115 (92).
Also
T4b32, 1927-1947, Amygdaloid, Sp. 16432. U. M. a genuine amygdaloid with fine-grained quartz, epidote amygdules, and two well marked generations of andesite.
T4b33, 1947-1967, trap, Sp. 16433.

Sp. 16433 is reddish brown with small lath-shaped feldspar phenocrysts. U. M. It belongs to the Minong type, has andesitic feldspar, and idiomorphic granules and sharp prisms of augite, and some olivine. Sp. 16434, also apparently represents the very bottom of the bed. Sp. 16435 is much like 16433. Unless there is some mistake, there are two flows here.

T4b34, 1967-2003, amygdaloid, Sp. 16434, U. M. glomeroporphyritic.
T4b35, 2003-2033, trap, Sp. 16435, U. M. texture intersertal, scanty granular augite, with olivine pseudomorphs.
107 (85)

The specimens are still feldspathic and belong to the porphyrite type.

25. T5b38, 2278-2292, amygdaloid.
T5b39, 2292-2327, trap.
Thickness, 49 (38).
Total, (1777).

This corresponds to
T3b34, 1820-1863.
T3b35, 1863-1878.
58 (46)
T4b36, 2033.6-2048.3, Sp. 16436, amygdaloid with calcite filling. U. M. calcite and zeolites, trichitic feldspar, scanty augite.
T4b37, 2048.3-2117.6, Sp. 16437, trap.
84.0 (67)

Sp. 16437 is medium fine-grained and not markedly porphyritic.

U. M. it is glomeroporphyritic, with andesite, scanty augite, olivine pseudomorphs, calcite and zeolites.

26. T5b40, 2327-2349, amygdaloid.
T5b41, 2349-2374, trap.
47 (37) .... Total, (1814)

Whether T5b42 is a real amygdaloid, overlooked in the other shafts, we cannot be sure. It may be merely a glomeroporphyritic belt.

This may correspond to
T3b36, 1878-1905, in part amygdaloid.
T3b37, 1905-1970, trap.
92 (72)

Compare TJ2, 673.75-695.5.
T4b38, 2117.6-2145.7, amygdaloid, Sp. 16438.
T4b39, 2145.7-2208.2, Sp. 16439.
90.6 (72)

Sp. 16439 is a coarsely mottled ophite, with olivine perhaps represented by serpentine. U. M. feldspar is andesite.

Sp. 16438 has calcite amygdules, but is of the same type as T4b22 and T4b25, a glomeroporphyrite, the whole flow being a feldspathic ophite, tending to differentiate. U. M. it shows somewhat agglomerated feldspar.

27. T5b42, 2374-2411, amygdaloid.
T5b43, 2411-2484, trap.
Thickness, 100 (79) .... Total, (1893)

This has by some been correlated with the *Pewabic amygdaloid.*
T3b38, 1970-2018, amygdaloid.
T3b39, 2018-2039, trap, Sp. 16491.
Thickness, 69 (45).

T4b40, 2208.2 amygdaloid, Sp. 16440. U. M. trichitic marginal plagioclase, amygdules with yellow and green epidote and quartz.

T4b41, 48.8 -2257, (39) trap. Sp. 16441, dark, with a few large feldspar phenocrysts. U. M. verges on ophite, rather scanty augite, with oligoclase.

The amygdaloid marking the top of this belt varies so in position in the different sections, that it is hard to explain. Is it near the end of the sheet?

28. T5b44, 2484-2513.
T5b45, 2513-2569.
Thickness, 85 (67).........................Total, (1960) feet.

This may correspond to
T3b40, 2039-2068, Sp. 16492.
T3b41, 2068-2111, Sp. 16493, a very dark ophite.
Thickness, 72 (57).

Compare with TJ2, 807-837.

Also with
T4b42, 2257.5-2305.7, amygdaloid, Sp. 16442.
T4b43, 2305.7-2333.7, trap, Sp. 16433.
76.2 (60)

Sp. 16643 is a very dark, massive labradorite or porphyrite=Sp. 16493. U. M. feldspar is Ab_3 An_4, augite scanty.

29. T5b46, 2569-2630, amygdaloid, (71).
T5b47, 2630-2684, trap, (54).
Thickness, 115 (91).........................Total, (2051) feet.

As the extra breadth of the amygdaloid belt indicates, there may be here two flows, or the porphyritic character of the two sheets may have led more of their contact belt to be classed as amygdaloid.

Compare:
T3b42, 2111-2143, amygdaloid, Sp. 16494.
T3b43, 2143-2164, Sp. 16495.
53 (42)
T4b44, 2333.7-2416.6=(83), amygdaloid. No samples.

Compare TJb1, 500.4, TJb2, 2887.4, T3, 2111, and T4, 2333.7.

30. T5b48, 2684-2708, amygdaloid.
T5b49, 2708-2753, trap.
69 (55)

Compare T3b44, 2164-2198, Sp. 16496.
T3b45, 2198-2247, Sp. 16497.
83 (66)

This probably represents a small part of T4b44, 2333.7-2416.1; no Sp. and the whole of T4b45, 2416.6-2471.8=(55.2+), Sp. 16445. Of Sp. 16445 there are two pieces, one amygdaloid with thomsonite, possibly T4b44, mislabeled, the other, a fine-grained, dark purple melaphyre, a diabasic melaphyre.

The porphyry tuff, jasper bed (see Isle Royale report, p. 74), at 460 feet in T1, seems not to have been noticed elsewhere.

U. M. 16444 is an ophitic melaphyre with large feldspar phenocrysts.

16445 shows low angled andesite.

Compare TJ1, TJ2, 1033, Red Jacket or Whiting shaft of Calumet and Hecla 1215, T3, 2247, T4, 2471.

31. T5b50, 2753-2796, amygdaloid.
T5b51, 2796-2981, trap.
Thickness, 228 (181) ....Total, (2329) feet.

This is the great sheet known as the "Greenstone," which is the "backbone" of Isle Royale, (drill hole VI, 124-363. See Volume VI, part 1. pp. 74, 126, 128, 134, 244) and is also a prominent ridge, being there much thicker, probably several hundred feet, with proportionately coarser mottling of augite, just north of the Cliff, Central, Phœnix, and other mines.

It is a type of ophite melaphyre, though in many places as coarse as many a gabbro. Yet the flow as a whole, contains glassy matter.

This corresponds to
T3b46, 2247-2274. Sp. 16498 is a fine-grained ophite.
T3b47, 2274-2513. Sp. 16499.
Thickness, 266 (212).

Compare TJ2, 1033.

Also to T4b46, 2471.8-2479.4. Sp. 16446, amygdaloid, fine-grained with small amygdules, zeolitic.
T4b47, 2497.4-2747.2, Sp. 16477. Fine-grained trap with small amygdules.
Thickness, 265.4 (211).
Sp. 16447 is not at all typical.

32. T5b52, 2981-3020 (or 3000 L. S. M. Institute report).

Conglomerate. *The Allouez conglomerate, one of the most important datum planes of the series, Marvines, No. 15, the Albany and Boston* (Peninsula and Franklin Junior).
Thickness, 39 (31) ....Total, (2360) feet.

Corresponds to
T3b48, only 6 inches at 2513. Sp. 16500.
T4b48, 2747.2-2754.2. Sp. 16448. U. M. decomposed syenite pebble?
T2, at 1256.
T1, at 876.
Calumet and Hecla, Red Jacket or Whiting shaft at 1656 feet.
Isle Royale drill hole VI., 363-386 feet.
T1, at 670 feet.

33. T5b53, 3020-3061, amygdaloid.
T5b54, 3061-3114, trap.
94 (75)

Corresponds to
T3b49, 2513-2588, amygdaloid.
T3b50, 2588-2629, trap.
116 (92)

T4b49, 2754.2-2826.5, amygdaloid. Sp. 16449.
T4b50, 2826.5-2875.9, trap. Sp. 16450, an ophite. U. M. like 16414, olivine pseudomorphs.
121.7

The belt T4b49-50, also corresponds to the next belt.

34. T5b55, 3114-3158, amygdaloid.
T5b56, 3158-3181, trap.
67 (53)

Compare
T3b51, 2629-2656
T3b52, 2656-2677
52

Also
T4b49, 2754.2-2826.5, amygdaloid. Sp. 16449.
T4b50, 2826.5-2875.9, trap. Sp. 16450, an ophite.
121.7

The upper belt of amygdaloid is much too broad to be one flow and corresponds to T5b53-54, and T3b49 and 50.

T4, 2826.5, is nearly =T3, 2651=T5, 3061.

35 and 36. T5b57, 3181-3221, amygdaloid.
T5b58, 3221-3320, trap.
139 (110)

This seems to represent two flows in T3, to wit:
T3b53, 2677-2703, amygdaloid.
T3b54, 2703-2720, trap.
43
T3b55, 2720-2742.
T3b56, 2742-2819.
99=142 (113)

Compare
T4b51, 2875.9-2973.8, amygdaloid.
T4b52, 2973.8-3050.4, trap. Sp. 16452, an ophite, medium coarse.
174.5

Obviously, in the smaller flows, less than 50 feet or so thick, the line between amygdaloid and trap is largely one of individual caprice, the upper flow in T5 and T4 is counted all amygdaloid and in the Red Jacket shaft the whole interval from 1700-1954 feet.

37. T5b59, 3320-3339, amygdaloid.
T5b60, 3339-3594, trap.
274 (217)

Compare:
T3b57, 2819-2834.
T3b58, 2834-3114.
295 (234)
T4b53, 3050.4-3064.5, amygdaloid. Sp. 16453.
T4b54, 3064.5-3334, trap. Sp. 16454.
284 (225)

Sp. 16454 is an ophite, but has one large feldspar phenocryst, perhaps a pre-effusive, or "brotocrystal." U. M. a medium, coarse-grained ophite with chloritic interstices.

Compare the ophite (202) feet thick in the Red Jacket shaft at 1754 feet depth.

This ophite is just here as large as the "Greenstone," but it has not the same topographic prominence, which is another indication that the "Greenstone" (p. 263) is thicker to the north. This is, however, thick enough to be a fairly persistent bed.

38. T5b61, 3594-3630, amygdaloid.
T5b62, 3630-3691, trap.
97 (77)
T3b59, 3114-3144, amygdaloid. Sp. 16509.
T3b60, 3144-3212.6, trap. Sp. 16510.
98.6 (78)
T4b55, 3334 -3358.4, amygdaloid. Sp. 16455.
T4b56, 3558.4-3444.9, trap. Sp. 16456.
110.9 (88)

Sp. 16455 is much decomposed, dark red with epidote and calcite.

Sp. 16456 is a fine-grained melaphyre. U. M. rather fine-grained.

Compare the belt at 1310 feet in the Calumet and Hecla cross-cut to Red Jacket shaft.

39. T5b63, 3691-3730, amygdaloid.
T5b64, 3730-3769, trap.
78 (62)
T3b61, 3212.6-3235 amygdaloid. Sp. 16511, laumonite.
T3b62, 3235 -3270.3, trap. Sp. 16512.
57.7 (46)
T4b57, 3444.9-3458.7, amygdaloid. Sp. 16457, laumonite.
T4b58, 3458.7-3500.7, trap. Sp. 16458, hard, fine-grained.
55.8

U. M. Sp, 16458 is slightly glomeroporphyritic; labradorite not high exangled; augite scanty, granular or patchy; olivine (iddingsite) scarce; iron oxides abundant.

Sp. 16457 seems to show melaphyre fragments with a red calcareous cement, and might cover a narrow scoriaceous conglomerate, (?) the Houghton conglomerate, of the ashbed type.

Sp. 16458 is somewhat glomeroporphyritic.

Compare the amygdaloid at 1218 feet in the long Calumet and Hecla cross-cut to the Red Jacket shaft, Plate I of Vol. V, Part I, and the feldspathic melaphyre beneath.

40. T5b65, 3769 -3783 amygdaloid.
T5b66, 3783 -3784 trap.
Thickness, 78 (67).

Compare:
T3b63, 3270.3-3312.4.
T3b64, 3312.4-3366.4, trap. Sp. 16514.
96.1
T4b59, 3500.7-3535, amygdaloid. Sp. 16459 hard. U. M. ophite with feldspar not abundant.

T4b60, 3535-3611, trap. Sp. 16460.
110.3
This is an ophite, red, blotched with enclosures.

41. Houghton conglomerate absent (Marvine's No. 14) ?

42. T5b67, 3847-3861, amygdaloid.
T5b68, 3861-3885, trap.
Thickness, 38 (30).

43. T5b69, 3885-3912, amygdaloid (possibly a vein breccia).
T5b70, 3912-3971, trap.
Thickness, 86 (68).
Compare:
T3b65, 3366.4-3385, amygdaloid. Sp. 16515.
T3b66, 3385 -3500, trap. Sp. 16516.
133.8
T4b61, 3611 -3649.8, amygdaloid. Sp.16461, light green.
Sp. 16461A.
T4b62, 3649.8-3719.7, trap. Sp. 16462, ophite. (March 16, 3860 feet).
108.7
Sp. 16461A appears to be a vein of breccia. Sp. 16462 is not so markedly ophite.
The Houghton Conglomerate (Marvine's No. 14), is due here, and the blotched appearance of the overlying flow and the breccia may be signs of it.

44. T5b71, 3971-3991, amygdaloid.
T5b72, 3991-4049, trap.
78 (62)
An ophite, a well identified bed.
Compare:
T3b67, 3500-3521, amygdaloid. Sp. 16517.
T3b68, 3521-3578, trap. Sp. 16518, an ophite.
78 (62)
T4b63, 3719.7-3740.6, amygdaloid. Sp. 16463.
T4b64, 3740.6-3794.4, trap. Sp. 16464, ophite.
74.7
In the Calumet and Hecla cross-cut this appears as flow (920-800).

