

10) into (5,500) as against (6,224-2,155) less than (4,100) at the Winona. Unless our correlations are wrong we must assume (for I do not think there is any possibility of a thickening of the formation this much) either extremely flat dips or that the felsite on Section 8 and the conglomerate on Section 10 are also separated by a fault, of one of two classes. It may be conceived as a strike fault throwing the southeast side down. Of this kind of a fault there are distinct indications,—to such a fault may be due the escarpment of bluffs that lie north of the Lake and Mass. Secondly one may think of a fault running through the Indiana properties about south and throwing the east side south. Drilling now in progress may settle the question.

§ 24. LAKE. (Pl. XIII and Fig. 51.)

The Lake property early excited interest by an abnormal strike. From the drill holes I determined the same and then an outcrop of conglomerate to the west showed that the strike was indeed nearly north (N. 60° E.).¹ Since the formations in the bluffs on the north side of Section 31 are certainly running with the general trend of the range, a large fault almost certainly runs through the property,—probably more than one. Abnormal strikes are, however, quite customary near the great Keweenaw fault. Compare, for instance, the Baltic lode twists on Plate X. There is, therefore, a good deal of uncertainty in connecting the upper and lower parts of this section.

Beside the section shown in drill holes there is above them a fairly continuous section of traps and amygdaloids dipping about 40° exposed in the bluffs which extend from the north quarter post of Section 31. (See File 15-29.) It is essentially the same as that shown in the Adventure mine and at the Mass. It continues drill hole 2 upward and shows that above the conglomerate of drill hole 2 there is for over a thousand feet no conglomerate.

This makes the correlation of that with the Winona conglomerate the more likely. The beds exposed are also feldspathic, *not markedly* ophitic,—a character which helps us in identification.

An old diagram (File 15-8) from Dr. Rominger is of historic interest as to the names applied to the amygdaloid lodes and may be summarized.

¹Recent developments on the Algoma indicate that the lode continues on this strike to the center of section 3 south, and drilling on the South Lake, which on Plate XIII is called the Aztec, and developments on the Lake property have led to a suggestion advanced in the report of the South Lake Mining Company for 1910, that the lode curves around to the north-west and finally dips south. See appendix.

"Knowlton" vein	width 10-15 feet	at 0	(268)
Piscataqua	3	"400; at 42 dip	
Champion	15-12	"1000	(669)
Adit at side of bluff			
Ogima vein	5-6	"1130	(763)
Evergreen	4-40	"1280	(857)
Evergreen shaft		"1480	(1091)

The coordinates of these lodes and the drill holes (south and east of the north quarter post of Section 31, T. 51 N., R. 37 W.) are as follows:

	South	East	Elevation above datum	A. L. S.	Inclination angle	Direction
Knowlton	140.17	673.94				
Butler	597.64	659.30				
Evergreen	514.16	2297.67				
No. 2 hole	712.81	1520.67	103.2		66° 20'	S. 33° 40'
Zero	484.74	366.78				
No. 1 hole	1200.	580.	83.8		no rock	at 337 ft.
7	5200	2600	170.	488	60	S 20 E
8	2200	1000	68.		no rock	at 250 ft.
5	3680	1960	94.1	408	62 26	S. 27 58 E.
4	4337.78	2069	108.3	422	60	S. 66 E
3	4123.92	2195.47	105.4	419	60	S. 66 23 E
6	4337.78	2369.61	127	441	55	N. 20 W
9	4025	2600	127	441	60	S. 20 E

Geological Cross-Section at the Lake mine (Fig. 51, File 1427). *Lake drill hole 2.* 712.81 feet S., 1520.67 feet East of the N. quarter post of Section 31, T. 51, R. 37. Elevation 103.2 above local survey datum, about 425 above Lake Superior and 1027 A. T. Planned to go down at a dip of 66° 20' toward S. 33° 40' E. This is intended to be practically at right angles to the formation. But the dip on the Butler lode is 34° to 38° more probably and the inclination of the sandstone bedding between 2.611 and 2.660 below indicates an average inclination of 16° $\frac{2}{3}$ from being struck at right angles by the core. Estimates of the strike of the range at this point vary from N. 75° to N. 58° E. It seems to me probable that the latter figure is more nearly correct, while there are a lot of little faults that make the general trend more easterly. But the reduction factor required to reduce the distances along the diamond drill hole to those along one with the same dip at right angles to the strike will be negligible, being less than those due to deviation of the hole,

For instance $75^\circ 20' - 55^\circ 20' = 20^\circ$; $\tan 20^\circ = .365$; $.365 \times \cos 66^\circ 20'$ (dip) = .146 \tan^{-1} of .146 = 8.5°; $\cos 8.5^\circ = .989$, but the factor is probably nearer 1, as the true strike is probably less than 75°. On the other hand the dip is probably nearer 38° which we shall take and to get the true thickness we must multiply by $\sin 66^\circ 20' +$ the dip, say $114^\circ 20'$ or $75^\circ 40' = .969$. This has been done with the slide rule.

1. Overburden, clay till d 2. 0-34. Vertical depth (31)

Abandoned brick yards are near. The clay is very heavy but somewhat stony.

2. Melaphyre, ophite. Evergreen lode and foot (83)
 Amygdaloid d 2. 34-46? (12)
 Trap with amygdaloid spots d 2. 46-120 (71)
 The amygdaloid is a reddish chloritic amygdaloid with copper—the Evergreen lode presumably, from 43-46 and at 47 and 71 are amygdaloid spots. There are occasional pseudamygdules pseudomorph after feldspar probably. The ophitic mottling is at 80, 85, 90, and 112 feet
 3 mm., 1-2 mm., 2 mm., and 2-3 mm.
 This is so irregular that I suspect carelessness in placing the cores, but it may be due to faulting.
2. Ophite (C3) (146)
 Amygdaloid d 2. 120-128 (8)
 Trap d 2. 128-185 (55)
 From 120-124 may be base of the floor above, from 120-122 being faint and at 124 a few inches of chloritic amygdaloid, but from there to 128 the bed is light gray-green, well-defined epidote amygdaloid with brecciated chloritic seam at base. Amygdaloid spots occur in the trap. The mottling is at 130, 145 to 150, 156 feet
 1 to 2, 2-3, 2-3 mm.
 At 156-161 it appears to be fine grained feldspathic with amygdules of chlorite rarely calcite.
3. Melaphyre (48) (194)
 Amygdaloid d 2. 185-190 (5)
 Trap d 2. 190-234 (43)
 The hanging contact of the amygdaloid is marked and it is green and red and white brecciated. The trap is massive.
4. Ophite (part of the previous belt?) (23) (217)
 Amygdaloid d 2. 234-241 (7)
 Trap d 2. 241-257 (16)
 The amygdaloid is sparse, red and green, and at 245-250 there is a 2 mm. ophitic mottling. But this bed perhaps belongs with the one above or is faulted. The cores are broken in halves lengthwise by a seam running at an angle of 15.5° with the core, and the grain is different in coarseness on one side and the other. If this seam be supposed vertical its strike must be either about N. 17° W. or N. 50° W. A seam in a pit in a gap over the Evergreen lode seems to indicate cross-faults running N. 15° W. to S. 15° E. and there are other evidences in this region of displacements having this trend.
- 5 &
 6. Ophite (disturbed) (180) (84) (481)
 Amygdaloid d 2. 257-259, and 274-289?
 Trap fissured and seamed, faulted, 295-306, relatively little core down to 338.
 Decomposed ophite d 2. 360-531
 The mottling is at 407 and 464
 3 mm. and 6 mm. (faint) respectively.
 and then grows finer to base. There is a seam at an angle of 45° to the