45. T5b73, 4049-4085.
T5b74, 4085-4137.
Thickness, 88 (70).
Compare:
T3b69, 3578-3619, amygdaloid. Sp. 16519, with *copper*.
T3b70, 3619-3769, trap. Sp. 16520, an ophite.
10 1
T4b65, 3794.4-3837.1, amygdaloid. 16465.
T4b66, 3837.1-3909.4, trap. 16466, ophite.
115.0
In the Calumet and Hecla long cross-cut, this appears as a flow (800—674=128x.62=79 feet thick) of ophite with a laumonitic amygdaloid.

46. T5b75, 4137-4183, amygdaloid.
T5b76, 4183-4232, trap.
Thickness, 95 (74).
Compare:
T3b71, 3679-3733 amygdaloid. Sp. 16521, small amygdules.
T5b72, 3733-3797.8, trap. Sp. 16522, ophite.
117.8
T4b67, 3909.4-3927.8, amygdaloid. Sp. 16467.
T4b68, 3927.8-3979 trap. Sp. 16468, ophite.
69.6
Sp. 16468 matches 16522 remarkably well.
In the Calumet and Hecla cross-cut we have a flow (674 to 660, and 660 to 557, i. e.. 117) (73) feet thick of melaphyre, with a brecciated amygdaloid.

47. T5b77, 4232-4254, amygdaloid.
T5b78, 4254-4358, trap. Ophite.
Thickness, 126 (100)
T3b73, 3797.8-3818 amygdaloid. Sp. 16523.
T3b74, 3818 -3898.2, trap. Sp. 16524, ophite.
100.4
Sp. 16523 has two pieces, one a well marked contact of two flows. A is the top of the lower bed, more amygdaloid.
The ophite is massive, chloritic, hard to break.
T4b69, 3979-4005, (26) amygdaloid. Sp. 16469.
T4b70, 4005 trap. Sp. 164670, ophite.
This has a quartz epidote amygdaloid (Sp. 16469). In the Calumet and Hecla longest cross-cut it is an ophite with olivine well marked and a thickness of (539—361+18=196, which x .62=122) feet, the amygdaloid appearing dark red laumonite.

48. T5b79, 4358-4386.
T5b80, 4386-4456.
98 (78)
Compare:
T3b75, 3898.2-3920, amygdaloid. Sp. 16525.
T3b76, 3920 -3970, trap. Sp. 16526, ophite.
72
T4b71.
T4b72.
This in the Calumet and Hecla longest cross-cut is a belt with augite grains (mottled) at least 2 to 3 mm. across and a thickness of (361—220=141x.62=87) feet.

49. T5b81, 4456-4525= 70, amygdaloid.
T5b82, 4525-4636=111, trap. A heavy ophite.
181 (144)
T3b77, 3970 -4008.7, amygdaloid. Sp. 16527.
T3b78, 4008.7-4044 trap. Sp. 16528, called amygdaloid in other records and really amygdaloid.
T4b79, 4044-4065, amygdaloid with copper. Sp. 16529.
T4b80, 4065- trap. Sp. 16530, ophite.

This is the Calumet and Hecla cross-cut, an ophite with augite grains (mottles) at least 3 to 4 mm. in diameter, indicating a flow at least 80 to 120 feet thick, the belt with the amygdaloid being 220 feet wide (x.62=145 feet thick).

The amygdaloid is chloritic with a little copper.

50. T5b83, 4636-4662, amygdaloid.
26 (20)

Not noticed in the Calumet and Hecla longest cross-cut, probably not present.

T3b81, amygdaloid. Sp. 16531.
T3b82, trap. Sp. 16532. A fine-grained black trap, appropriate to a thin flow.

51. T5b84, 4662. Calumet and Hecla conglomerate. Marvine's No. 13. T3b83, at 4183, in T4 at 4393 feet.

The Rest of the Keweenawan Section.

From the Calumet and Hecla conglomerate down to the Kearsarge amygdaloid, which is the important belt worked by the Ahmeek, Mohawk, Wolverine, Allouez (new vertical shaft), Centennial, and Osceola which has also been recently opened up by the Calumet, there are a number of sections.

In Volume V, Part 1, will be found the sections of their long drift in the foot wall, furnished by the C. and H. Mining Co. In Volume VI, Part 2, p. 130, will be found a section of the Franklin Junior, which was furnished by Mr. Pope. The long drifts from the Tamarack vertical shafts over to the lodes also show the section down to the Kearsarge conglomerate and to within 200 feet of the Kearsarge amygdaloid. A lot of work has recently been done in developing the section below the Tamarack, which I trust to take up more fully in the future and will therefore give merely in abstract for convenience of reference here.

CENTENNIAL.

Calumet and Hecla in cross-cut, 2.33 feet.

1. Amygdaloid, 27 (17) feet and trap; Sp. 16545-16550; 187 (115).

2. Amygdaloid, 54 (33) feet; ophite; 16551-16559; 441 (271); coarsest about 174 feet above its base, where the augite mottles are some 6.5 mm. across; cut by a 2 to 3 foot slip about 266 (208) feet from its base. Comparing the various cross-cuts from the Calumet and Hecla, given in Volume V, we see that either this slip has been the cause of various interpretations of the section according to the degree of alteration produced, or really is crossing the formation obliquely, so as to give different sections at different points.

3. Amygdaloid, very much brecciated lamonitic and almost conglomeritic in texture for 44 (37) feet,—then coarse ophite, 168 (103); Sp. 16561-16565.

Total from top of Calumet and Hecla to top of Osceola, (491).

In a cross-cut in the 13th level from Tamarack No. 1, it was, according to R. M. Edwards, 750 (461) feet from the bottom of the Calumet and Hecla to the top of the Osceola, the records being amygdaloid trap 35, trap 145, amygdaloid 50, trap 220, amygdaloid (which is probably a pseudamygdaloid along a slip in reality) 20, trap 95, amygdaloid with copper 40, trap 145, to the Osceola. It is probable that strike faults produce some of this variety in sections.

Down to the Kearsarge-North Star conglomerate No. (11) are some four belts more or (412 at the Franklin Junior)—(481) feet.

This is about 1,000 feet below the Calumet and Hecla. The next 600 feet below the top of the Kearsarge are taken up by about four belts or flows, often heavy ophites, which are cut by the long cross-cut of the Calumet and Hecla. This is pretty well down to the Kearsarge amygdaloid which is one of the most important lodes, being opened by the Calumet, the Kearsarge branch of the Osceola, Centennial, Wolverine, Mohawk, Ahmeek, Allouez, and is below the top of the Kearsarge conglomerate about (880) feet. It is not far, about 200 feet, from the bottom of Tamarack shaft No. 2.

The Kearsarge amygdaloid is the top of a peculiar bed of ophite characterized, as Dr. Hubbard has remarked, by quite frequent long porphyritic crystals of feldspar (labradorite phenocrysts), which appear to be quite early formed. At the base of this ophite which is about (180) feet thick, is a sandstone or conglomerate 40 to 60 feet thick, the Wolverine sandstone (Marvine's No. 9), so that the total from the top of the Kearsarge conglomerate to the top of the Wolverine sandstone is say (1060) feet; going south it may thin to (880) feet, and the whole thickness from the top of 11 to the top of 9 around Portage lake may be not over (875) feet.

Below the Wolverine sandstone comes a broad belt which has few notable sediments and no mines. One horizon has been denoted by Dr. Hubbard the "inclusion bed," about 461 feet below. There are some heavy ophites and coarse doleritic traps such as are associated with the Arcadian and Isle Royale horizon which is below the top of the Wolverine sandstone, say (2200) feet.

Not very far below this is an important sedimentary horizon, that of conglomerate No. 8. This is quite probably the same as the Bohemia-St. Louis conglomerate which Dr. Hubbard has traced quite extensively in Volume VI. It seems to mark the upper horizon of one set of acid felsitic flows, such as occur at a number of points and the interval between it and the No. 9, the Wolverine sandstone, is perhaps (2750) feet. It is about 5,000 feet up to the Calumet and Hecla.

Below the Bohemia conglomerate horizon comes the porphyry exposed on the Torch Lake R. R. (and shown in the map of Allouez Gap, given in Volume VI) which is probably at nearly the same horizon as the Mt. Houghton and other extrusive felsites which Dr. Hubbard has described out on the point, and the felsite found at the base of the Isle Royale (Wendigo) section. We do not find these farther south, but we do find a group of conglomerates sometimes as much as 200 to 300 feet thick, corresponding to Marvine's numbers 5, 6, 7, and 8, with perhaps others intercalated, a more careful description of which may be left until later. However, between the top of conglomerate 5 and top of 8, are about 10 belts around Portage Lake, included in a thickness of about (1000) feet.

Near Calumet the presence of irregular masses of porphyry makes it difficult to give any general figure.

Below the horizon of conglomerate (5) which probably does not appear at its ordinary level there is in the long cross-cuts of the Atlantic mine on Sec. 16, down to (No. 3), the Baltic conglomerate, (2050) feet. The flows are mainly heavy ophites with scoriaceous amygdaloids that are liable to develop normal sediments at very short notice. The Baltic conglomerate is the one not far below the Baltic lode or shear zone in the mines of the Copper Range Consolidated. Dr. Hubbard tells me that toward the south, the distance between the two increases. But this is not the base of the formation, which is nowhere visible. Toward the end of the point there must be exposed below the Bohemia conglomerate, faulting apart, not much less than 5000 feet, or below the Baltic conglomerate (No. 3) level, say (1400) feet.

East of Houghton to Marvine's conglomerate (1), there is some 2000 feet horizontally, or about the same thickness. There is no real indication even here that we are at the base of the series or beginning of the volcanic activity. To obtain any lower beds, however, we must go elsewhere. I propose, in the coming year, to have prepared a section from the Gogebic range (where the Keweenawan is said to be more nearly conformable to the Huronian) north, and see if we can find comparable horizons, and any light upon the base of the Keweenawan. It is, of course, conceivable that the lowest beds of the Keweenawan exposed there, may be overlaps of beds far from the base of the series, but that is not my present belief. There is one comment that I think worth making. From the level of the top of Tamarack No. 5 to the Baltic conglomerate No. 3, is about 11,000 feet and there are at least 12,400 feet of beds. Now, the top of Tamarack No. 5 is by no means the top of the formation, though it is not far from the top of the main series of traps and the lake shore traps most likely do not appear here. There is perhaps 1,400 feet of mixed sandstone and trap above. Then there is the great conglomerate and the lake shore trap (probably absent), above which Irving draws the line between upper and lower Keweenawan, that are 700 to 2300 feet thick, so that there is not less than 13,000 feet of the lower Keweenawan.

Above this is an unknown amount of red sandstone and shale, certainly not less than 1000 feet, for which Irving estimates 9000 feet. Now is it likely that the base of the series could ever have been buried 22,000 or even 14,000 feet at an early date in geological time (when the rate of increase of temperature, unless we adopt Chamberlin's hypothesis, was higher than at present and then steamed) without having the augite altered to hornblende as it is around the Mt. Bohemia intrusion for a considerable breadth? It does not seem to me likely. It seems probable on this ground as well as on account of the basic pebbles found in the conglomerates that uplift and tilting took place at several times during the formation of the series. One I suspect is about the time of conglomerate 8, i. e., the Bohemia; another about the time of the great conglomerate, and at the time of the basic (Nonesuch) black shales there must have been extensive erosion of the Keweenawan traps.

What the condition of the traps in the undisturbed center of the basin may be we can but guess. I suspect they will be much like many of the amphibolites (so-called diorites) of the copper country.

DEEP BORINGS

FOR

OIL AND GAS.

The position of the geologist relative to borings for oil and gas in Lower Michigan is trying. He cannot absolutely discountenance explorations with such confidence as he can predict the failures of coal explorations outside of the coal basin at Norwood or Petoskey, for instance. Neither can he promise favorable results with such confidence as he can promise brominiferous brines, or gypsum or salt. He can only say that the chances are generally unfavorable, but more favorable in some places than in others. Not a little of my time has been spent in examining borings and discussing prospects, and I thought of making quite a full report on recent borings something like that in the 1901 report. But a number of important records are not yet finished and I do not like to break up an elaborate record between two reports. The borings along the Detroit river should very soon receive exhaustive treatment in the Wayne county report and may therefore be omitted here. In this region the results so far are discouraging, as I have already mentioned, with this exception, that the quarries at Sibleys and at Anderdon, across Detroit river in Canada, dip to the southwest instead of the northwest or north, which should be the normal direction of dip. This may indicate that they lie on the northeast side of a synclinal or monoclinal to a fault, and that just northeast of them in turn is the axis of an anticlinal running and pitching to the northwest. The depth of the Sylvania sandstone in the various wells along the Detroit river indicates the same thing, the depth being less beneath Wyandotte than either above or below. This, then, would be the most favorable point to test, but the upward bend does not appear to be more than 30 feet or so, and the well of the Eureka Iron and Steel Co. (Van Alstyne) or that of the Fords (Michigan Alkali Co.) have not shown any noteworthy amounts of oil or gas. The line thus indicated produced northwest would, however, pass close to a field in Livingston county where some oil and gas has been found. Here also are oil horizons known as the Berea.

In previous reports (Volume V, and annual for 1901 and 1902) I have ventured to indicate other regions also as more likely to have the necessary structure, to wit: Khagashewing Point on Little Traverse Bay; somewhere near Manistee; an anticlinal through the city of Saginaw, probably running a little west of north; one at Port Huron; an area north of Mt. Clemens, and finally coming up from Indiana a region east of Niles.

In regard to the Manistee district, Mr. T. Percy is going to do some testing upon which, with his knowledge of this region and oil wells elsewhere, we may depend so far as he goes. A disadvantage is that the drift is thick, and the oil horizons deep. At Rapid River on the other side of Lake Michigan, the newspapers report oil to have been struck in quantity,[1]

[1]The following is given us as a test of the oil:

Milwaukee, Nov. 4, 1903.