- drill hole at about 360 feet. It is clear that there is a heavy trap 150 feet thick or so surrounded by some disturbed beds including very likely another flow.
 From 253 to 306 the hole evidently passes through a belt of disturbance.
7. Conglomerate 8. the Winona. d 2. 531-571 (39) (77.5) (560)
 Sandstone d 2. 571-611 (39)
 The conglomerate contains various types of felsitic pebbles. The sandstone as compared with the Eastern sandstone of Hole 7 is darker, finer, heavier, more cemented. A magnification of 5 diameters barely shows individual grains, largely not quartz. The bedding shows well and varies from 6° to 24° from being at right angles to the hole, averaging (21 observations) 16°.6. If we suppose the strike to be at right angles to the direction of dip of the hole, this would mean a dip of 40°, or if the strike is N. 75° E. 38°, quite such dips as are probable.
 The total thickness between this conglomerate and the top of the Evergreen is about 500 feet. This would bring it about in the position of the Caledonia or Nebraska conglomerate of the Mass mine.
8. Melaphyre (104) (663)
 Amygdaloid d 2. 611-613 (2)
 Trap d 2. 613-718 (102)
 The amygdaloid is well-marked and bears copper. Cf. Adventure section belt 16. The trap decayed looking, feldspathic, coarse, light gray, the feldspars up to 2 to 3 mm. long at 679.
9. Amygdaloidal conglomerate d 2. 718-742 (22) (684)
 At the beginning a few inches of red argillite passing into a conglomerate with gray sediment and dark and white scoria of amygdaloid; includes the amygdaloid of the underlying trap. This might be called a "calico lode." Capt. Wearne says it looks like the lode of that name 140 to 150' above the Minnesota conglomerate.
10. Ophite (750)
 Amygdaloid? d 2. -742
 Trap d 2. 742-810 (66)
 At 760 2 mm. mottling (69) (819)
11. Feldspathic ophite (69) (819)
 Amygdaloid d 2. 810-813 (3)
 Trap d 2. 813-873 (58)
 Bottom amygdaloid 870-879 (9) (860)
12. Conglomerate 6? (879-918+) (41+)
 Marked felsite conglomerate, good sized pebbles. Dip in one place appears to be 26.5° from being across the core. This section is not now continuous as Holes 1 and 8 did not reach rock.
- Lake drill hole 1.* 1200 ft. S., 580 E. of the N. Q. P. of Section 31, T. 51, R. 37. Elevation 83.5 above local datum (which is 314 above Lake Superior) went 337 feet without finding rock.
- Lake drill hole 8.* 2200 ft. S., 1000 E., Sec. 31, T. 51, R. 37. Elevation 68 above local datum, 250 ft. deep, also did not reach rock.

The next hole is No. 5, but its distance in the geological column below d 2 is entirely uncertain as the strike has apparently changed many degrees.¹ The distance between Hole 2 and Hole 5 is 3000 feet and that must probably correspond (faults apart) to not less than 1500 feet. So that the top of a conglomerate which occurs below the bottom of d 5. 738 would be probably over 2200 below the Evergreen and 1453 below the top of the conglomerate at the bottom of Lake d 2.

If the strike is nearly north as it seems, Holes 3, 4, 5, 6, 7 and 9 all overlap each other extensively and that really seems to be the case. The highest horizon seems to be reached by Hole 5, which we therefore use as a standard so far as we can, but in all there appears to be faulting and disturbance.

Lake drill hole 5. 3680 feet S., 1960 ft. E. of the N. Q. P., Section 31, T. 51, R. 37. Elevation above local datum 94.1 (408 A. L. S.), put down at an angle of 62° 26' to S. 27° 58' E. It was 127 feet to bed rock. From this hole is a continuous stream of about 1 cu. ft. a minute at a temperature of 45°. Analytical tests show a notable amount of Cl. from the upper rock levels, but it is nearly tasteless, as follows:

- Cl 760 parts per million
- SO₄ 82
- Ca 24 or 10
- CO₂ 25 (or 15+18)
- Na₂ as Carbonate 14

To reduce from thickness along the hole to true thickness we assume a dip of about 40°, somewhat flatter than the surface dip but agreeing with some seams in the hole and also with indications of flatter dips in the correlations. For 4 and 3 the corresponding reduction factor is .97, for 6 it is .455.

1. Feldspathic ophite d 5. 127-207 (200)+
This also appears to occur in d 4. 108-277

The coarsest augite at d 4. 96-147 and d 5. 140 shows in sunshine about 5 mm. cleavage fractures, but there is so much feldspar that the mottling does not show otherwise. At d 5. 160 is a seam at 14.5° with the core, at d 5. 190 another at 21° 20'. These may be nearly vertical seams running a little east of north along which displacement has taken place, or as they have an easterly dip the strike may be more westerly. At d 4. 96 there is a doleritic band making an angle of 66° with the drill hole, and these are usually parallel to bedding. With a northerly strike a dip of some 50° would be indicated.

2. Melaphyre (31) (231)

- Amygdaloid d 5. 207-223 (14)
- Trap d 5. 223-242 (16)

The amygdaloid is epidotic, the base well-marked and probably corresponds to d 4. 277.

3. Feldspathic melaphyre (41) (272)

- Amygdaloid d 5. 242-250 (7)
- Trap d 5. 250-290 (34)

This trap is slightly amygdaloid and porphyritic, some of the feldspar being a little more conspicuous. This is also characteristic in 4 about 301. d 4. 277-340 (66) appears the same and it appears also in d 3. 92-

¹There is drilling going on in the intervening space and on the South Lake and North Lake properties to the west and to the northeast. There are uncertainties caused by faults, and the Adventure cross-section is probably as good as any for filling in the gap.