The Cream City Development Co., City:
Gentlemen:—In accordance with your request I have carefully examined your sample of raw

(estimates ranging from 30 to 300 barrels a day) at 1,000 feet. But as I understand that the casing was not in order, and that 1,000 feet would be down in the preCambrian, and certainly could not be above the Potsdam, such estimates should be taken with great reserve. The oil may come by a leak from superficial strata.

In Muskegon, the Central Paper Co. put down a deep well and kept a careful set of samples, the results of which are as follows:—

Muskegon well No. 6. Central Paper Co., on lot 1, N. E. 1/4, Sec. 34, T. 10 N., R. 17 W., about 4 1/4 miles from Ryerson well.

Pleistocene.		
Sand	50	50
Red calcareous clay, a little lighter than in No. 5, 126-200.		
Smooth, red, calcareous clay	183	233
MISSISSIPPIAN (SUB-CARBONIFEROUS).		
Marshall.		
Sandstone, greenish, calcareous, very fine at the bottom, a typical Marshall grit	77	310
Lower Marshall?		
Shale, dark, bluish, more or less calcareous	315	625
Limestone, a clayey and dolomitic waterlime, with selenite, like limestones of the Michigan series	35	660
Shales, blue, calcareous	185	845
Limestone, red and white, fossiliferous	25	870

petroleum from Delta county, Upper Peninsula, Mich., handed to me for physical and chemical investigation. In the following please find the results at which I have arrived.

1. *The color of the same* is a brownish black, *the consistency is liquid though moderately viscous.*

2. *Specific gravity of your oil compared with that of other prominent fields:*

Your Delta county oil, Michigan, 0.873; Pennsylvania Petroleum, 0.801 to 0.817; Ohio Lima field, 0.816 to 0.860; West Virginia, 0.841 to 0.873; Russia Bakerfield, 0.859 to 0.871; Beaumont, Texas, 0.904 to 0 926; California, 0.920 to 0.983.

3. *The flashing point of your raw petroleum:*

You will undoubtedly understand that petroleum coming from the well must be safe for transportation, handling and for storage. Very few petroleums as they come from the well have these qualifications. All contain a greater or less percentage of naphtha, or some lighter hydrocarbons which have a tendency to reduce the flash point and make the oil easily inflammable. *The flashing point of the sample of your raw oil proves to be between 165 and 170 degrees F. which indicates that the same is perfectly safe for any kind of transportation as well as for the required storage.*

4. *Results of its fractional distillation:*

Temperature.	Percentage of distillate.	
Below 150° C. or 302° F.	6.8	
150-250° C. or 302-482° F.	64.3	
250-325° C. or 482-617° F.	11.2	
	8.6	Paraffin and vaseline, and
	9.10	Residue, which later proved to be mainly asphalt.

The first part (the 6.8%) of the above distillates contained but a very small qnantity of light resp. volatile hydrocarbons (gasoline, benzine, etc.) while more than 60% of the raw oil proved to be first-class illuminants

From the foregoing it is clear that the oil is of excellent quality, partly of a paraffin but mainly of an asphaltic base.

Very respectfully,
FR. RUSCHHAUPT.
Geologist, Mining Engineer and Chemist.

Coldwater.		
Flags, i. e., blue and green siliceous shales, with bands of very fine-grained grits, or sandstone, at times more or less calcareous	530	1400
DEVONIAN.		
Horizon of Berea.		
Shales, red and green	80	1480
Antrim.		
Shale, black, bituminous, pyritic, especially at the base	135	1615
Traverse.		
Shale, blue, calcareous	35	1650

I wrote the Central Paper Co. the letter below, and I understand that further tests may be made. I sent also sample bottles for samples of the Black Creek or Fruitport well, but mischevious boys carried them off before I got them, and the drillers did not keep a record.

Lansing, Mich., May 1, 1903.

Central Paper Co.,
Muskegon, Mich.

Gentlemen.—I send herewith blue print diagram of your well.

I presume the well is at about the same height above the lake as the Ryerson well and about 10 feet lower than the old Mason well. The bottom of your well extends down into the Traverse (Hamilton) series of blue shales and limestones. A small area of this is found near Milwaukee. Thus, the easterly dip from across the lake is some 20 odd feet per mile (1615 feet ÷ 84 miles). From your well to the Mason well the dip continues about the same as that from Milwaukee (1700—11?—1615÷4).[1]

The bed of red fossiliferous limestone which shows in your well at 845 to 870 feet is ignored in the old Mason record, but shows well in the samples from the well recently put down near the old Mason well, but on lower ground, at a depth of 890 to 904 feet. The dip is still easterly but not so great,—only about 11 feet to the mile. This is quite what we should expect for we know that this series of beds thickens going east and thins out near Milwaukee, and this is just about the dip which would be expected. Now, although the Ryerson well is not absolutely in the line of the Central Paper Co. and Mason wells, it is so nearly so that we should expect the beds in it to be deeper than in the Mason wells. This is not true. This bed and other corresponding strata appear higher in the Ryerson well, than in the new well near the Mason well,—No. V of my annual report for 1901.

Accordingly, if I wanted to try further for oil, I should go up the lake, —say on sections 15 and 16, and see if there might not be an anticlinal in that direction. The oil sand is, however, so fine-grained that it is not likely to be a free yielder unless it is struck in some exceptionally coarse

[1] The difference in depth to the same horizon minus the difference in elevation divided by the distance between the wells.

spot. It is barely possible that oil or gas might be found at the point indicated as the Dundee,—2100 feet or so down, but this would probably be of the Canada quality.

I should like to know the record of the well and the sample of the Fruitport well put down not long ago, and with your permission, I should like to send a copy of this letter to Mr. Kimball of Chicago. If we recognize that same limestone in the Fruitport well, it will be of considerable advantage.

Very respectfully yours,
ALFRED C. LANE.

In connection with the abnormal elevation of the Ryerson-Hill well above referred to, it is worth noting that as I have myself observed, it continually exudes some oil. The amount, according to newspaper[1] report, probably exaggerated, is half a barrel a day.

DIVINING RODS.

There has been considerable activity in exploration near the Indiana line, not all of it on business principles. Wells have been located on the witch hazel divining rod plan worked up to an instrument supposed to be scientific, but which is beyond my science. Many would up and down denounce it as a fake and those who work it as fakirs.

I am inclined to think, however, in some cases the person using and having bought the instrument may be honestly deluded, and I think, therefore, that it may be worth while to give a description of the instrument and its working (the witch hazel and other water diviners are similar), to show how one may fool one's self as well as others. It belongs to a class of instruments like the planchette, which are very sensitive to conscious or unconscious muscular action.[2] The Assyria well was located by it.

Two flexible rods of whalebone about a foot long corresponding to the branches of the witch hazel, issue from a weighted disk corresponding to the fork or crotch of the witch hazel divining rod, to the other side of which is secured a tube (A) containing oil, or some substance which is

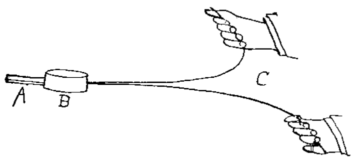

Fig. 8. Illustrates divining rod instrument.

supposed to be attracted by the substance in the ground. In working it the rods are bent until their ends are parallel, as shown in the diagram at C, and are held one in each hand, the palms turned upward, and the weight also being upward. In such a position it is clear that it is in a very unstable position, and that the weight (B) has a strong leverage against the grip of the hands which have only the thickness of the rods to

[1]Grand Rapids Herald, 11/1/1904.

[2]James' Psychology. My predecessor, Dr. M. E. Wadsworth, published in the American Geologist, January, 1898, an explanation of the mechanical action of the divining rod, which however, differs radically, in that the ends of the twig fork are supposed to "enter the closed fist on the exterior side of each fist," and the difference between wrist and finger action is not emphasized.

work on. Under such circumstances, by gripping it tight, one can keep the bob erect, but the least relaxation of grip, *and what I think is more important*, a turn of the wrist so slight that I could not in watching my own wrists detect it, will let the bob over. *In fact, the wrist has vastly greater and easier control than the fingers.* Now it is easy to see from well recognized principles of modern psychology, that one thus holding it will from time to time either at points where he is otherwise led to expect oil, or from mere weariness, see it dip, quite unconscious of any cooperation on his part, if his attention is riveted on the grip of his fingers or on visions of oil, and may be led to believe the instrument full of magnetic power. So long as water is concerned and no special depth guaranteed, it is easy to see that here in Michigan, in almost all cases it will succeed. Possibly a little of that "horse-sense" by which animals are supposed to divine the presence of water may linger in some men yet and help them to guess good places to dig, which guess may be consciously or unconsciously recorded by the instrument.[1] But in view of the fact that, generally speaking, the rocks below ground water level (say 30 feet depth at most), are saturated with water, it can hardly be believed that the rod can pick out what are known as veins of water, which are really merely more pervious places where the water will more readily flow, and be pulled by them, and not be strongly pulled by the general mass of water. The same thing applies to oil. There is more or less organic, oily, matter in most rock, especially black shale. Mr. Wood, for instance, made an analysis of a sample from the Assyria well at 1575 feet, under the direction of M. A. Cobb, in the laboratory of the Lansing high school, which, though it is only a student analysis, will illustrate the point. Others will be found in the coal report, Volume VIII, part 2, p. 105. It is as follows:—

Analysis of shale from 1575-1700 of the No. 2 Assyria well. Oct. 22, 1903.

Moisture	6.595%
Volatile carbon (largely oil)	6.025
Fixed carbon	3.95
Ash	83.435
	99.985%

How could a body of oil make itself felt through a belt of rock over 300 feet thick and so saturated with oil and gas as this, merely because it happened to be in a more pervious rock which would more readily yield it?

The Assyria well went through the Dundee, but no oil to speak of was found. I did not expect it. A strong brine peculiarly free from sulphates (Mr. Ware wrote in a letter that he thought he detected a trace of barium spectroscopically, which would account for the absence of sulphates), was found, whose analysis was as follows:—

Ann Arbor, Mich., Oct. 31, 1903.

Mr. Alfred C. Lane,
State Geologist,
Lansing, Michigan.

Dear Sir.—We have just completed the analysis of the salt brine sub-

[1]Remarkable successes have been reported to me. For instance, for Jacob Wood of Farmington, now living one mile from Grand Ledge; also for C. D. Woodbury of Lansing.

mitted to us by you, and find it contains strontium, bromine, and lithium (spectroscope anal.). A 40 cc. sample contained 1.044 grams CaO; .510 grams MgO; and 6.9482 grams chlorine (in form of chlorides).

Very truly yours,
Chemical Laboratory, U. of M.,
Elmer E. Ware.

Mr. Alfred C. Lane,
Lansing, Mich.

Dear Sir.—We beg to report the following analysis of the sample of brine received from you, from Assyria, Michigan:—

Gravity	24° Baume
Bromine	0.11%

We have no means of determining the potash. This being a very difficult matter to obtain on account of the presence of so much sodium.

Yours truly,
(Signed) THE DOW CHEMICAL CO.,
Jas. C. Graves, Supt.

Oct. 24, 1903.

Of course, the believer in the divining rod said that the oil was there but farther down, in the Trenton, and I advised the secretary of the company to go ahead down to the Trenton, because they were a good deal over half way down, and they might as well make the test thorough while they were about it, in accordance with Prof. Blatchley's remarks.[1]

The one thing that I would urge with all my power upon those who want to take a venture with nature by testing for oil, is that they write to me or some other competent person, find out how far they are likely to have to go to meet the various oil bearing horizons, and how much water they are liable to meet, and accordingly how many times they will have to case, and reduce, and decide before beginning how deep they propose to go before quitting, and begin with a hole large enough. Otherwise, before they have reached the Trenton, if that is their goal, they may have so much water and so small a hole that progress becomes practically impossible; a very unsatisfactory conclusion. It is much better to begin with a little too large a hole than a little too small, as there are a number of heavy flows in Michigan strata.

Then if they want to use divining rods or similar machines or spiritualistic media, to precisely locate their hole, which I do not pretend to be able to do, it is at their own expense, and they will at least have the satisfaction of finding out whether they are right or not.

I may, however, say in general, that so many holes have been put down in Michigan with such ill success, that testing for oil is no enterprise for people who have not money to spare, and that to test for oil and gas, planning only for a single hole, is about as absurd as for a farmer to organize a company to put down on his place one test hole for coal. The successful coal companies have put down holes by the hundred, only a small minority of which have shown workable coal. The state will be very fortunate if the results are no worse in the matter of oil and gas.

The following remarks of Prof. Blatchley are applicable equally to

[1] Next page.

Michigan, with the exception that a boring as far as the Corniferous (Dundee) may reveal whether or not the structure is favorable:—

"Shallow Bores in Central-Southern and Western Indiana.

"Investigations carried on during recent years in the central-southern and western portions of Indiana, and records of many bores which have been sunk in those regions, have led me to believe that the majority of drill holes sunk there in in search of gas or oil failed to reach Trenton limestone, the rock formation which produces the most of the gas and oil in this state. This failure to sink the bores deep enough was due to several causes, chief among which is the great difference in the strata overlying the Trenton limestone in these portions of the state from those overlying the same formations in the main gas and oil-producing areas. In the latter areas the Niagara limestone of the Upper Silurian age and the Hudson river limestone and Utica shales of the Lower Silurian, are the only formations to be pierced by the drill between the drift or surface and the oil and gas-bearing Trenton. In the central-southern and western portions, especially the latter, a number of formations which are wholly absent in the main gas and oil field intervene between the surface and the top of the Niagara limestone. The drillers employed during the gas and oil excitement of 1887 to 1895, to sink the bores in these regions were, for the most part, from the gas fields. Their knowledge of geology was small, and in many instances, after passing through a shale which resembled the Utica, and which they doubtless thought was that formation, they called the underlying rock "Trenton limestone," and soon abandoned the bore as barren. The shales which they had pierced may have been any one of a half dozen carboniferous shales, or, what is more likely, the black Genesee shale, no one of which occurs in the main gas field.

"In a number of instances in the southwestern counties, the Corniferous limestone, which in places is oil and gas bearing, was not even reached, though it lies 900 to 1,200 feet above the Trenton. Wherever a bore was thus abandoned without reaching the Trenton, all the money spent was wholly wasted, there being neither negative or positive results. Moreover, much territory was condemned as non-productive without being given a fair test.

"If the earlier bores had of a certainty reached Trenton and proven barren, then negative evidence would have been available. The one fact which I do wish to impress upon the citizens of the regions mentioned, is that much of their territory has not been properly tested. Another and more important reason for the statement is to induce companies who sink future bores to see to it that nothing stops the drilling before the Trenton is reached, or, rather, before that formation has been pierced at least 75 feet. Beyond that depth there is little probability of finding either gas or oil. A contracting driller of experience can easily and without great expense case off any salt water which may give him trouble. An accurate record of the thickness of each formation passed through, together with a small vial of the drillings of each, will aid much in determining the horizon which the drill is piercing at any depth, and such records and samples should always be kept."

Another important feature in testing for oil and gas (or in fact anything), is to have enough capital to give a proper test. A weakness of many, if not most, developing companies is that the stock is sold so low that after the promoters' and organizers' stock is taken out and selling commissions subtracted and allowance made for the fact that not all the treasury stock will be sold, there is not enough working capital to really do much, even if there are no salaries to the officers. Mr. F. A. Cook of the Niles Star was good enough to keep a careful record of a well drilled at Niles, by the Niles Oil and Gas Co., the record of which is given below. The business record of the company will also be found in the files of that paper for March and April, 1903. (see especially issues of April 6, 11, and 14), but as it is not geological, even though there may appear to have been something subterranean about it, it will not be fit to introduce here. The only interest the geologist, as such, has, is in noting that explorations on that basis are not satisfactory to anyone. There has been no exploration of the Trenton in the southwestern part of the state, with the possible exception of one hole at Dowagiac.

Southwestern Part of the State.

This district was discussed and a sketch map given in the annual for 1901, and contours of the base of the Devonian black shale given. The

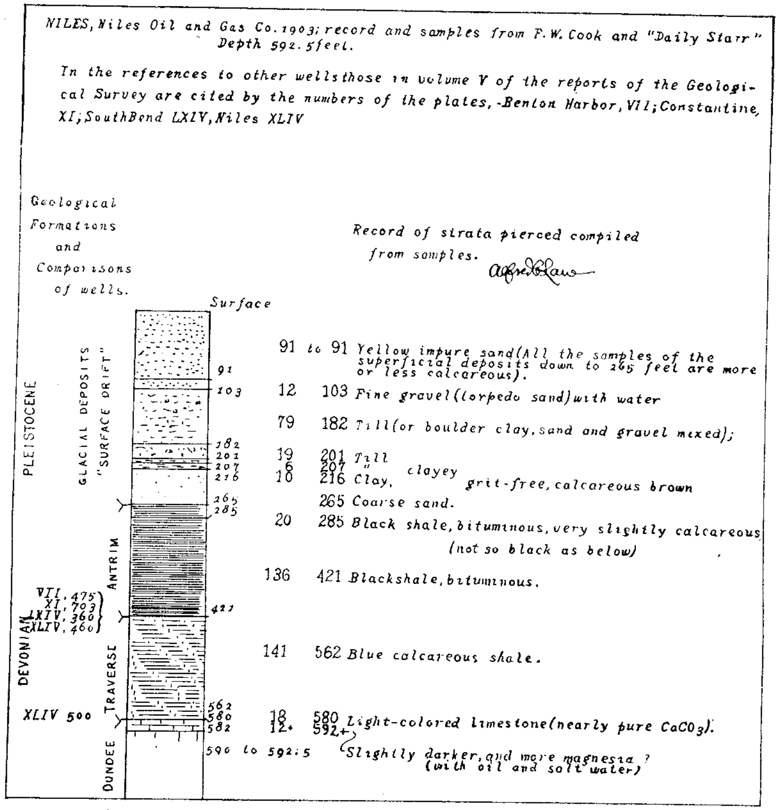

FIG. 8. Niles Well.

anticlinal indicated as running northeast from Grangers, is apparently the Kankakee uplift of the Indiana geologists.

The record of the Niles well is given in the cut above. It will be noticed that the elevation of the base of the Devonian black shale (the Corniferous or Dundee horizon is within the next 200 feet below) agrees with the map fairly. This well was on the Baumann farm, about a mile west of Niles. The elevation is probably about 660 A. T.—at any rate between 646 and 680 A. T.

Of this well a proper record has been kept (thanks to Mr. F. W. Cook), and returned to this office.

The following data on this district have been gleaned from newspapers and correspondence. A well at Dowagiac was recorded in Volume V of our reports, Plate XVI to 1760 feet. An interesting editorial in the Dowagiac Herald (9—18, 1903), says that it was continued to 2,200 feet by a stock company, i. e., probably to the Trenton and later put down 500 feet or more by Mr. Beckwith, and encountered only salt water, no oil, but on application to the Beckwith estate, we are informed that the record of Volume V is all there was. A good record of this well would be of great interest. We may summarize as probably:—

DOWAGIAC.

Pleistoçene.		
Surface, sand, clay, till	200	200
Coldwater.		
Blue shale	82	282
Berea or Bedford horizon.		
Red shale (land surface belonging to Antrim?)	12	294
Antrim.		
Blue shale and sandstone	346	640
Brown and black shale	125	765
Traverse.		
Dark blue, shaly limestone	110	875
Dundee.		
Light limestone, not dolomitic. Salt water	125	1000
Monroe.		
Gypsiferous dolomites (anhydrite)	325	1325
Niagara.		
Light colored dolomitic limestones	345	1680
Lorraine and Utica.		
Blue shale (possibly Rochester shale)	40	1700
Dark limestone	60	1760
(Uncertain.)		
Shales, blue, black, and calcareous, probably to	440	2200?
Trenton and Lower strata	500	2700?

This is a little different from the division in Volume V.

The Umholtz Oil Co., Geo. S. Green, President, bored a well on the Umholtz farm about 8 miles north of Niles and 4 from Buchanan, striking through black shale into oil and gas at 618 feet, stopping at 620 (or 625) feet,[1] close under black shale (amount unknown).

They started about Oct. 20th,[2] and were down to 250 feet Nov. 12. By Dec. 1 they were down to 565 feet. At 138 feet it was reported that they went through 7 feet of what proved to be dolomitic pyritic rock. The brine, which followed the oil was analyzed at Northwestern University.

WHITE PIGEON.

Near White Pigeon a well was put down[3] by the White Pigeon Oil and Shale Gas Co., cased as follows:—

140 (?)	feet	10 inch	
220	feet	8 inch	Total, 360
345	feet	6 inch	Total, 705

It was shot at about 765 feet, July 15, without effect. It was down 250 feet on June 19, and was drilled about 800 feet in all. The last 80 feet were probably the Dundee (not Trenton) limestone.

I have to thank the treasurer, Mr. Ed. Roderick, for a careful and complete record and set of samples.

Elevation about 10 (?) feet above Lake Shore and Michigan Southern station at Constantine or about 800 feet A. T. Compare the well at Constantine reported in Volume III, Part 1, p. 93, and in Volume V, Part 2, Plate XI. The location is near the northwest corner of the northeast ¼ of Sec. 22, T. 8 S., R. 12 E.

Pleistocene.

Sample 1. Quicksand, fine silt........	120	120
Sample 2. Gravel, ¼-inch pebbles (limestone, chert, quartzites, dark traps)....	20	140
130 feet of 10-in. casing shutting off fresh water.		
Sp. 3. Clay, blue calcareous............	42	182

Compare surface to 93 or 136 feet in the Constantine wells.

Coldwater.

Sp. 4. Shale, blue non-calcareous........	31	213
Sp. 5. Quicksand.....................	28	241

Calcareous and from the varied character of its grains, evidently a glacial sand, which must come in from some vertical fissure traversed by the drill, and yet is peculiar as being in very nearly the horizon of the Berea grit which yielded a strong brine and gas from 283 to 383 in one of the Constantine wells, while in the other it seems to have been represented by 15 feet of red shale, from 286 to 301, while in this well it is not to be recognized at all. This variety in record is probably due to an unconformity at the base of the Carboniferous, and the red shale which appears in various records in this corner of the state may be due to the weathering and oxidation of black and green shales beneath an old land surface.

[1]Niles Star, Dec. 12 and 14, Letters, Nov. 12 and 18, Buchanan Record, Dec. 15, 18, 1903, Feb. 2, 32, 1904, "Soo" Ev. News, 3/1/1904.
[2]Buchanan Record, 10/16/1903, Dec. 1, 1903.
[3]Saginaw News, 7/15/1903; Niles Star, 6/19/1903; Constantine Adv.-Record, 7/8/1903; Free Press, July 15, 1903.

8-in pipe driven into No. 5, 9 ft., i. e., about 220 ft. in all.

Sp. 6. Shale, dark blue, probably in part Antrim, belonging with the next division	224	465

DEVONIAN.

Antrim shale.

Sp. 7. Black shale.....................	108	573

This apparently corresponds to the base of the dark shales at Elkhart between 375 and 350 feet down, and in the first Constantine well record the red calcareous shale immediately underlying is counted in, and 211 feet of shales given between 492 and 703 feet. Corresponding horizons are found about 82 feet deeper at Constantine.

Traverse formation.

Sp. 8. Red calcareous shale............	32	605
Very calcareous, gritty with a few large grains of sand and some crinoid buttons.		
Sp. 9. Soft blue limestone.............	78	683

This formation was apparently not separated off in the Constantine records, but its base and the top of the Dundee is probably nearly marked by the brine and sulphuretted hydrogen which occur at 790 feet and correspond to the horizon of the "salt sand" from 696-711 feet here. The red, gritty shale at the top may also mark a time between the Traverse and Antrim as here developed, when there was a land surface here. The paleontogist Schuchert[1] assumes that there was a neck of land here at about such a time, and the more recent Niles and Dowagiac wells show a greater thickness of blue calcareous shale with no red shale mentioned, while from Coldwater and Elkhart no Traverse is reported. The Niles well in Volume V gives us from 415 to 500 feet very similar strata.

Dundee.

Sp. 10. Missing. Said to be similar to those below	13	
Sp. 11. Limestone, very white, clear, fiercely effervescent in acid, leaving a little quartz sand residue.............	15	
"Salt sand," here a brine was struck which filled up the hole about 400 feet, no casing done when the well was shot.		
Sp. 12. Five samples, all yellowish, fiercely effervescent limestone with a little quartz and microcline sand and more chert	45	
At bottom, "oil sand"..................	73	756

[1]American Geologist, September, 1903, p. 149.

Sp. 13. Limestone; record says "blue shale," but sample is a coarsely chipping, fiercely effervescent, somewhat darker limestone, stuck together with gypsum, possibly from the brine 7 763

The well was torpedoed here, but as it was not a dry hole it was not a fair test.

An interesting thing is the irregularity of the Berea grit shown by this and adjacent wells. I think that a well might possibly strike gas in this formation, enough to be valuable, if placed so that it could be used near by.

The base of the black shale is at about 227 A. T. At Constantine it is about 137 A. T. At Elkhart it is perhaps about 205 A. T., but the record and elevation are uncertain. At South Bend the base is at 375 feet A. T. It is apparent that the dip from this well to Constantine is pretty sudden and that the contour of the figure below, repeated from the annual for

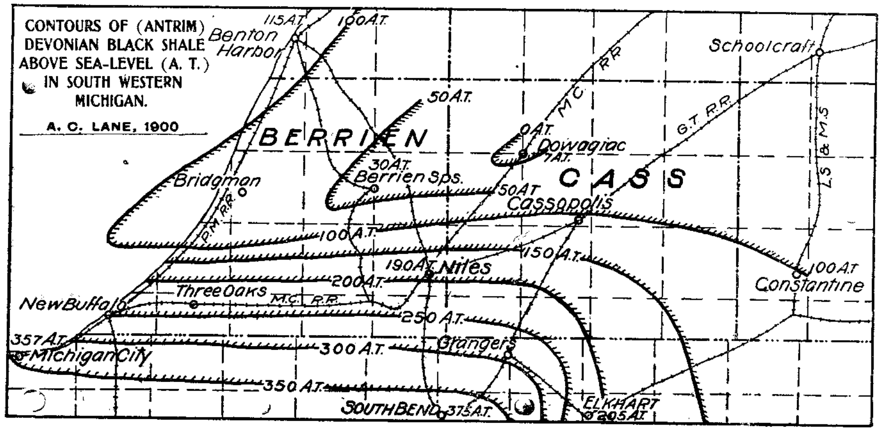

Fig. 10. Sketch of contours of the base of the black shale. (Repeated from annual for 1901 and not quite right.

1901, should continue on further to the east instead of turning sharply south, and then if the Elkhart record is right, there must be a sharp drop (fault?) along a line running between South Bend and Elkhart, and passing east of Constantine and White Pigeon. One or two more wells in the south part of St. Joseph county, ought to cost less than $2.00 a foot for less than 1000 feet and might develop something of interest and value. There has been some talk of a well at Sturgis. I do not, however, advise planning to go down to the Trenton until we know a little more about the lay of the upper formations.

At Granger, just over the line in Indiana, a well was put down over 350 feet.[1] The Bridgman Oil and Gas Company,[2] has started to put down another well at Bridgman. The old well put down over 20 years ago, went about 100 or 175 feet to rock, 50 to 130 feet in rock, probably the Devonian shales (compare the Berrien Springs record), when a pocket of gas which burned some time was struck. The new well has the following

[1]Niles Star, 6/19/1903.
[2]Benton Harbor News, 9/2/1903; Benton Harbor Daily Palladium, 8/31/1903. South Haven Sentinel, 7/2/1903.

record, most of it reported through the kindness of R. J. Stahelin and G. W. Bridgman.