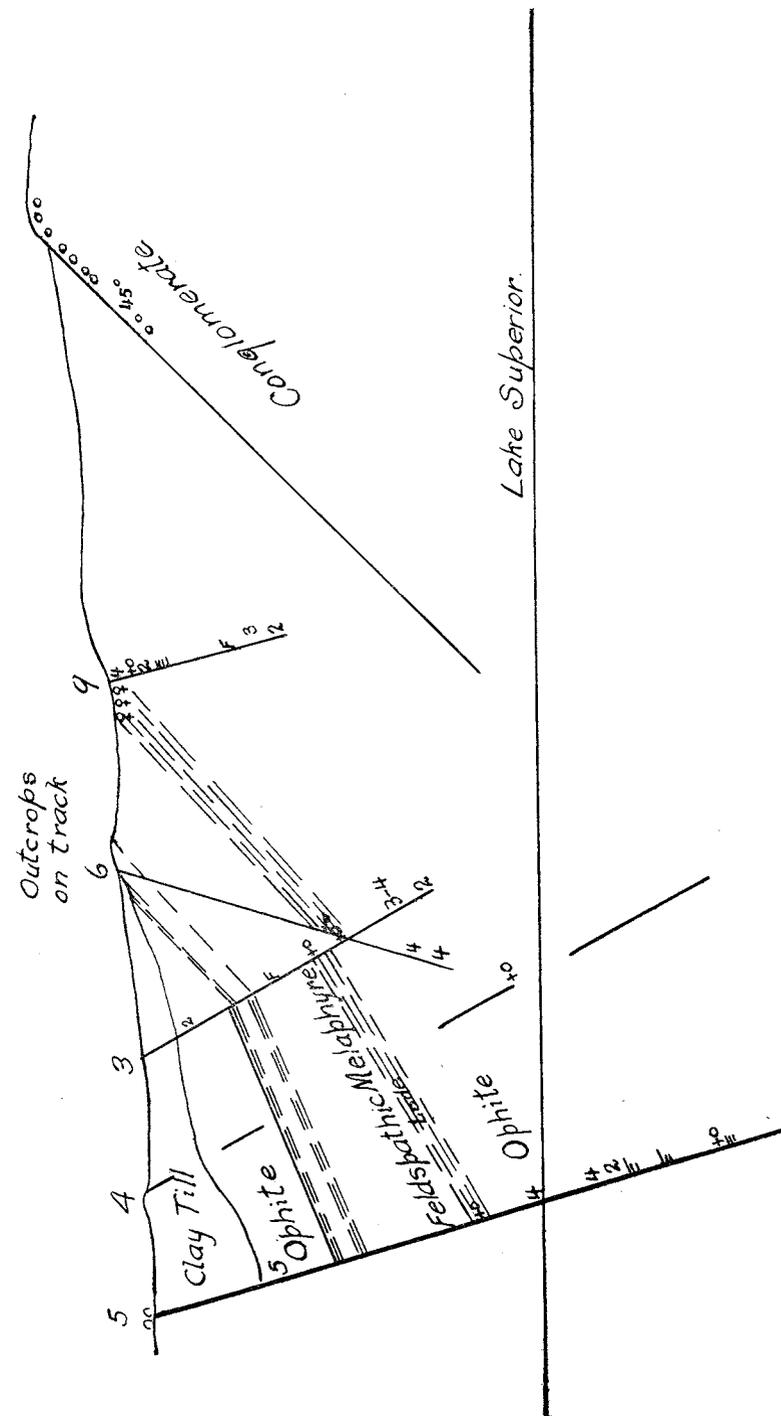


FIG. 51. CROSS-SECTION OF LAKE COPPER COMPANY'S DRILLING.

120. The larger feldspars are up to 6 mm. long, but there is no sharp distinction between them and the smaller.
4. Feldspathic melaphyre (70) (342)
- Amygdaloid d 5. 290-301 (9)
 Trap d 5. 301?-372 (61)
- The amygdaloid banding and flow lines seem to be at about 45° to the diamond drill in No. 5 at 372 to 400 indicating with a northerly strike a dip of about 50°. This is presumably the same as d 4. 343-358-425 (80) which, however, appears to be faulted. d 3. 121-129 a fine grained red and white glomeroporphyritic amygdaloid might be this or the amygdaloid above but the trap to d 3. 208 and the whole thickness in 3 of (87) feet agrees better with this. (120)
5. Ophite, the top of which is the LAKE LODGE (120)
 Amygdaloid d 5. 372-401=29
 Trap d 5. 401-558=157
- The amygdaloid is prehnitic and has forms like porphyritic crystals with a speck of copper at 381, and it remains a fine grained slightly amygdaloidal melaphyre with the trend of the blotches at 45° to the hole, as far as 401. The augite mottling is at 420, 433, 451, 462 much seamed, 460, 488, 513, 533, 538, 550 feet 2, 2½-3, 4, 2, 3, 2-3, 4, 2-3, 1-2, 1 mm
- The coarsest mottling reached (4 mm.) would indicate a flow about 120 feet or somewhat more thick. There seems to be a distinct faulting by which 451 and 513 are about equivalent. The east or lower part of the lode is thrown down the hole 62 feet which would mean a horizontal heave of the outcrop to the east 85 feet.
- Such a fault would account for the relatively flat dip from drill hole 6 to 5, and just such a horizontal displacement would bring the dip about into line. I think therefore it is not safe to assume over 120' thickness for this belt.
- In the drill holes it often appears thicker. Is this always due to duplication by faulting?
- Compare the following figures.
 d 5. 372-558=186 (158)
 d 4. 425-629=204 (at about 579 5 mm.) (200)
 d 3. 208-360+20 or so=172 ± (168)
 d 6. 236-430+ leaving off in 3-4 mm. ophite (86+45 to 60)
 d 9. 8-58 beginning in 4 mm. ophite (58x2+) crossing a calcite and copper vein at d 9. 29 (38)
6. Feldspathic melaphyre (38)
 Amygdaloid d 5. 558-563 (4) d 9. 58-64 (5)
 Trap d 5. 563-603 (34) 64-90? (22)
- This amygdaloid is marked. The trap feldspathic. At 580 to 583 is a green streak, a seam of calcite making about 66° with the hole may be parallel to the dip.
 Cf. Amygdaloid 4. 589 or 613 (fault) -629
 Trap feldspathic faintly ophitic 629-767
 Faintly ophitic 2 to 3 mm. at 708 (43)
7. Amygdaloid ? d 5. 603-613 (3) d 9. 90-95? (4)
 Trap? d 5. 613-660 (40) 95-130 (cf. 4. 677)

Amygdaloid is coarse, calcite and chloritic, the trap is in small broken pieces, possibly with some porphyritic crystals, and slightly opbitic 1 to 2 mm. (Cf. d 4. 767)

8.

(66?+ about 100)

Amygdaloid d 5. 660-680 (17?) d 9. 130-160

Trap d 5. 680-738+ (58+) 160-246+

The upper amygdaloid is well-marked with a little copper. Flow directions seem to make an angle of 56.5° with the hole. The trap is fine grained with chloritic amygdules in spots. At d 5. 698 (about center 33') there is a 1-2 mm. mottling and amygdaloid spots too and it keeps of about the same grain so long that one is tempted to infer that the bed is cut very obliquely.

In d 9. below 130 there is an epidote and calcite amygdaloid and a heavy epidote vein at 174 feet. The mottling is as follows:

at 163,	200,	232,	242
3,	2,	1-2,	1-2 mm.

Thus as the grain is getting finer it must be more than half way through the flow.

In d 4. there are no well-marked amygdaloid belts and toward the end it is a perfect net-work of seams. We may note the grain at the following points:

at 786,	840,	849,	858
2,	2-4,	5?,	5 mm.

At 767 the core is in small pieces with spots of amygdaloid, at 790 is a light green bomb of amygdaloid. From 849-858 is full of seams. The general impression is that there is an ophite 120 feet thick or so.

Lake drill hole 7 (if the strike is near north) would overlap drill holes 4 and 5 down to the point (433) where it is cut off by the Eastern sandstone.

The record is:

Feldspathic melaphyre d 7. 12-74

Amygdaloid d 7. 74-78

Feldspathic trap ophite d 7. 78-198

Amygdaloid and breccia red glomporphyritic (like d 3. 121-129) d 7. 198-202

Chloritic feldspathic amygdaloid d 7. 202-215. These resemble Belt 4.

Feldspathic melaphyre (feldspar laths, 1-2 mm., chlorite 2-3 mm., on a red ground of augite and olivine) 215-250 growing more and more seamed. At 253 epidote and calcite, possibly the lode.

Ophite d 3. 253-264

At 319 faint, dark, much fissured¹, at 347, 357

1-2, 2, 3 mm.

This may be the ophite foot of the lode, or perhaps Belt 8. At 364 is a clay seam, at 370 a chloritic banded amygdaloid spot, like d 4. 677. At 385 is a marked seam at a 45° angle to drill, with calcite seams at 29° and across the hole. At 410 are heavy seams parallel to the hole, the rock highly feldspathic with glomeroporphyritic seriate feldspar up to 3 mm., which continues to 433, when the Eastern sandstone begins. This is for two inches heavier, harder, more compact, but even in this the rounded

¹One set of seams at 39° with the hole and the other at 52°, also at right angles to each other.

(1, rarely 3 mm.) quartz grains are distinct, the color light to white banded, and by 455 it is white sugary quartz, with occasional flesh colored feldspar and little cement.

This may be represented by d 4. 629-677 but that is not an independent flow. Both in d 5 and d 4, toward the bottom, approaching the Eastern sandstone the beds are more disturbed and harder to make out. Lake d 9 below 95 is feldspathic to 130, where it is epidotic and calcitic. Thus in hole 7 the section hardly goes below Bed 8. On the other hand going east across country we seem to have a longer section.

9. Melaphyre? (70)

Between the bottom of Hole 9 which seems to be near the bottom of a flow and the conglomerate east of it there is according to the cross-section room for 80 feet of trap.

Total from hanging of lode to conglomerate - - - - (371) ft.,
from beginning of rock in d 5. - - - - (713) feet.