BRIDGMAN.

"Record of the Bridgman Oil and Gas Co.'s well, located about 40 rods south of depot, on ground about 3 feet lower than railroad track, i. e., 636 A. T.—May, 1904."

	Feet.	Feet.
Pleistocene.		
Sand	3	3
Clay, sticky	100	103
Sand, fresh water	5	108
Clay, blue	50	158
Sand, some fresh water	5	163
Clay, blue	40	203
Sand, fresh water	20	223
Gravel, cement	5	228
Clay, blue, waxy	30	258
Coldwater.		
Clay (really shale), big break	50	308
Antrim.		
Brown shale, gas near top, scum on water after striking gas	200	508
Dundee.		
So called Trenton, bastard	5	513
Samples 520 to 700, limestone with echinoderm fragments, quick effervescence.		
Salt sand	25	538
Brown sand, salt water here rising nearly to the top	25	563
Trenton, porous, drilled nice	200	763
Salt water at bottom of this 200 feet, with traces of gas above.		
Monroe.		
Sample at 768 a gypsiferous dolomite.		
Water stands 600 feet deep in the well	5	768
Total		768

"The above report was given me today by one of the workmen who is still here. It may not be quite accurate, but think it is as near correct as it can be had, as there was no record kept while drilling."

A company was also organized to operate near Galien, but Mr. Loomis, who was also connected with the Niles Oil and Gas Co., above referred to, was interested in it, and nothing seems to have come of it. Mr. J. J. Callendar, the same who located the Assyria well with his "instrument," is reported to have located the oil.[1]

The Assyria well, 917 A. T., might be treated in this connection, though it is in some respects more allied to those of the central district. It is the one I referred to as having been located by a modified divining rod. Through Mr. Geo. D. Conner and J. J. Callendar I have received a good set of samples and I also visited the well to get the elevation and temperatures. It was to be put down further in the spring of 1904 and the record is postponed, so that it may be given complete. The Berea—Bedford red shale was from 1400-1450 feet, and the Traverse from 1810 to 1875 feet.

About 1½ miles east of the corners another well was put down in 1899, of which, in spite of various endeavors, I never was able to get a satisfactory record. I did, however, meet the driller, Mr. John Brogan, at Mr. Stearns' well in Ludington, and obtained some of the data from him. The bottom of the black shale, top of the Traverse or Dundee, was at 1875 feet. This is quite a little lower than the other well,—about 870 A. T. on Sec. 14, T. 1 N., R. 7 W.

The Milan well reported in 1901 was deepened and the record now runs from samples as follows:—

MILAN.

Pleistocene	130	130
Traverse.		
Blue limestones and shales	168	298
Dundee.		
Limestone	97	395
(About 100 feet less in depth than at Britton.)		
Monroe.		
Lucas.		
Dolomite, gashed or acicular[2] at 395, 415, etc.	35	430
Gypsiferous dolomite	25	455
Gypsum, mainly	80	535
Sylvania sandstone, pebbly at base	288	823
Tymochtee?		
Calcareous shale	7	830
Dark, oily dolomite, H_2S water	15	845
Cherty dolomite	55	890
Dolomite, blue, with mineral water at		890
With some black specks mixed	100	990
Blue clay shale	5	995
(Compare Britton 1015.)		
Dolomite (at 1025 to 1100 anhydrite, also at 1210 and 1275)	305	1300
Red, then blue shale	100?	1400
Brown, oily dolomite—fine laminated	75	1475
Dolomite	65	1540
Rock salt	5	1545

[1]Port Huron Times, 6/6/1903; Detroit Journal, 5/16/1903; Buchanan Record, 12/15/1903.
[2]It has recently been suggested by Kraus in Science that these gashes are due to dissolved crystals of celestite.

Niagara?		
Dolomite	98	1643

Of a well on the farm of Uriah Arnold near Clinton, Sec. 2, T. 4 S., R. 3 E., we have learned only that they struck little if any oil, but a strong brine at about 1000 feet.[1]

This seems to be as far south as the rock salt occurs and it is interesting to note that here, as in Ludington and other points, the rock salt at its greatest extent occurs close to the base of the formation, and the higher beds occur only near the center. The total thickness from the base of the Sylvania to the base of the rock salt is 722 feet, the brown, oily dolomite above being nearly the same as at 1500 to 1550 feet at Britton, and the Niagara, the typical white Guelph coming immediately below.

Around in that region shallow wells, as already remarked by Sherzer and myself, are very likely to find small amounts of oil or gas of local value only. At Britton, where a deep well was reported on in 1903, on the lot of John Wiggins a well for water at 90 feet struck a pocket of gas, the glow of which when lighted, could be seen in Tecumseh. How much was wasted before it was controlled I do not know, but the pressure is said to have increased since,[2] from 35 pounds per square inch to 41, which is probably about the hydrostatic head. I would again call attention to the probable value of such modest wells, their relatively short life, and the possibility that in the ordinary way of accidentally striking them, thousands or even millions of cubic feet of gas may be wasted before they are controlled.[3]

In this connection it may be well to introduce a comparison of nearly equivalent formations and names in Michigan, Ohio, and New York, as used by Prosser[4] and Clarke and Schuchert.[5]

[1]Detroit Free Press, 6/24/1903.
[2]Adrian Times, 6/22/1903, Free Press, 5/27/1903.
[3]Such a blow out of gas was struck at Halfway near Detroit at a depth of 460 feet, News and Free Press, 4/9/1903.
[4]The Nomenclature of the Ohio Geological Formations, Journal of Geology, Sept.-Oct., 1903, Vol. XI, No. 6, pp. 520-521.
[5]American Geologist, Feb., 1903, p. 118.

COMPARISON WITH THE NEW YORK SERIES.—CLARKE & SCHUCHERT.

Era or system.	Period or group.	Age or stage.	Prosser, Ohio.	Michigan.[1]
Cambric or Taconic	Georgian	Georgia slates.		Lower Keweenawan.
	Acadian; Potsdamian	Potsdam sandstone		Upper Keweenawan. Potsdam or Lake Superior.
Champlainic (1) (Lower Silurian and Ordovician).	Canadian (3). (Paleochamplainic)	Beekmantown limestone (15). Chazy limestone.		Calciferous. Unconformity.
	Mohawkian (4) (Mesochamplainic).	Lowville limestone (16); Black river limestone; Trenton limestone	Trenton	Trenton.
	Cincinnatian (5) (Neochamplainic)	Utica shale	Utica	Utica.
		Lorraine beds (17)	Lorraine	Lorraine.
		Richmond beds (Ohio and Ind.)	Richmond.	
Ontaric (2) or Siluric	Oswegan (6) (Paleontaric[1])	Oneida conglomerate; Shawangunk grit; Medina sandstone	Saluda; Medina	Unconformity, erosion.
	Niagaran (7) (Mesontaric[1])	Clinton beds	Clinton	Niagara (Manitoulin).
		Rochester shale; Lockport limestone; Guelph dolomite	Niagara	
	Cayugan (8) (Neontaric)	Salina beds	Tymochtee	Salina } Monroe.
		Rondout waterlime (18)	Sylvania	Sylvania } Monroe.
		Manlius limestone (19)	Lucas	Lucas } Monroe.
Devonic — Mesodevonic — Paleodevonic	Helderbergian (9)	Coeymans limestone (20); New Scotland beds (21); Becraft limestone (22); Kingston beds (23)	Unconformity of erosion in Ohio and Michigan.	
	Oriskanian (10)	Oriskany beds.		
Devonic — Mesodevonic	Ulsterian (11)	Esopus grit (24); Schoharie grit; Onondaga limestone	Columbus; Sandusky	Dundee.
	Erian (12)	Marcellus shale; Hamilton beds	Olentangy shale	Traverse. (erosion in southwest part ?)
Devonic — Neodevonic	Senecan (13)	Tully limestone; Genesee shale	Ohio shale	Antrim shale.
		Portage beds	Bedford shale	Antrim shale.
		(Naples beds	Berea grit	Berea grit.
		Ithaca beds	Sunbury shale	Berea shale
			Mississippian Carboniferous.	
		Oneonta beds. local facies	Cuyahoga formation	Coldwater.
	Chautauquan (14)	Chemung beds (Catskill sandstone, (25) local facies)	Black Hand	Lower Napoleon Upper } Marshall.
			Logan formation; Maxville	Michigan, Lower; Maxville, Upper } Grand Rapids.
			Unconformity, erosion.	*Pennsylvanian.*
			Pottsville 250±	Saginaw.

[1]Leaders connect the more or less precise correlations. The correlation of the Marshall with the Chemung and Catskill is lithologic and physiographic, not paleontologic.

Port Huron District.

In regard to this district, C. H. Gordon has made the following report in addition to that which he prepared last year. We have also records from the Port Huron Salt Co. and the Diamond Crystal Salt Co., which will find an appropriate place in treating of the salt formations, and in connection with the Detroit river wells.

Valley Center, Mich., Aug. 9, 1903.

Dr. A. C. Lane,
Lansing, Michigan.

Dear Dr. Lane.—Two wells have been put down in this vicinity, reports of which interested me, and I made inquiries, the results of which I send you herewith.

1. Brown City well. This well was put down recently to secure an adequate supply of water for the use of the village. It is located near the depot (Elev., 812 A. T.)[1] and stopped in sandstone at a depth of 227 feet. The thickness of drift passed through was 180 feet, consisting of clay and "hard pan" to within a few feet of the rock. The space between the "hard pan" and rock was occupied by gravel as at Valley Center[2] and elsewhere, but was not so full of water, which was found in abundance in the sandstone below. This shows that the drift is not so thick here as previously supposed. In our report, the only information we could obtain was to the effect that the Harrington well, located within a hundred yards of the new well, was sunk 212 feet without reaching rock.[3] The papers reported that copper and silver had been struck in the new well. On inquiry I learned that what was regarded as copper was found in the gravel bed overlying the sandstone. It occurred in small particles associated with a white metal taken to be silver, the latter quite rare.[4] My information was obtained from the president of the village board. Water stands within 11 feet of the surface in the well.

2. Graves well. This well is a drilling made for water on the farm of G. Graves, 1¾ miles south and ¾ miles west of Valley Center in the N. E. ¼ of the S. W. ¼ of Sec. 34, of Maple Valley Tp., T. 9 N., R. 13 E. In this well it is claimed that hard coal was struck at a depth of about 114 feet which the drill (a light affair) would not penetrate, being broken three successive times. On losing the drill head the drillers attempted to break up the rock and get the lost drill out of the way by dynamiting, with the result that the casing was broken and the well lost. A second and third attempt, each at a distance of six to ten feet from the first met with the same result. The fourth hole is now down to a depth of 104 feet but no drilling is being done owing to a press of other work. The record of the drilling as given me by Mr. Graves, is as follows:—

[1] Report on Sanilac county, p. 5, Vol. VII, Part 3, Mich. Report.
[2] Ibid, p. 11.
[3] Report on Sanilac county, Vol. VII, p. 10.
[4] It may have been bronze and white mica.

1.	Clay	about 70 feet
2.	Hard pan	about 30 feet
3.	Gravel with water coming to the top	about 7 inches
4.	Soapstone	about 4 or 5 feet
5.	Stone, hard to drill	about 8 or 9 feet
6.	Gravel with water	4 inches
7.	Hard coal. Very hard to drill. Could not make more than 3 or 4 inches a day. Broke the drill each time. Penetrated about 10 or 11 in.	
	About	114 feet, 10 in.

Mr. Graves says there has been no hard coal about the place for a long time and he is of the opinion that it could not have been put in from the top. Each night the hole was covered and a heavy weight put over it. No motive can be suggested for "salting" the well. The loss of the wells rests entirely on the driller who contracted to furnish a satisfactory well at $1.00 per foot. In one of the holes he says a coal seam was struck somewhat higher than in the others but the main bed, if such it is, was found at the same level. I send you specimens of the coal brought up by the drill. There seems to be no question of its being anthracite.

I give you the facts as he gave them to me. My impression is that someone is trying to "do" the driller, possibly to even up an old score.

Very truly yours,
(Signed) C. H. GORDON.

Central Part of the State.

It will be remembered that in previous reports[1] I have mentioned anticlinals as probably existing in the central part of the state, and pointed out that one probably passed through Saginaw (Wiley Brothers' well is near the crest), but was not able to give its course. The prosecution of coal mining and exploring makes it more and more probable that the Saginaw seam, 180 to 190 feet beneath West Saginaw runs up into the same mine at about 155 feet south of East Saginaw. Again, according to the reports of Mr. Chas. Page, the well of the Monitor Oil and Gas Co. on the S. W. ¼ of the S. W. ¼, Sec. 26, T. 14 N., R. 4 E., considerably higher (605 A. T.), than the South Bay City well,[2] 582 A. T., ran some 30 to 40 feet less depth.

The Upper Marshall is said to have been from 800 to 930 feet. A sample of fine grained, red sandstone at 1050 looks like lower Marshall. The tools got stuck at 1700 feet, but this and other records bring out clearly in a section prepared by Mr. Cooper for his Bay county report, an anticlinal between Bay City and Midland. It is probable, therefore, that the Saginaw anticlinal ran rather nearly north, passing 3 or 4 miles west of Kawkawlin, at which town corresponding strata are much higher than in Bay City.

[1] Vol. VIII, Part II, p. 176, Annual Report for 1901, pp. 211-237.
[2] Annual for 1901, p. 224.

LIVINGSTON COUNTY.