10. Conglomerate, running N. 6° E. for several hundred 10+ feet at a horizontal distance of 550 feet from the hanging of the lode. The apparent strike varies from 5° to 10° N. of E. and the dip from 45° to 48°. Its thickness can not well be less than 10 feet.

11-14. Covered for a horizontal distance of 700' (490)

15. Conglomerate exposed on creek and in pits and trenches, possibly a faulted repetition of 10. (40 to 140)

Strike N. 12° E. Dip 28°.

16. Ophite (100) (240)

Amygdaloid on creek

Trap 3 mm. ophite.

17. Amygdaloid (100) (340)

Trap 3 mm. ophite last on creek in Section 32, T. 51 R. 37 before Eastern sandstone.

To the northwest of the Lake property in Section 25, T. 51, R. 38, and important in determining the horizon, are heavy ophites with coarse grain found around the Toltec shafts. Compare the belt on which the Powder House stands north of the National mine sandstone in Rockland. Still farther north in Secs. 19 and 24, T. 51, R. 37, and also in Sec. 33, T. 51 N., R. 38 W. is felsite, about 8660 feet from Hole 1,—at a 41° dip about (5700) feet of thickness. This felsite like that in Sec. 9, T. 50, R. 39, just north of Rockland and on Section 17, T. 57, R. 37, is close under the Great conglomerate and Eagle River groups extensively exposed in Section 24, T. 51 N., R. 38 W., and must be high in the series.

But if the conglomerate in Lake Hole 1 is No. 8 as A. H. Meuche thinks, with weighty reasons, the section, as compared with the Winona, must be (about 6181 as against about 3869) very much thicker, over 2000 feet. A correlation of the National sandstone and Minnesota conglomerate with 8 and 6 I was once inclined to favor. To accept this other correlation is to assume that the section is thickening mightily or that a slide fault has cut a good bit out of the Winona section, or that an upheaval fault like that of the Porcupines and the great Keweenaw fault has repeated the section here. There is, to be sure, a cross-fissure going just a little west of the gap through which the road goes, but there is but little displacement as the correlations show. I do not think we can here possibly depend on cross-fissures to help out the difficulty, but there are indications

of strike faults. If it is near an old volcanic focus, with felsite intrusions, we may expect some part of the section to thicken.

On the other hand, in crossing faults there is a gap in our correlations and there remains, *so far as the sediments are concerned*, a possibility that the National and Minnesota beds correspond to No. 8 and 6 and that the conglomerate beneath the Evergreen bluff which is an almost continuous scarp from the Lake to the Michigan mines, may be lower beds or the same beds repeated. Above Conglomerate 8, however, there is not so marked an ophitic texture as above the National sandstone.

The "Aztec" in the west half of Section 31 is now the South Lake. It is drilling south of the bluff. An 1864 record (File 15-14) of the bluff gives a dip of 45° and an adit 408 feet long exposing (amygdaloid) lodes at 85 A (60)

137 B + (30)
280 to 295 ft. + (100)

The profile indicates these lodes at the surface and also two others, one (70) and the other (Hilton) higher¹ (95)

§ 25. ADVENTURE (Fig. 52 and Plates XIII and XIV.)

The Adventure is separated from the Lake by the west half of Section 31, T. 51, R. 37 where the "Aztec" (now South Lake) property lies. The continuous bluff exposures, broken only by short gaps, enable us along here to locate more definitely cross-fissures which displace the formation slightly. The Conglomerate No. 15 of the Adventure section is without question also the first of those of the Lake property.

The maps show the general course of copper beds, and the Nonesuch sandstone and conglomerates are exposed just off Plate XIV, north of Greenland, about 1,500 paces north of the northeast corner of Sec. 27, T. 51, R. 38 in Sec. 22 where a conglomerate is extensively exposed along the 560-foot shore line and is underlain by a dark basic sandstone which dips 11° to 23° to N. 25° W. This is about 12,300 feet (8,200) feet or less above the coarse ophites at the Toltec mine and the exposures are not continuous enough to warrant a section.

Adventure Cross-section. Holes 2, 3 and 4 are from the Knowlton vein running up at an angle of 23°, 30° and 27° respectively.

Hole 5 is from the foot of the Evergreen about 800' horizontally under Shaft No. 3 on the Knowlton vein, pointed down at 46°.

Holes 6 and 7 start close under Conglomerate 8, the Winona at the same angle.

Hole 1 is near the extreme S. E. corner of Sec. 36 at an average angle of about 65°.

The dip of the formation is supposed to be 44° and the direction to N. 10° W.

In order to make a continuous section Hole 2 is taken in reverse order from the farthest end, then the mine section, then Hole 5, are given.

¹Very extensive drilling on the South Lake has been conducted since 1909, roughly similar to Adventure holes 5, 6 and 7. See appendix.

Hole 6 supplements Hole 5, while 7 parallels part of it. Hole 1 continues the section S.

Adventure drill hole 2. From the 13th level of No. 3 shaft at right angles to the strike and up 23°; the dip of the formation being 44°, we must reduce thickness along the hole by $\cos(44+23)=67^\circ=0.92$.

1. Feldspathic ophite d 2. 430-527+ (92+)

At the end the augite has 2-3 mm. mottles, the olivine (altered) and feldspar about 1 mm. each. About 494 it is slightly amygdaloid,—I think, however, a narrow streak,—below at 466 it has more of the porphyritic character, the 1 mm. green feldspar standing out on a red ground, it is more or less speckled and the olivine more conspicuous.

The seams near 430 at 12° to 15° to the core are presumably at about right angles to the dip following columnar jointing. This is of the same type as 57.

2. Feldspathic melaphyre d 2. 318-430 (104)

Amygdaloid from 417-430, and speckled beneath.

Above the base the brown altered olivine specks (1-2 mm.) are conspicuous; the feldspar varies from 0.4 to 1 mm. There are chloritic seams at 15° to core, others at 70°, and amygdaloid seams at 56° roughly parallel to the dip.

3. Feldspathic melaphyre d 2. 275-318 (40)

Epidotic (altered amygdaloid ? 304-318). About 280-290 fine grained with feldspar somewhat glomeroporphyritic in appearance.

4. Melaphyre 2,217 d 2. -275 (58)
3,215 d 2. -258+

This is brecciated with calcite and epidote seams and seamed at about 34° to core. This is also entered in Adventure No. 3 from 215 ft., where it has the characteristic base of this group, in which 1 mm. green feldspars look porphyritic on the red ground. In Adventure No. 4 the altered olivine is given as 2 mm; the feldspar as 0.6 mm.

5. Feldspathic melaphyre with a sometimes *copper* bearing amygdaloid at top Adventure 2,0 d 2. -217 (200)

3,0 -215
4,0 -217

At bottom a hard fine grained trap, the 4 feet of 2" core take a fine polish; size of feldspar 0.4 mm; altered olivine 1-2 mm; feldspar about 153, 1-2 mm. Amygdaloid inclusions begin about 173; *copper* at 192 near base of amygdaloid, epidotic and calcitic to 205; from 205 to 225 more of a brecciated trap separate flow?

Chloritic joints at 15° to 29° with core.

In Adventure No. 3 we have the same type; size of olivine and feldspar about 1 mm., very faint; augite mottling at 113 (109) feet up 2-5 mm. across?, the amygdaloid more conspicuous at 178 (170) with calcite and epidote seams, and at 186-190 brecciated.

In Adventure No. 4 I estimated the size of altered olivine as 1 mm. at 46, 1-2 mm. at 89; the feldspar as only 0.4 mm. at 0-46 ft. There is less amygdaloid in this hole, though it is brecciated about 217.

A regular ophite of this size should have a well-marked mottling more than 7 mm. across.

Hole 3, at right angles to the strike of the vein, at an angle of 30° up from the 12th level, 400' E. of No. 3 shaft has had the record given in connection with No. 2.

Hole 4, also at right angles to the strike of vein and at an angle of 27° up from the 12th level, 100' W. of No. 3 shaft has also been recorded.