There have been pronounced signs of oil and gas discovered and quite an oil excitement recently in the northwestern part of Livingston county[1] near Fowlerville. I have also some records of a well near Morrice, which, though incomplete, are interesting, and seem to indicate a well marked anticlinal at least down to the Berea grit. This occurs according to J. J. Mason, at Columbiaville,(764 A. T.) at 1500 feet, 90 feet of sandstone full of brine; at Flint (723 A. T.) possibly at 1200 feet depth; at Blackmar (610 A. T.) at about 1675 feet depth. On the other side of the basin it is absent, but its horizon apparently occurs at Jackson at 1400 feet depth, and at Assyria (917 feet A. T.) at 1400 to 1450 feet depth and at Charlotte at 1680 feet depth. But between we do not find the Marshall and Berea deepening as might be expected. It is possible that the deepest well at Lansing reached it at or before 1400 feet.

There was a well put down by C. W. Gale in the 1860's close to the Looking glass river (850 A. T.) on Sec. 25, T. 6 N., R. 2 E., of which we can get a record only from memory, that it was about 1100 (1135) feet deep, that at the bottom a strong brine was struck of which a sample was sent to A. Winchell, that it did not smell of sulphur, that this brine flowed and that a little oil used to show on the river, that much black shale was traversed and also a lot of "blue clay." The first casing was 45 feet to rock, which was sandrock. At about 100 feet a second casing was put in and at 600 feet a seed bag was put in so as to use the top water when it was decided not to use the brine. The top was drilled wet and water was never over 10 feet from the top at any time.

This sort of a record with so much blue and black shale suggests the Coldwater and Berea or Antrim shale, as does the Durand well given in Volume VIII. But if this sandstone and brine is the Berea there can be but little doubt that that of Jason and Shumway is also, who put down a well northwest of Fowlerville on the farm of Mr. Grill on Sec. 17, T. 4 N., R. 3 E., about 1000 feet A. T. The record of this is given as follows:—

Well on Sec. 17, T. 4 N., R. 3 E., about 945 A. T.

Surface to rock (8-in. drive pipe)	95	95
Slate (at 120 feet oily at the house)	35	130
Shale (gas at 155 feet)	63	193
Gray sand (dry well from 200-600 feet)	25	218
Brown shale (gas at 380 and 600 feet)	382	600
8-in. hole for 587 feet, cased at that depth with 5⅞-in. casing.		
Coarse gritty sand with salt water	200	800
As analyzed, filled the well, and slowly oozed out in spite of a plug, with bubbles of fuel gas, and a temperature of 65°.		
Black shale	20	820
Brown shale	150	970

Though full of salt and plugged there was a constant leakage of gas. This coarse sandstone full of a very strong and pure salt brine at so shallow a depth, must be either the Marshall or the Berea. But the Marshall

[1] Free Press, 5/17/1903; also 5/23/1903; 5/30/1903; Fowlerville Review, 10/16/1903; South Lyons Herald, 5/15/1903; Detroit Tribune, 5/26/1903, with photographs; Lansing Journal, 5/23/1903, 11/4/1903.

is not usually associated with black shale, while the Berea is. In that case there must be a marked anticlinal uplift, which also probably includes the wells at Durand and Howell, which were interpreted in Volume VIII, Part 2, as the Coldwater. The recent well at Holly showed apparently mainly Coldwater shales. What becomes of the Marshall is quite a question. It may be that this uplift, like others, antedates the coal measures, but not the Grand Rapids series, and is connected with the break between the Pennsylvanian and Mississippian systems, and that the rocks between the coal measures and the Coldwater were in good part either not deposited or eroded away. The sandstone at the base of the coal measures and Marshall are hardly distinguishable. The prevalence of brown and black shale in these wells is not unfavorable for oil.

If this is right, the anticlinal probably runs in a northwest and southeast direction from Laingsburg. Moreover, we may infer that coal is most likely to be found on its northern and southern flanks.

Beside the well above mentioned, two relatively shallow wells have been put down about 6 miles away on the Henry White farm on N. E. ¼ Sec. 6, T. 3 N., R. 4 E. The shooting of the second was witnessed by my assistant, Mr. W. F. Cooper, on Nov. 3, 1903. It was down 50 feet on Oct. 6. It is 40 rods south of an earlier well which is said to have had salt water. The record as given, is as follows:—

Fowlerville Oil Well.

Two miles south and 2¾ miles east of Fowlerville in the N. E. ¼ of Sec. 6, T. 3 N., R. 4 E.

Pleistocene.		
Clay	30	30
Sand	8	38
Gravel	2	40
Sand	6	46
Blue clay	28	74
Sand	30	104
Gravel	2	106
Sand and gravel	22	128
Sandrock	8	136
Blue shale with oil and gas, the flow being about ½ barrel per day	30	166
Dark sandstone at 157 feet.		

All samples 60, 70, 80, 95, 120, very effervescent clay till.

Samples from 60 to 120 I should class as calcareous clay till, and a sample at 157 as a dark sandstone. This well might pump ½ barrel a day.

This may be the best place to insert a reference to the four or five wells at Mt. Pleasant, and two or three at St. Louis, which have been put down to make bromine and salt. Those at St. Louis are 1300 to 1330 feet deep and draw from the same stratum as those at Mt. Pleasant,—the Upper Marshall or Napoleon sandstone, the record of which is in brief:—

MT. PLEASANT.

Surface deposits and glacial till............	1- 400 ft.
Coal measures with particles of coal at 410-430-560 down to 620.	
Parma sandstone,—calcareous and with 10 to 20 ft. of limestone......................	810- 840
(There was plenty of water and may be drinkable,—something like the Harrington House water at St. Louis.)	
Maxville limestone,—as at Bayport.........	970-1050
Michigan series, with gypsum as at Alabaster	1050-1408
Marshall sandstone	1408-1550

The temperature varied from 67.6 degrees at 1450 feet to 49 degrees at 200 feet. The rate of increase is not absolutely uniform.

In closing my notes on the subject of boring for oil and gas this year, I take pleasure in referring to the elaborate reports issued by Prof. W. S. Blatchley, State Geologist for Indiana, from Indianapolis and the auspicious resumption of the publications of the Geological Survey of Ohio under E. Orton, Jr., by Bulletin No. 1, containing a report on the occurrence and exploration of petroleum and natural gas in Ohio, by J. A. Bownocker, published at Columbus, Ohio. This contains in Chapter V, a good review of the theories of the origin of oil and gas, which will save my going into the subject now. I may also say that so far as lower Michigan is concerned, oil and gas seem to arise from the decomposition (very likely bacterial, most decay is) of buried animal and vegetable matter.

If the deep well at Rapid River strikes oil or gas down in the preCambrian, I shall begin to believe there may be something in the theory of inorganic origin of petroleum as applied to the commercial product.

PEAT.

Dr. Rominger closes Chapter II of Volume III of these reports with the following prophecy, "fuel is too cheap yet, but the time will come when peat will be appreciated at its true value." With the exhaustion of our forests, which has caused the development of the coal, cement and brick resources of this state, the time seems at hand for the fulfillment of this prophecy. The problem of the utilization of the peat is one for the mechanical engineer as well as the geologist. But fair questions for this board to help solve pertain to the properties of the different kinds of peat as they lie in the bog. How stringy is it and how does this factor depend upon the plants that made it or upon the variations of water level? What liability is there to be logs of wood, stumps, and other obstacles to easy working scattered through the swamps, and what kind of swamps are most free? What is the effect of a certain admixture of mud and silt? Suppose a peat thoroughly dried, how much will the different kinds reabsorb from the air (for they will take up some)? These are some of the questions upon which we have obtained data. I had hoped for a report ready for this year. I think we shall certainly by next year have something worth while to add to our brief statement in the 1902 report.

Prof. C. A. Davis has been at work for us, and writes as follows:—

"I had a chance to spend some days in the camp in Roscommon county where the Bureau of Forestry party is at work and availed myself of it and am very glad I did so, for it took me into a country where peat bogs are really a feature of the surface geology, and not simply an incident or accident. I found there that the plants are the same that occur at Ann Arbor in bogs and that they occur in the same relationship to each other and to the water level and the shade that they do there, and that the bogs pass through the same stages of development, reaching a climax which is practically permanent so long as the water level is constant or rising only as fast as the bog builds up, but if anything occurs to cause decided elevation or depression then a change occurs, which, if the water level is raised, is in the nature of a rejuvenation, in which the bog goes back to the marsh or even pond stage, and begins over again, or if it is lowered then the bog plants are crowded out by more aggressive species from the higher land around. Thus around the camp where I stopped, were numerous bogs which had been rejuvenated by the building of dams by the lumbermen, and it was easy to see that the rising of the water level had killed out the old plant covering and had given the sedges and grasses a chance to come in again and there were numerous "hay marshes," as they call them up there, which had evidently been cut out of the older cedar and tamarack swamps by fire, the peat burning down to the level of the ground water, after which the same sedges and grasses which build out over the lakes here have gained possession and have started in a new cycle which will progress from sedge to grass, to heath-sphagnum, and finally to cedar-spruce-tamarack and possibly to elm and ash swamp. In my studies of the bogs north, I have been interested to see that the plants which south all huddle in the bogs and keep at about the same distance above water level, are, as we go north, separated by degrees, until it is practically certain that several of them are not bog plants at all in the north, but occur only on the deeper levels of rather poor soils, and even some species, which botanists are inclined to call bog plants exclusively, do not get down into the bogs, but are simply confined to their margins and the indications are from the analogy of the plants which get away entirely from the bogs, that most if not all of the bog plants down in this part of the state, get into dry situations to the north and give place to other species from farther north in the bogs. This is an interesting discovery from the point of view of the ecologist, and from our point of view as well, for it opens up a way to form a hypothesis that the northern bogs grow more slowly, or possibly more rapidly than the southern. I think it is likely that I shall decide that it is more rapidly, for if the broad leafed shrubs and trees cannot get into the bogs until a relatively great elevation of surface has occurred, then sphagnum, which is probably a rapid peat maker when once it is established, has the longer chance to grow and build before the higher plants shade it out. On the other hand, if it is true that the higher plants make the most rapid accumulations of peat then the northern bogs would grow more slowly. At any rate it seems certain that the more northern the bog the longer it will remain open so long as the water levels do not change. It is also possible to tell the present condition and stage of development of a bog by the flora of the surface of it, but evidently from the foregoing, it is not possible to tell anything about the quality of the peat, for present conditions may be the result of very evanescent conditions which have not been in existence but a short period of time. So much for this side of the investigation, which is one of much interest. The region south of Roscommon which, by the way, Leverett has mapped with some care[1] is full of extensive peat bogs, probably of varying depth, but some must be quite deep. The aggregate area is large and from the configuration of the country and the nature of the soil the peat must be of good quality. I did not bring samples back as I had my grip full of stuff and had such long distances to travel by carriage, but they can easily be obtained if wanted. The peat I examined up there was mainly fibrous and not thoroughly decomposed, a kind hard to handle as the Capac people are finding out; it does not cohere in the compressors, so that the briquettes are not durable. I may say that seems to be true of all the northern peats I have examined. I have worked up the Ann Arbor R. R. to Frankfort, and looked around quite a good deal on other roads, and near the railroads there are not many large areas of peat that I have seen. The deposits near Jackson, I went over with Thompson and from Jackson on down the old drainage channel to Kalamazoo and beyond, there is a great area of peat, which is more thoroughly decomposed than that north, and which is also more compact, as would be expected. This grade is of course, higher in ash, but it can probably be put into form for consumption without much compression and possibly by some drying, so it is well worth trying. There seems to be an abundance of this sort of material in the region, and in fairly large areas, but much of it is still covered with bushes and trees so it is not so easy to get at as the open bogs. Thompson says that he went into the Upper Peninsula and prospected a number of bogs but found them full of submerged tree trunks and stumps so that he could not get his sounding rod down in them, and I presume he is right about the matter, since I had the same difficulty in the bogs around Cadillac and in Roscommon county. Such bogs, of course, add materially to the cost of getting the peat out, since they have to be handled individually and cannot be scooped up by machinery. They are having some trouble with such material at Capac, although the amount of it there is not very large. In Roscommon county I learned that in some places where bogs had been cleared, the buried logs and stumps were so thick that when they were logged up and burned down to the level where the land could be plowed, the surface was lowered so that the attempt at cultivation was abandoned because the water stood on the surface and the cultivation plants were drowned out."

Alma, Mich., June 10, 1903.

Dear Doctor.—I herewith transmit copy of notes on peat analyses of samples taken from near Ludington.

No. of samples.	H_2O. %	Sand. %	Dry peat. %	B. T. U.
1, 3, 5 and 7	86.5	1.6	11.9	
4	87.0	3.0	10.0	
2	90.0	2.0	8.0	
6	88.0	......	......	8633

You will notice that about ten per cent. of the wet substance is combustible matter, and that the amount of sand is very large. Sample No.

[1]See Livingston's map in this report, Plate III.

6 when dried in oven gave 8633 B. T. U., so I calculate a ton of thoroughly dry peat of this quality is equivalent in heating value to an equal weight of beech and maple wood.

Yours truly,
A. N. CLARKE.

Prof. R. T. Jackson of Harvard University made a not profitless trip to some of our chief later paleozoic localities, from which we had hoped for paleontological light. The report has not been received in time for incorporation here.

RELATION TO OTHER ORGANIZATIONS.

Relations with the U. S. Survey have been as close as heretofore not only in coöperation in the topographic survey leading to the publication of the Ann Arbor quadrangle and preparation of three-fourths of the Detroit quadrangle, but also in the continual interchange of information, in the preparation of the Ann Arbor topographic and geologic folio, by Messrs. Russell and Leverett, in the study of water powers, in charge of Mr. R. E. Horton and W. M. Gregory, and the water supply through Mr. W. F. Cooper and M. L. Fuller and Alfred R. Schultz, and in the study of the sedimentary section of the Upper Peninsula by Mr. Alden.

Mr. Chas. S. Prosser, working for them mainly in Ohio, has recently published a classification of the Ohio column[1] elsewhere given, in which he has adopted our term Monroe, after discussion with us and the U. S. authorities, and we expect to use his terms Lucas and Sylvania. I would call attention to a pamphlet recently issued by the U. S. Geological Survey[2] on coöperation with the state surveys.