In the Mine, the following amygdaloid tops or "lodes" are exposed.

6. Knowlton lode and foot trap	60 ft.	say (42)
7. Merchant's lode (51) and foot trap	55 ft.	say (39)
8. Mass lode (50) and foot trap	110 ft.	say (77)
9. N. Butler (70) and foot trap	160 ft.	say (102)
10. Butler (10 to 12) and foot trap	100 ft.	say (70)
11. Ogemaw (?) and foot trap hanging of Evergreen Lode	300	(210)
	785	540

to Evergreen foot 800 (560)

This feldspathic ophite group also appears in the bluffs, all along, but rarely shows luster mottling distinctly.

Adventure drill hole 5. Begins going down from the Evergreen lode on the 6th level about under this shaft, and 800' horizontally from it, at a dip of 46°, (i. e., perpendicular to formation). It is thus similar in position to Lake No. 2.

12. Evergreen lode and foot, Feldspathic trap Adv. d 5. 0-40 (60)
2 Lake d 2. 34-185 (83)

A fine grained red feldspathic trap with small amygdules all along.

13. Amygdaloid melaphyre Adv. d 5. 40-108 (68?)
3 & 4 Lake d 2 185-257 (71)

White, very abundant amygdules to 43 then epidotic and calcitic to 49, then a fine grained trap -82, then slightly amygdaloid with epidote and calcite to 82 corresponding to Lake d 2 at 234, then more massive, faintly ophitic at 105.

14. Feldspathic ophite (7 mm.) Adv. d 5. 108-375 (267)
5 & 6 Lake 257-531 (274)

The amygdules are large white ones 10 mm., and it is either red and white or has an epidotic yellow-gray base. The mottling is rather faint, but appears to have a grain at

152, 155, 170, 182, 195, 200, 205, 210, 217, 225, 228 feet about
2, 3, 6-4, 5-6, 7-8, 5-7, 5-8, 4-5, 2-3, 2, 1 mm. respectively.

At 233 it is specked with epidote and spots of amygdaloid but there was no marked contact and it remains trap to the end. The peculiar faintness and variation in grain is repeated at the Victoria 480-183 and Lake properties. The plagioclase feldspar is less than 1 mm. long.

15. Conglomerate underlaid by brown sandstone. Probably No. 8.

The Caledonia, Winona, probably Forest, etc., one of our chief stratigraphic horizons. It will be noted that there is no conglomerate above it for at least 1300 feet and that the beds in that interval are not well-defined ophites, whereas in the thousand feet under it sandstones, ophites, and amygdaloid conglomerates are more abundant.

- Adventure d 5. 375-419 (44)+
7 Lake No. 2 conglomerate 531-571 sandstone -611 (78)
Just above Mass No. 5. (Cf. No. 3 at 450.)

The top has an epidotic cement with trap and felsite pebbles and many calcite seams. The seams make angles of 20° and 56° with the core. The bed soon changes to sandstone which seems to have fine dips at 50° and at 56° and 58° to 45° with the core. This would mean that it was nearly vertical or horizontal. Seams nearly parallel to the core, probably vertical, are faulted by others more nearly across the core toward the acute angles (reverse faults). It would seem that the west or southwest side is thrown down or to the southeast, and the unusual thinness here as compared with the other places is also probably due to loss on the seams which make it appear to dip at such an angle to the core instead of at right angles as the formation does normally, and the sandstones below.

16. Feldspathic melaphyre Adv. d 5. 419-543 (124)
Lake 2 611-718 (104)

A very little amygdaloid -428, quite a little disturbed with clay slips, etc., which may have cut out part of it. There is copper in this amygdaloid at the Lake. Then massive feldspathic trap (2-3 mm. feldspar as at the Lake), somewhat speckled and finer looking to 543. The Lake does not match well below this.

17. Feldspathic melaphyre Adv. d 5. 543-593 (50)

The amygdaloid is much altered into angular flecks, and the trap is fine in appearance (down to 562, beyond which is all sludge for a ways). Then dark chloritic with bare suggestions of 1 to 2 mm. mottles. The seams at 67° and at 8° to the core are conspicuous. The latter may be parallel to the fissure that runs north near by.

18. Feldspathic melaphyre Adv. d 5. 593-661 (72)
9 & 10 Lake 2. 748-810 (68)

Amygdaloid poor with large angular amygdale forms like that at 543 to 597.

The trap is very light colored in the core, coarse looking; altered olivine is 1-2 mm; feldspar 1-2 mm; iron oxide 1-2 mm; augite does not show well up to 2-3 mm. probably. At 661 an epidotic sandstone dipping apparently 67° against core and charged with copper, may be a clasolitic seam, or be faulted in. There are pronounced seams at 26° to core and the trap the other side looks dark chloritic and mottled 1-2 mm. The very base just above the sandstone is charged with copper. The contact dips about 59° with hole.

19. Sandstone and trap mixed. Adv. d 5. 661-679 (18)
(Cf. 9 Lake 718-742), 11 Lake 810-873

The sandstone is yellowish, epidotic, appears to dip against core 68°, and contains copper. It may be a clasolitic seam, since pieces occur to 679, and it is not found at this horizon at the Mass or Lake mines.

20. Feldspathic ophite (2 mm.). Adv. d 5. 679?-710 41
11 Lake 2 810-873

There are pronounced seams and no amygdaloid at the top, samples of sandstone and trap are mixed together. It is dark, chloritic, and has 1-2 mm. mottles about 695.

21. Brown sandstone and conglomerate Conglomerate 6 Adv. d 5. 710-784(74)
d 6. 56-161(105)
d 7. 290
87C-

The dip is practically perpendicular to the hole, Lake 2 making an angle of from 78° to 82° with it, that is what should be expected. It is mainly a dark brown sandstone. The pebbles which occasionally occur are vari-colored brown mottled, buff, red felsite and amygdaloid. The conglomerate is largely sandy,—the cement at times epidotic.

The gradual passage to a very unusually pumiceous amygdaloid, while it is liable to be local, seems as a matter of fact to be fairly persistent, being the same also apparently in Holes 6 at 161 down; 7. 174-182. Victoria specimens 1128-1131 feet (?). Cf. Mass 5. 350 ft.

It looks as though the underlying amygdaloid had flowed while the sandstone was forming and wet. In No. 6 this begins at 54 ft. as an amygdaloid conglomerate, then there is a shale with fine bedding within 4° of being at right angles to core, at top black as the Nonesuch, then red, with chlorite on joints and *copper* in a slightly coarser seam, has streaks of green basic sandstone and conglomerate, felsitic conglomerate; there is *copper* also in a pebble at 88 ft.

- 21a. The real unit of thickness should probably be 21, 22 and 23 which is 137 ft. in Adv. d 5; 166 ft. in Adv. d 6; 156 ft. in Adv. d 7; 147 at the Mass; 142 (Beds 16, 17, 18) in the Victoria cross-cut, as the amount and position of the pumiceous melaphyre is rather variable. The black chloritic shale top appears also to be quite persistent, and the tendency to specks of copper. This gives also a thickness comparable to (235) feet of the conglomerate No. 6 at the top of Winona d 13.

22. Pumiceous melaphyre Adv. d 5. 784-824 (40)
Copper at 808 ft. This is more or less amygdaloidal throughout and at times pumiceous, a regular froth of amygdules.
Cf. Victoria mine cross-cut at 1131 feet.
23. *Brown sandstone*, passing into amygdaloidal conglomerate Adv. d 5. 824-847 (23)

Epidotic to 830, then a deep brown sandstone much jointed and with clay seams dipping 45° to 54° against core.

This is evidently closely affiliated with the sandstone just above, the pumice being a mere interlude, but sufficient probably to show that these beds 710-847 are not a repetition by faulting either of the sandstone just above or that at 1350 to 1458.