Another similar pamphlet of interest[3] relates to coöperation in the collection of statistics between the various bureaus.

I endorse the recommendations thereof and repeat my suggestion of past reports that there be more uniformity in the gathering and publication of statistics. Changes in the method of gathering or even of presenting these is a very great detriment to their value. Statistics form a science by themselves, and though, as the paper shows, in many states some statistics are handled by boards which also conduct geological investigations, I am not entirely convinced of the wisdom of this. I think the mineral statistics and reports of inspectors of mines, etc., should be published in connection with the other industrial statistics, though there may be friendly coöperation in gathering information. Mr. Hanna, the present commissioner, has started some very valuable tables which should be kept up continuously and systematically.

I do not think that this board should gather such statistics. There are, however, two other extensions of the work of your board which seem to me more desirable. For some years the Michigan Academy of Science has recommended a biological survey of the state. This has been carried on in connection with the geological survey in a number of states. An abstract of the reasons for, and utility of, such a survey is given by them as follows, and has been the theme of Prof. Newcombe's presidential address:—

[1]Journal of Geology, Vol. XI, No. 6, 1903, p. 519.
[2]Extract from the 22d Annual Report of the Director.
[3]Cooperation and unification in Federal and State Statistical Work, a paper read at the 19th annual convention of the Commissioners of State Labor Bureaus, Washington, D. C., Apr. 28, 1903, by S. N. D. North, Washington, D. C., 1903, pp. 5, 6, 7, XI.

Reasons for a Biological Survey of the State of Michigan, Prepared by the Michigan Academy of Science.

I. States making or having made such surveys.

New York, Pennsylvania, Ohio, Indiana, Illinois, Wisconsin, Minnesota, and California.

Various other states not appropriating funds directly for a biological survey, empower various boards to do such work. Thus the health board of Massachusetts makes biological surveys of rivers and lakes used as water supply for cities.

Michigan, in connection with the geological survey, began a biological survey in 1837, which, for lack of funds, was discontinued in 1840.

II. Reasons for making a biological survey.

1. To add to the sum of human knowledge.
2. To furnish data for nature study in the schools.
3. To furnish data on the past and present resources of the state in timber, fish, game, forage plants, fruits, peat, marl, etc.
4. To furnish a scientific basis for practical work in preserving and replenishing these natural resources. (Forest are to be grown again in Michigan, and peat can be made to reproduce itself. One-half the area of the state is water or land unfit for agriculture, but can be made a source of wealth on account of its forests, fish, and game. The commissioners of fisheries and game in Maine estimate the amount spent in 1902, in that state, by those coming from other states to hunt and fish, at $6,000,000 to $12,000,000.)
5. To secure the introduction of new plants and animals of economic value.
6. To restrict the spread of plant and animal diseases.
7. To furnish data for just legislation on forestry, water-supply, and the taking of game and fish.

III. Lines of work to be followed in a survey.

1. The collection into accessible form of the scattered publications on the plants and animals of the state, and the completion of the examination of the whole state, so that every school and everyone may know the plants and animals of his neighborhood.
2. The study of the habits of plants and animals, their food, their migration, their reproduction, and their beneficial or injurious effect.
3. The study of the relation of plants and animals to soils, to climate, to rainfall, etc., so as to enable one to know where agricultural plants, fruits, etc., may be raised.
4. The special study of rivers and lakes to determine the food of fish and the means of propagating fish in waters now furnishing no support to them.
5. The especial study of the habits and propagation of game birds and animals.
6. The especial study of problems in reforestration of waste lands.
7. The study of the water supply of cities.
8. The especial study of insects, fungi, and bacteria, and the means of combatting pests and diseases, for instance, distribution of malaric mosquitoes.

Granted its advisability, the reasons for its being conducted by the board are three-fold:—

(1.) The precedent of other states.

(2.) The economy of administration, over having a separate board of survey.

(3.) The unifying of the scientific research of *all the higher schools* of the state, rather than having such a survey conducted as it is in some states, solely by the university. If the board of regents of the university were in this state, as in New York, the center of all the educational interests of the state, this argument would not apply.

Feeling that the arguments for a biological survey as above given, were weighty, I favored an appropriation to that end, introduced as a separate bill, which passed both houses though it failed to become a law. My experience, however, with another separate appropriation which *did pass*, to aid the topographic survey, has, as below mentioned, not been entirely satisfactory. The keeping items charged to different petty accounts means much more work, both in my own and the auditor's department, and one great advantage of having the biological survey attached to the geological survey,—the ability to attach a biologist to a geological field party—would very probably involve us in bookkeeping snags. Would it not be better simply to provide in one act for the extension of the work of your board to cover this field, and then to provide separately for such increase in your general appropriation as might be deemed advisable, trusting to your board to apportion the same fairly, or directing that not less than an average fixed sum be expended in certain directions?

The same thing applies in regard to the topographic survey which has been urged by the Michigan Engineering Society as well as the Academy of Science, and was favored by the late Senator McMillan. The utility of the joint topographic survey is unquestioned, and I append Col. Muenscher's report to the Michigan Engineering Society.

Report of Committee on the Topographical Survey of the State.

To the President and Members of the Michigan Engineering Society:—

Your committee on the Topographical Survey of the state would respectfully report that they have done nothing as a body the past year in furtherance of the object for which they were appointed. The indifference with which their memorial to the state legislature of 1901-2 was received, was very discouraging, and would seem to indicate that the people of Michigan are not yet sufficiently informed of the value of such a survey to make it for the interest of their representatives to promote it.

It is gratifying, however, to know that a commencement of this work has been made, for which we are indebted almost entirely to the zealous efforts of our member, Mr. Alfred C. Lane. By devoting to this purpose a portion of the appropriation for the state geological survey for 1902-3 he was enabled to obtain the coöperation of the United States Geological Survey so far as to secure the survey of the quadrilateral enclosed between the parallels of longitude 83° 30′ and 84° west and of latitude 42° and 42° 30′ north, and including the cities of Ann Arbor and Ypsilanti, most of Washtenaw county, and portions of Livingston, Oakland, Wayne, Monroe, and Lenawee.

Mr. Lane also succeeded, with very effective assistance from the Michigan Academy of Science in persuading the last legislature to appropriate the meager sum of $1,000 to be expended during the year ending June 30th, 1904-5, for the continuance of this work. It is hoped that by means of this appropriation, with the aid of the United States, the survey of another quadrilateral, including the city of Detroit will be accomplished. The map of the first quadrilateral has been completed, but has not yet been published. A very few moments' inspection of this map ought to be sufficient to convince any intelligent man of the immense value of this survey, not only to engineers, but to all persons owning property or interested in public works or industrial enterprises of any kind in the state. It is reported that by the use of a single sheet of the Topographical Survey of Ohio, the locating engineers of the Wabash railway were recently enabled to change their previous location so as to save 2,300 feet of distance, and a summit termed 800 feet long, at an estimated money value to the company of more than $70,000.00. If such an amount can be saved by a single sheet by a single enterprise, how much can we not fairly hope for from a complete survey of the state.

Possibly a copy of this completed sheet placed in the hands of each member of the legislature to be elected next fall, would be the most convincing argument that could be used to advance the object which we have in view.

It would be, perhaps, too much to hope that this legislature can be induced to make any large appropriation, or to enter upon any general plan of survey, but it is not impossible that the members of this society from those sections of the state which are most largely represented, such as Grand Rapids, Saginaw, Kalamazoo, Battle Creek, etc., could, by personal efforts with their representatives, induce them to combine to carry through an appropriation which would cover the survey of those sections, and thus carry on the good work which has been begun.

E. W. MUENSCHER,
Chairman.

Prof. E. E. Bogue of the Agricultural College wants a similar survey as soon as may be to cover the college area. It is in the line of work which the board can do with limited means but very slowly. To aid in the work the legislature of 1903 made an appropriation, which was cut down before passage to $500 per annum,—not even enough to make one-half of the smallest unit of mapping without supplement.

In the course of the summer I found out by expensive experience from the auditor general that having had an appropriation for a specific purpose, the general appropriation could not be used for that specific purpose, though the same object be covered by it, and the only way I could aid was by doing a certain part of the work entirely at our own expense.

But it caused me a good deal of anxiety of mind and I also had personally to carry something like a thousand dollars worth of expense for a month or two. I would therefore recommend that any further additions which the legislature may see fit to give to hasten the work of the topographic survey may be either in the shape of additions to the general fund, or in sums of not less than $2,500 per annum.

The schoolmaster's club, and teachers' association as well as the Academy of Science are showing more interest in the work of the survey as the equipment of the teachers improve. I am not inclined to urge the study of geology as such into the grades. Too much preliminary knowledge is required before beginning its scientific study. What is advisable and useful can best be given in connection with a good physical geography. One can hardly describe the earth as it is, without some reference as to how it came to be so, especially when the agencies are still at work.

I would also urge that mineralogy is a very interesting subject, giving play to the collecting instinct, and of peculiar interest to many boys. In the boulders or hardheads scattered over our fields almost any mineral may occur. Practical experience shows that it tends to hold boys in school better than biology and I should recommend that mineralogy be allowed as an alternate to botany or biology, where the teacher desired and the local conditions made it advisable.

A committee of the teachers' association have prepared a handbook for the use of teachers. If possible it would be well to have this widely published and distributed among the teachers.

By an arrangement with the university, needed analyses have been made for the board under the direction of Prof. E. D. Campbell at half the usual rate, mainly by E. E. Ware and L. Kirschbraum. Many, such as those of the Lighthouse point quartz diabase, and those of a series of clays for Prof. Sherzer, are inserted in appropriate places.

A piece of fusible slag from our Michigan coal was sent me. Such slag occurs rarely but occasionally in connection with the Saginaw seam. It seemed to me worth while to have it analyzed to verify my suspicions that it was due to black band ore. The following is the result:—

Loss on ignition	......
SiO_2	33.84
Al_2O_3	32.50
Fe_2O_3	5.68
FeO	13.80
CaO	22.60
MgO	1.64
	100.06

This was tested for ZnO but the chemist could find no appreciable trace of it.

In the notes turned in by W. M. Gregory for the gypsum report, Volume IX, Part 2, on the Alabaster region, there were some remarks on recent changes of the Lake Huron shore which seemed hardly pertinent to that report but were of such interest in themselves as to deserve insertion here.

RECENT SHORE FORMS.

BY W. M. GREGORY.

Outside of the glacial region and between the lake level and the Nipissing beach is a strip of land which is due entirely to recent lake formations, some of them within historic times. The general shore structures of the eastern edge of this area show the direction of the adjustment of the beach to the lake currents by the smooth curves, convex to the lake, present in the outline of the shore, both in the larger features and the smaller ones. The most interesting place where these recent formations have been more rapidly built, is at Tawas point. This formation is spoken more of at length below. The places in the "bight" of Tawas Bay show how the building out of this point is gradually weakening the building effects of the waves on the shore in its shelter.

One of the familiar features along the shore are the sand dunes; in many places arranged by storm waves and wind action into lenticular dunes with the longer axes northeast and southwest. These are often cut later into several smaller ones by wind action, or perhaps the entire top blown off, forming a dune which resembles the crater of an old volcano.

The cutting of the lake shore is going on very extensively in regions which may be located as in general above prominent points. The erosion of the lake bank a mile and a half above Tawas point, has carried the bank inshore some 50 feet within the memory of the fishermen living there and as shown by recent surveys. Cutting has also taken place below Tawas City, and this is due to an eddy current which is traveling in the bay, and its effects have been very extensive. A large amount has been expended in building a revetment and otherwise lessening the erosive action of this current which is often aided by the northeastern storm waves. In this same region the Detroit & Mackinac R. R. once ran in front of the old Presbyterian church, but because of the extensive cutting, thus causing the caving of the bank, the track was moved a distance back of the church and at the present time where the track stood the bank has been cut out some five to ten feet, almost wholly through wind action. This has been done within the last 15 years. Very extensive cutting has also taken place in a long stretch of this shore from Harmon City down nearly to Point Lookout. In this region, the average height of the bank varies from 10 to 20 feet. All of the points below these regions of extensive cutting are building spits and are otherwise rapidly enlarging, thus showing where part of the material being removed is being placed.

FORMATION OF TAWAS POINT.

This has been spoken of as Ottawa Point, Tawas Point, or Whittemore Point, and is located some two miles directly east of Tawas City in Iosco county, and it is so excellent an example of the formation of "cuspate forelands" that it is deemed worthy of a rather careful consideration. It has long been known by the settlers of this region that the point has been in process of rapid building. The bay has always been one of excellent refuge for ships in the case of storms and a lighthouse has always been maintained for aiding navigation. The trouble with the location of these lighthouses has been that they were built on the end of the point and by its rapid growth needed to be moved from time to time not to be misleading. There have been two of these lighthouses and also a fog horn, built in recent times. This of course, has been due to the action of the currents in rapid building and similar phenomena have been discussed by different people in other regions, but this particular point, excellent as a type of formation of cuspate foreland, has been overlooked. It has been used by the writer as a practical exercise in geological excursions (field) in school work and has been a source of excellent results to the pupils who have lived in this vicinity.

A few notes may now be given pertaining to the building at this point. The first lighthouse which was located in this region was built in 1856. The light was located on the end of the point at that time and the water's

edge was only 15 feet away, and there was no land to the southeast. At this time there were several small ponds in back of the lighthouse. This was 1800 feet northeast of the present light, which was built in 1876. Thus in 20 years a stretch of land some 1200 feet in length and 1000 feet wide in average was added. This enables somewhat definite estimate of the power and the rapidity of the point building forces of this region.[1]

The building action is largely due to waves throwing up the sand and the wind blowing the sand out of the water and piling it up in dunes, thus slowly adding to the land already in place. The water coming down the shore is supplied with plenty of sand and what is not extracted from the waves by the winds is carried to the point where the waters of the lake meet the waters of the bay and at this dead water triangle between the two currents opposite in direction, it is utilized in prolonging the length of the point. These normal conditions are often disturbed by a change of wind which introduces changes of the currents.

The new lighthouse, as has already been stated, was built in 1876 and was entirely surrounded by water, being built on a firm area of land between which and the mainland there was a passageway from the bay to the lake through which fishing boats of large size often passed, and through which the surf boats of the life-saving crew were taken from the station to the bay to work in the lake. At the present time this passageway has been closed at the ends and is only a swamp between two high ridges of sand. The old shore lines on the point are marked by faint beaches of well worn brown, sandy, shelly pebbles. The surface of this point has been made over almost entirely by wind action where many forms of dunes are seen covered with very little vegetation. It is possible to see the dunes in the embryonic stage, its fullest development with a smooth full top, and in the stage when the top becomes blown off, which is characteristic of its old forms.

In addition to the lighthouses above mentioned, there was built in 1900, because of the point's rapid growth, a fog horn .6 of a mile southwest of the present lighthouse, being at the present end of the spit. The land between the fog horn and the lighthouse has a width of some 600 to 800 feet, spindling down to some 200 feet at the fog horn and turning off sharply to the northwest where it forms a hooked spit. The average height of the land between the present light and the end of the point is some three to five feet. On the lake side of this formation at the water's edge, are many small pebbles, well worn and making a distinct beach. Going lakeward these increase in size. Out 100 feet from the present shore line, there is a distinct bar or ridge formed, which is the predecessor of the point which is to come. On the off shore side of the point the water is very shallow in this region, being from one to four feet deep, out for a distance of more than three-fourths of a mile, where it drops off very suddenly to a depth of 15 feet. In the inside curve of this spit or as it is locally known, the "bight" of the bay, there is no distinct shore line as along the outer edge of the point. The sediments here are very fine silt, mud, bark and floating debris, and it is a place much loved by ducks, the mollusca and other fresh water shells. Here are many good examples of ripple marks, wave prints and the tracks of different animals. A large

[1] It is adding say 1,200 feet in 20 years, 3,168 feet in 24, say 60 feet a year, or in area 1,200 × 1,000 in 20 years or 3,168 × (700 to 200) in 24 years, or almost exactly 60,000 square feet a year. The area of the point proper from section 13 to section 21 is only about 1.6 square miles, projecting perhaps four miles from the normal coast contour, so that figuring by length it would only take some 350 years or by area 460 years to have produced the whole point.—Lane.

part of the bottom is exposed by the water when the level of the lake is lowered by reversed currents of water due to wind action.

The currents which cause the building have been carefully observed throughout a period of several years by the writer and some explanation of the facts may be attempted on the data attained. The currents are dependent upon the direction of the wind. The prevailing direction of the wind for one-fourth of a mile out from the life-saving station is to the southwest, but this direction is reversed during a heavy southwest wind. The general current has been shown to be as above stated by the drifting of boats, floatwood and a series of tests with bottles. The objects when placed in the lake from small fishing boats, located off the life-saving station, were found to take a course to the southwest which brought them to a point near Alabaster. In heavy storms from the northeast a very strong current runs down this shore and strikes the shore of Saginaw Bay at Harmon City and Alabaster. This was shown to be the case when the steamer Baltimore was wrecked above AuSable, which occurred in 1900. Some of the wreck material was thrown on the beach just below Alabaster and the course of the wrecked boat was in this direction, which the current takes during heavy northeast storms. At such times there is formed an eddy in Tawas Bay, this eddy current having a direction on the shore opposite to that of the lake, and thus where the eddy current and the lake current come together at the end of the point, there will be formed a dead water triangle, and in this triangle the addition to the land will take place. The prevailing direction of the currents are as indicated above and have been tested several times to prove the correctness of the theory. During the use of the dredge at Tawas City, the muddy water was carried in the direction of the eddy referred to, and W. O. Emery of the custom office has observed these currents for a number of years and believes that the eddy's general direction is to the northeast along the shore of the bay, while outside the point the prevailing current is to the southwest. In considering these currents in this discussion, we must remember that these directions can be reversed during a storm.

The ridges which are formed and which are the most prominent feature of the point, are believed to be the result of big storms. At Tawas beach there are as many as a dozen of these ridges nearly parallel with a decreasing elevation as they reach the water. The heaviest storm of the season builds the highest beach, and thus when the water stands at the same level there are a series of beaches commenced. The sharpness of these storm ridges which have been formed during the building of the point decreases as we pass up the bay under shelter of the point. The old ridges which are prominent and extend entirely across the point and are being cut by the lake waves at present, were built before the point was formed and resulted from the formation of a similar point before the present one, for if the present point were to build rapidly across the bay and close in a body of water, we should have exactly the conditions under which Tawas lake was formed and later Lake Solitude. Some of the members of the U. S. L. S. station have observed the formation of these storm ridges which have been built in a single night's storm to some 5 or 6 feet above the lake level.

The water of Tawas Bay varies in its level considerably, being dependent upon the direction of the wind and its strength. In November, 1901, the wind from the northeast raised the level of the water some three feet, according to the authority of Engineer Black of the East Tawas Water

Works, and on April 14, 1901, in four hours the level of Tawas Bay was lowered 1.64 feet by a southwest wind.

Lake Solitude, which is located on the "bight" of the bay, is a shallow lake with muck and silt in the bottom with a large sandy ridge nearly dividing it into two distinct parts, and with an elevation of 2.5 feet above Lake Huron. This lake had two outlets at one time, or more properly was connected with Lake Huron, being merely a passageway between two sand ridges. When the level of the lake fell the water was partly drained off, and because of the sand bars which choked the entrance, a considerable area of water was left behind forming a lake, which in time demanded an outlet, and this was accomplished by cutting across the places where the wave action was slight under the protection of the building spit, and thus making a small outlet to the lake, while the older became clogged by the action of the waves on the Lake Huron shore. This is a rapid sketch of the formation of many of the lakes along this shore.

Tawas lake, which lies to the northwest of these smaller lakes just described, has the same general characters, being nearly filled with silt, muck, and abundant growth of vegetation. It evidently was formed between the Algonquin and the Nipissing beaches, and was evidently the first point formed in this region by the action of the currents in building off the shore bars and spits, as its western border in many places rests on the eastern edge of the Alcona moraine.

From Au Sable all along the shore to Au Gres, the tendency of storm waves to build ridges has formed heavy ridges running parallel to the shore line, having between them swales and swamps, rendering the drainage very much obstructed, and in many places where the distance between the ridges is large, cranberry marshes have been formed. These large ridges in many places have been cut away and now the old cranberry marsh is being cut into by the waves. There are several places along the shore where this is shown and also places where the sand has been duned and carried in shore by the wind, exposing a section of the cranberry marsh at its base as the waves cut away.

The Tawas river and other rivers of this section have a tendency to build deltas where the force of the river currents is less than that of the lake currents. This has taken place at the mouth of Tawas river. The building takes place in the spring and fall. The current of the AuSable is much stronger than the prevailing lake currents and the sediments are carried some two miles down the shore where, according to Captain Small of the U. S. life-saving- station, there is a large shallow area, some one-half mile off shore, and this is being converted into an island whose sediments are derived from the river. The Rifle river has built a large delta at its mouth, some five miles square in area, and the Au Gres river has a current which is so sluggish that the channel to Saginaw Bay is kept open with difficulty, and a long area of land in front of the river mouth is slowly forming the river delta.

PUBLICATIONS.

In publication this year has been signalized by the completion of Volume VIII of our reports, containing three papers bearing on the raw materials of cement. (We are still at work upon the limestones, concerning which many facts have been given in our annual reports.) This report has elicited such comments as this from Municipal Engineering (Aug. 1903, p. 121): "The most valuable work on the manufacture of cement from clay and limestone or marl which has yet appeared." See also the letter from Mr. Wentz. I also quote from the Indiana State Chemist:—

"Lafayette, Ind., Nov. 21, 1903.

. . . . "Having had some experience in cement manufacturing in your state, it is evident to me that you have made a very broad and comprehensive treatment of the marl question and I wish to thank you very much for bringing Part III to my attention.

"Very sincerely yours,

"(Signed) CHAS. S. McGOVNEY."

Dept. of Geology, Drury College,
Springfield, Mo., Aug. 10, 1903.

Dear Sir.—I thank you for Volume VIII of the Michigan Geological Survey, and also for the annual reports for 1901 and 1902. They are of great value in my library, and I congratulate you on the character of the publications sent out by your Survey.

Very sincerely yours,

(Signed) EDWARD M. SHEPARD.

East Tawas, Mich., July 3, 1904.

. . . .

Gentlemen.—I have received the Geological Report of Michigan and am very much obliged for same. I find it a very valuable book and shall enjoy reading it.

Yours very truly,

(Signed) TEMPLE EMERY.

Union City, Mich., July 14, 1903.

. . . .

Dear Sir.—Please accept my thanks for Volume VIII of the Geological Survey of Michigan. The work contains just the information I was in search of.

Respectfully yours,

(Signed) E. G. ARDAGH,
Of the Peerless Portland Cement Co.

I have also issued as Part 1 of Vol. IX a paper which otherwise would have been included in the annual report, but was needed by the attorney

general's department as soon as possible, on the "Growth of the St. Clair Delta," by Leon J. Cole.

Part 2, of Volume IX, a report on the gypsum of the state by G. P. Grimsley will probably have appeared before this report is printed.

The expense is given in the financial statement below.

Our present system of distribution, which involves sending to none but college libraries and exchanges, except upon especial application, and to very few other than teachers outside the state except upon payment of a fair price, makes small editions sufficient. Possibly in some cases a more liberal distribution would be worth while as advertising the resources of the state more, and possibly in reaction against a too lavish distribution of public documents I may have been niggardly, but I do not think so. The press usually announces such publications, and those who do not care enough for them to write, will probably get along comfortably without them (and never know what they miss) and can better be reached by the periodical press. Large parts of our reports, at times practically the whole, are reprinted in magazines and technical periodicals, in particular the "Michigan Miner" and "The Gateway." I believe that your policy of extending the widest opportunities to editors who desire to use our material is a wise one.

PRINTING EXPENSES.

	Vol. VII.	Vol. VIII.	Annual, 1901.	Miscellaneous.	Total spent.	Total appropriation.
Sec. 2, Act 78, 1899:						
Prior to Jan. 1, 1902..........	$2,299 59	$626 84	....	[1]$28 49		
Jan. 1, 1902-Jan. 1, 1903.....	....	404 24	$637 25	[2]3 59		
		$1,031 08		$32 08	$4,000 00	$4,000 00
	Ann. 1903.					
Sec. 1, Act 231, 1901..........	$20 32	1,031 74	715 15	[3]118 50		
		$2,062 82	$1,352 40	$150 58	$1,949 17	$2,800 00
Sec 1, Act 178, 1903.........	90 00	Vol. IX.				
		Pt. I $257 78			$501 98	$1,250 00
		Pt. II 153 85		35		
		$411 63		$150 93		

[1] Covers and binding for reports 1899 and 1900 which were printed by Michigan Miner.
[2] Binding report 1902.
[3] $45.00 for maps of the State for separate distribution and the balance for illustrations of fossils.

The above is the financial statement of the expenditure of the annual appropriation. Money spent in conjunction with the U. S. Geological Survey in the topographic survey of the Ann Arbor sheet (you allotted $2,000), is included under field expenses. Salaries and office expenses are less than usual. This does not include the expenses for printing, which are given below. We have used up the appropriation of Act 78, session of 1899, for printing, and start on that of Act 231, session of 1901. The completion and binding of Volume VIII, which is now in press, and the printing of this report, if you so order, will use most of that.

1902-1903.

	Salary.	Field.[1]	Office.	Total.
July	$380.76	$396.67	$143.85	$921.28
August	279.47	38.90	104.21	422.58
September	273.67	554.11	37.55	865.33
October	355.24	71.13	158.33	584.70
November	312.00	78.39	46.56	436.95
December	344.31		45.02	389.33
January	313.80	56.67	12.52	382.89
February	428.17	49.78	76.75	410.70
March	311.53	6.18	61.91	379.62
April	274.00	242.93	91.01	607.94
May	[1]825.40	164.63	41.44	1,031.47
June	[2]1,133.75	178.72	69.97	1,382.44
Supplementary		171.60	5.00	176.60
Charged back unexpended				8.17
Total	$5,088.10	$1,909.61	$894.33	$8,000.00

[1] Including in part pay of temporary field assistants and payments on chemical work, etc., by contract.
[2] Including most of the salaries of assistants hired by the month or longer, and some payments on contract, e. g., $200.00 for gypsum report.
The above statement of expense follows the usual form. It is not always practicable to draw a consistent line between field expenses so far as temporary assistants are concerned, and salaries. The salaries of the permanent staff really amounted to about $300 00 per month.

I would call your attention to certain requests for new work which have come into this office, although it really seems to me we have all we can do for a year to finish work on hand and keep up with current explorations.

The American Institute of Mining Engineers, Mr. Merrill, one of the Smithsonian curators and others, are anxious that we should reprint the earlier reports. Inasmuch as they can no longer be obtained even from second hand book dealers, I think it would be wise so to do. The Academy of Science would like a natural science hand book for teachers published. The I. Stephens estate and the Upper Peninsula experiment station people are anxious for a map of the Upper Peninsula surface geology.

The Waverly Stone Co. and others would be glad to have a report on the building stones of the state like that recently issued by Wisconsin.

I cannot close this report without a reference of honor, respect, and regret to the departure from this life of Jacob Houghton, Esq., brother of Douglass Houghton, the first State Geologist of Michigan, who was, I believe, the last survivor of that survey. He also contributed to Volume II of the present series of reports, and to the end of a long life never lost interest in geology and faced camp life even when past the allotted three score years and ten.

Very respectfully,
(Signed) ALFRED C. LANE.

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