Cf. N. Lake 3 at 550

24. Ophite 3 mm. Adv. d 5. 847-932 (85)
d 6. 222-302 (80)
d 7. 231-327 (96)
Mass. d 5. 353-421 (68)
Victoria 19. (98)

The amygdaloid is mainly represented by the amygdaloid conglomerates above. The augite grain at:

875, 882, 892, 899, 908, 915, 922, *932 feet is respectively
2, 3-4, 2-3, 3, 2, 1-2, 1, $\frac{3}{4}$ mm.

The rate of increase A is about 1 mm. in 16 ft.

The maximum grain 3-4 mm. at d 6. 257 and 3 to 5 at d 7. 290 and 3-5 mm. at the Victoria, agrees well. Cf. also Winona d 13. 62-150. The shale above has probably saved it from disturbance.

25. Ophite, 7 mm. Adv. d 5. 932-1035+ (103+37?)
cf. d 6. 302-400
d 7. 327-403
Mass. d 5. 421-491+
Victoria 20. (106)

Amygdaloid epidotic brecciated 932-940

There are some specks of amygdaloid at 960.

The augite grain at:

960, 965, 980, 1005, 1010 feet is respectively
2-3, 3, 4-6, 7, 3-4 mm.

At 990 it is epidotic seamed, at 1010 yet more seamed, and at 1021 full of laumontitic seams at 12°, 23°, 78° with core, and all the way to 1035, at which point are two feet of epidote. It seems quite probable that part of the bed is faulted out if a yet more important fault does not occur. The grain reaches 7 mm. also at the Victoria, but in Holes 6 and 7 and at the Mass 5 not over 5 mm. are noted. In all the holes signs of disturbances, laumontitic seams, are noted. In this hole there is no bottom contact, but beyond 1035 the grain begins to increase again. If we assume the coarsest grain at 1005 was near the middle, or the rate of increase to it symmetrical, then 40 ft. below should be 2 mm. like 40 ft. above and we should allow at least 30 ft. to the contact, which would make about (140) feet thickness, which it most probably originally was.

But, of course, the same slipping *may* have wiped out any amount more from the section, not represented in 5.

26. Ophite 5 mm. Adv. d 5. 1035-1150 (115+15)
d 6. 400-517 (117)
d 7. 403-473+

The augite grain is at:

1053, 1069, 1077, 1085, 1100, 1126, 1135+
1-2, 2, 4, 3, 4-5, 4, 2, 1-

The rate of increase A is hardly worth computing, the rate is so irregular. This ophite has lost its amygdaloid, and is somewhat irregular in grain; there seems possibly, however, to be some repetition by faulting; a 5 mm. ophite is usually about 100 ft. thick. Part of this should perhaps be credited to No. 25.

Adventure d 6. 400-517 is also a 4-5 mm. ophite, d 7. 403-473 also reaches 3-5 mm; so faintly does Mass d 5. 530-688 perhaps but really the Mass correlations seem to stop with seams that cut Mass d 5. 493 at 35° to 45° with core, probably nearly vertical.

27. Ophite 5-6 mm. Adv. d 5. 1150-1262 (112)
d 6. 517-627 110

Epidote 1150-1160; then fine grained trap and epidote to 1169; then 2 mm. ophite and amygdaloid inclusions to 1176.

The augite grains at:

1176, 1182, 1192, 1204, 1212, 1235, 1244 feet shows mottles respectively
about 2, 2, 4, 5-6, 5, 2-3, 2 mm.

The maximum grain (5-6) and rate of increase A 1 mm. in 11 ft. are quite normal. Adv. d 6. 517-627 is about the same size, but the grain was not estimated quite so coarse (4 mm. at 579). The Mass has mottling like it in 5.

28. Ophite (2-3 mm. or 4 mm.?)
 Adv. d 5. 1262-1350 (88)
 d 6. 627-716 (89)
 Brecciated and epidotic amygdaloid, the so-called "Adventure No. 1"
 lode, fine grained to 1265
 Gray epidotic to 1275
 Then epidote, quartz, copper?
 The augite grain at 1295, 1331, 1348 shows mottles respectively
 1-2, 2-3, 1-2 mm.
 There are seams (tending to gape!) at 45°, 26°, etc., with the core at 1348.
 Adventure 6 while about the same thickness has coarser and more normal grain noted, 3-5 at 681, 3-4 mm. at 686. Faulting or inaccurate observation may account for this.
29. Sandstone and amygdaloid conglomerate; Conglomerate 5?
 Adv. d 5. 1350-1410 or -1439 (60) and (29) (89)
 d 6. 716-813 (97)
 This is massive, more so than the sandstone beds above, with long cores and dips almost at right angles to the core (7° off); no conglomerate, but felsite and hematite granules with calcite and laumontite cement, seamed at 20°, 12° etc., to the core. The transition to amygdaloid conglomerate is very gradual, the amygdaloid fragments appearing one by one. This is not unlike No. 23 at d 5. 824-827. From 1428-1434 appears to be a well-marked trap, but there are seams at 26° to hole and since there is no amygdaloid and this is pretty thin for a trap, and the thickness agrees better by counting it as a mere block and the amygdaloid conglomerate below as a continuation of the bed, we do so.
 Mass 5 does not show this unless it is that below Mass d 5. 1391, which would imply something like a 500 ft. fault between the top and bottom of this hole or that.
30. Ophite 4 mm. Adv. d 5. 1439-1529 (90)
 d 6. 813-900 (87)
 The trap has amygdaloid inclusions every few feet to 1528 feet. The augite grain at:
 1465, 1473, 1477, 1488, 1501, 1509, 1518, 1520, 1525 ft. shows mottles respectively
 2-3, 3, 2, 3, 3-4, 4, 1-2, 1, 0.5 mm.,—
 though at about 1518 ft. there is a range of 1 mm. grain to 4 mm. grain in the same piece in alternate bands. It is much jointed about 22° to core along 1501-1518 feet.
31. The amygdaloid conglomerate in Adv. 6, is not shown so clearly in 5.
32. Ophite? Adv. d 5. 1529-1619? (90)
 Down to 1550 epidotic amygdaloid, then fine grained, dark, chloritic slickensided (at 31° to hole) trap, 1-2 mm. in grain. Adv. d 6. from 900-913 intercalates an amygdaloid conglomerate (Belt 31) but at 948-954 is also about 1-2 mm. in grain.

Adventure drill hole 6. Parallels 5 pretty closely. It is drilled from the surface on the E. side of the Adventure gap near the Copper Range R. R. and just below an outcrop of the Caledonia conglomerate, Belt 15 Adv. above.

¹It does not look like an intrusion.

20. Feldspathic ophite Adv. d 6. 1-54+ (54)
 Amygdaloidal, almost amygdaloid conglomerate 51-53
 Gray, massive, fine grained trap.
21. { Sandstone and conglomerate (No. 6) and
 22. { Pumiceous amygdaloid Adv. d 6. 54-222 (168)
 23. { Black chloritic shales, chlorite on joints 1 foot
 A 2 mm. coarser seam charged with copper red shale within 4° of perpendicular to core for 20 ft.; then basic green sandstone and amygdaloid conglomerate of greenish gray amygdaloid and white amygdules, with a grayish green sandy matrix.
 At about 78 amygdaloid, or green and white red bordered ones to 84. Then felsitic conglomerate with inch pebbles, and epidote and calcite cement, green basic sandstone, and one block of trap a foot long, occasionally a calcite and prehnite cement, and in one case a pebble is impregnated with copper. Then mainly brown sandstone whose dip is nearly perpendicular to core, varying at times as much as 22° from it but oftener 12°-7°. From 161 shading into amygdaloid, apparently alternate streaks of sandstone and amygdaloid conglomerate; between that and 198 is No. 23 a well-marked amygdaloid (which however shows 1 mm. mottles) with a markedly pumiceous base, dip about 20° to core; then a dark sandstone with a speck of copper, then gray epidotic sandstone, then red with gray streaks, full of epidote and red sand grains. At 211 a marbled brown mud often found near the base, then amygdaloid conglomerate bedded almost perpendicular (within 5°) to the core, i. e., dipping 40° to 50°, but jointed at about 59° to core. This passes into an amygdaloid conglomerate with black and white amygdaloid scoria, and a matrix of gray epidotic sandstone or red mud down to 222 ft.
24. Ophite 3-4 mm. Adv. d 6. 222-302 (80)
 Amygdaloid 222-224; epidote and copper at 232. The luster mottled flashes have less size than the mottles brought out in the drill core pattern. The latter are at:
 227-229, 232, 242, 245, 251, 257, 268, 275, 274, 289, 292, 298 ft.
 1, 1.5, 2, 2-3, 3, 3-4, 3, 2-3, 3, 2-3, 1-2, 0.5 mm.
 The rate of increase A is about 1 mm. in 17 ft. from the bottom; 1 mm. in 13 ft. from above. Laumontite veins at 292 running at 68° with core.
25. Ophite 3-4 mm. Adv. d 6. 302-400 (98)
 There is a trace of amygdaloid conglomerate at top, then black and white amygdaloid to 308, then a foot of epidote; beneath it is specked and fine grained with many chlorite slips as far as 321, and there are numerous bomb-like inclusions of amygdaloid below. The augite grains at:
 321, 329, 359, 392 feet are respectively
 1-2, 2-3, 3-4, 1½ mm.
26. Ophite 5 mm. with banded mottling. (117)
 Adv. d 6. 400-517
 Marked amygdaloid 400-405. The trap is epidotic, gray and specked beneath, and even the ophitic pattern is brought out in yellow mottles, the size of the mottles varying much in flow bands. This feature seems to be characteristic of this flow; also in Adv. d 5 etc. The increase A from the bottom is about 1 mm. in 10 ft. The mottles at 414 ft. are 2 mm; then finer to ½ mm; then coarser in flow bands up to 2-3 mm. at 414 feet. The mottles are at:

- 422, 425, 450, 460, 470, 477, 486, 495, 502, 507, 510, 515 ft.
3, 1-2, 3, 4, 4-5, 3, 2.5, 1.5, 1-2, 1, 1-0.5 mm.
27. Ophite 4 mm. Adv. d 6. 517-627 (110)
Cf. Mass d 1. 198-329 *poor match*
The amygdaloid is epidotic and brecciated. The trap is epidotic at 542. The augite grains at:
535, 537, 551, 562, 568, 572, 579, 582, 601, 613, 625 ft. gives mottles about
1, 1-2, 2, 2-3, 3, 3-4, 4, 3, 3, 1-2, 1-0.5 mm, respectively
The rate of increase A is low; from above about 1 mm. in 13 ft.; from below 1 mm. in 20 ft.; at about 613 are seams parallel to core, at 39° and at 68°, often with pink Jaumontite.
28. Ophite 4 mm. Adv. d 6. 627-716 (89)
Cf. Mass d 1. 329-394 *rather poor*
There is really about 2 ft. of amygdaloid conglomerate at the top and down to 640 there is strongly brecciated and epidotic amygdaloid, and there is 2 ft. of amygdaloid at the base. The grain at:
640, 650, 656, 662, 672, 681, 686, 692, 699, 707 ft. shows mottles respectively
2, ½-2?, 2.5, 2-3, 2-3, 3-5, 3-4, 2-3, 2, 0.5 mm.
A large amygdule has calcite center and heavy chlorite border surrounded by little parallel lines of iron oxide in the rock around, like water lines.
29. Sandstone Adv. d 6. 716-760 (44)
Amygdaloid conglomerate 760-813 (53) (97)
Cf. Mass d 1. 398-430
The sandstone has characteristic, even long cores almost at right angles to the hole varying not over 9°. The jointing at 34° to the core is probably about vertical. It is not disturbed in appearance, and the very gradual transition to amygdaloid conglomerate exactly as in Adventure d 5 seems characteristic. The total thickness is the same. There is some resemblance to 21 and 23, but for one thing the associated traps are much more ophitic, augitic.—Cf. also the sandstones in Mass d 5. between 1391 and 1591
and Mass d 1. 394-430
30. Ophite 4 mm. Adv. d 6. 813-900 (87)
d 5. 1439-1529 (90)
Cf. Mass d 1. 430-443
Amygdaloid 813-827
The augite grain at:
827, 848, 858, 870, 895, 900 feet shows mottles respectively
0.5, 2-3, 2-4, 4, 2, 0.2 mm.
A is about 1 mm. in 11 ft.
31. Amygdaloid conglomerate Adv. d 6. 900-913+23 (35?)
Very epidotic, pumiceous, most of the matrix yellow. The scoria of amygdaloid are dark slate color with white amygdules.
32. Ophite (1-2 mm.) Adv. d 6. 940-961? 21+
The augite grain at 940, 948, 954+ shows mottles respectively 0.2, 1-2, 1-2, finer
The amygdaloid at the top is merged in the amygdaloid conglomerate and there seems to be a seam at 961 ft.

33. Amygdaloid conglomerate and sandstone Adv. d 6. 961-996 (35)
This begins with amygdaloid conglomerate, with sparse scoria passing into brown and epidotic sandstone bedded at nearly 90° to core (more than 83°) down to 967; then almost wholly epidotic sandstone to 997; then to 985 is a pumiceous amygdaloid, and pumiceous amygdaloid conglomerate continues to 996. This is a bed of the same type as 21 to 23, but not nearly as thick, and not in the same association. In the Atlantic Section 16 and other similar cross-cuts amygdaloidal conglomerates occur at several levels under Conglomerate 6.
Cf. Mass d 5. 1543-1591
d 1. 443-478
34. Ophite, small. Adv. d 6. 996-1003 (7)
Part is no doubt represented in the amygdaloid conglomerate, but *the mottling is minute, characteristically so.* See Mass, bed 70.
35. Ophite 5 mm.+ Adv. d 6. 1003-1142 (139)
Well-marked amygdaloid 1003-1015.
The augite grain at:
1021, am. spots, 1045, 1053, 1065, 1068, 1078, 1083, 1093, 1117,
1-2, 0.5, 1, 2-4, 3-4, 5, 4, 4-5, 5,¹ 4,
1127, 1132, 1138 ft.
3, 2, 1 mm.
The rate of increase A from below is somewhere about 1 mm. in 10 ft.; the upper 40 ft. are quite irregular the mottles being only ½ mm. near amygdaloid spots. There are also seams about across the core at 75° to it. Toward the base there are dark gaping, partly chloritic filled seams.
35. Amygdaloid conglomerate Adv. d 6. 1143-1172 (30)
Black and white amygdaloid scoria and red mud cement to 1150, then the matrix is more yellowish and epidotic. Different kinds of amygdaloid and blocks of trap may be recognized.
36. Ophite 5 mm. Adv. d 6. 1172-1240 (68)+(40)
Amygdaloid replaced by the conglomerate above. It is epidotic at top and at 1198. It looks weathered and cracked. The mottling is yellow and shows its nearness to a fault. The augite grain at:
1172, 1178, 1187, 1198, 1208, 1226 feet shows mottles respectively
0.5, 1-2, 2, 2½, 3-4, 5 mm.
The so-called "First Adventure lode" 1252-1288
At this point, Adv. 6. 1240 there is plainly a fault. It *may* only have cut a few feet from the core, but it is probably more important, judging from the jumbled condition of the samples on the south side certainly clear to 1379.
Mass No. 5 between 290 and 491 (the latter apparently the main slip) is full of seams and slips, and therefore Mass. No. 5 can not be correlated. The Mass 5 hole is at 70° and the seams are from 35° to 59° against the core which would mean a possible dip of about 65° to the north. This hole dips 46°. The dip of the sandstone beneath seems nearly parallel to the core at only 20° from it, while the faulting or seams and joints appear to be at right angles to this dip. It is a question whether the apparent dip is not a mere pressure or shearing cleavage. At any rate the abnormal condition is plain. I am inclined to believe that a large strike

¹Spots on core, reflections in sun about 3 mm., 5-7 mm., from center to center of next.

fault runs near Mass d 5. 491 and Adv. d 6. 1240. The division of the remainder of Hole 6 for 200 ft. into belts is quite uncertain and even more so their distance from the beds above; the ophites below are brown, weathered looking with light gray mottles and have a different aspect from those above.

38. Sandstone Adv. d 6. 1240-1243 and amygdaloid conglomerate 1243-1265 (15)
Cf. belt 33.
39. Ophite, broken up, feldspathic 1-2 mm? Adv. d 6. 1265-1325 (60)
No amygdaloid separable from the bed above. The augite mottles at 1269 ft. are 1-2 mm; at 1282 and 1287 it is a speckled fine grained trap; at 1297 is another seam parallel to the core; at 1305 it is trap and at 1315 the grain is 1-2 mm.
40. Feldspathic melaphyre Adv. d 6. 1325-1403 (78)
At 1325 is an epidote and calcite amygdaloid, immediately beneath the trap is seamed at 12° to the core, and the feldspar stands out porphyritically (1 mm. or so) greenish from the red matrix and to 1356 it is a feldspathic melaphyre with 1 mm. feldspars, no mottling. At 1368 there is possibly a fault; 2-3 mm. mottling; near 1379 to 1386 it is much fissured with laumontite joints.
41. Ophite 5 mm. Adv. d 6. 1403-1497 (94)
There is epidote and amygdaloid 1403 to 1410, then fine grained and speckled to 1421, somewhat amygdaloidal to 1424, then mottled. The augite grains at:
1437, 1446, 1456, 1458, 1480 ft. are respectively
2-3, 4-5, 5, 3-4, 2 mm.
Cf. belt 34.
42. Feldspathic ophite (3-5?) mm. Adv. d 6. 1497-1612 (115)
There is amygdaloid to 1502, perhaps further, and there are lots of slips and it is speckled and epidotic to 1521. The augite grain is at:
1541, 1553, 1571-1577, 1580, 1600, 1612 ft.
3-5, 3, 1-2, 2, 1-2, finer respectively
At 1612 feet is epidote seams at 64° come in which may produce faulting.
43. Feldspathic ophite 2 mm. Adv. d 6. 1612-1691 (79)
The grain at: 1628, 1638, 1652, 1671 ft. is respectively
1-2, 1-2, 2, 1 mm.
All the ophites along here are brown, weathered looking, with light gray ophitic mottling quite different in appearance from the rocks above 1240 ft.
44. At 1691 there is epidote and calcite and quite a little copper.
This is Adventure No. 2.
Adventure No. 3 is said to have been encountered about (300) feet geologically below in drilling done since.

Adventure drill hole 7 was on the east end of the Adventure bluff close to the gap, and about 75 feet lower than the shaft as well as farther south. The record at the time I looked over the cores was very closely parallel to 5 and 6, Beds 20 to 26.

20. Melaphyre, feldspathic, Adv. d 7. 5-75
Light, greenish gray, hard; feldspar laths less than 1 mm. long; occasional amygdaloid streaks across the core; iron oxides an alteration product from olivine; at 37-39 epidotic with disseminated copper.

21. Together seem as before to make up Conglomerate 6
23. Sandstone and conglomerate Adv. d 7. 75-170 (95)
Begins with one foot of dark shale as in Holes 5 and 6 passing into fine grained (less than 0.1 mm. largely) brown sandstone, whose bedding is practically directly (with 2 and 6) across the core; from 99 down there are streaks of conglomerate, and at times greenish beds and mud bands, near 165 a seam at about 29° to core (that is perhaps about vertical) faults the bedding normally (toward the acute angle)
22. Pumiceous amygdaloid and ophite Adv. 7. 170-213 (43)
Amygdaloid d 7. 170-192
Very pumiceous at first, then from 182-188 a common brown amygdaloid with white amygdules; then to 192 a lot of small amygdules come in.
Trap d 7. 192-211
Speckled 1 to 2 mm. ophite.
Bottom amygdaloid d 7. 211-213
In thickness and peculiarly amygdaloid character this matches the other holes so well we may be sure it is not accidental, and I think we may infer that it flowed into the rather shallow water (lake or desert pool) in which Conglomerate 6 was laid down just here. This was perhaps in the center of a desert basin ("bolson") and the mud bands and black shale tops suggest the same explanation. Bed 16 of the Victoria section must have been formed under similar circumstances and may very well be the same bed. Mass d 5. 358-376 may be equivalent.
23. Sandstone and amygdaloid conglomerate Adv. 7. 213-226 (13)
Mainly sandstone, with numerous slickenside seams at 59° to the core; toward the base gray and epidotic, and at the very base a foot of amygdaloid conglomerate occurred.
24. Ophite 2 to 5 mm. Adv. d 7. 226-316 (90)
Amygdaloid d 7. 226-231
Black and white
Trap d 7. 231-316?
Speckled and epidotic at top; between 231 and 290 gaping chloritic veins. The grain at
231, 252, 265, 277, 290, 305, 307, 311 feet shows
1-2, 2-3, 3, 3, 2-5, 2, 1-2, 1 mm.
mottles respectively, then there is a fine grained epidotic band.
25. Ophite 5 mm. Adv. d 7. 311-403 (87)
The upper amygdaloid is obscured in an epidotic band, but between 327 and 329 is plainly amygdaloid and there are also chloritic amygdaloid spots near 337. The grain at:
337, 338, 346, 352, 358, 363, 375-382, 392, 398, 403 feet shows
1-2, 2-3, 5x3, 3, 3-5, 5, 3, 2-3, 2, 1-2 mm.
mottles respectively. Near 352 are laumontite seams at about 45° to the core.
26. Ophite 5 mm? Adv. d 7. 403-473 (100)
Amygdaloid d 7. 403-415
Brecciated, epidotic for 3 feet, then black and white but in streaks still brecciated and epidotic to 415 ft.
Trap d 7. 415-473

At 420-421 and again near 430 it is gray and epidotic. The grain at:
 426, 431, 440-449, 461 feet shows
 1, 1-2, 2, 3-5 mm. mottles respectively.
 At 461 are seams at about 40° to the core.

Adventure drill hole 1. Near 200 N. of S. E. cor. Sec. 36, T. 51 N., R. 38 W. about 2900 ft. S. of Evergreen lode, i. e., at 44° (2000) ft. beneath it. Dips towards S. 10° E. at an angle of 70° at the beginning, flattening to 60, say on an average 65°. If the formation dips 44°, this would make it cut it at an angle of 71° and at the beginning 66°. Observations on the sandstone at 779 ft. suggest that it cuts it at an angle of (tan⁻¹ 5:2) 68°, which is in agreement. If to get true thickness we multiply by 0.93 we shall not be far wrong. This begins in the same kinds of beds that No. 6 is in at 1691 and were it not for faulting and difference in elevation would probably lap. There were 384 ft. of overburden in No. 1. Its elevation is close to 438 above Lake Superior. 1040 A. T.

- 48? Feldspathic ophite (5 mm.). Adv. d 1. 385-572=187 (174?)
 Much seamed at 7° (veins) 32° conspicuous, nearly vertical? 24.5° to 45°, and veined also at 64.5° to core, parallel to bedding. The augite grain at:
 395, 472, 506 feet is respectively
 2, 3-5, 5 mm.
 between 472 and 506 the seams at 24° and 36° at right angles to others at 64° probably represent the columnar jointing.
49. Melaphyre. Adv. d 1. 572-620=25 (48)
 Dark amygdaloid with white amygdules to 576, harder and gray to 581, redder, decomposed; the seams at 20° to 24° and amygdaloid bands at 24° to 36° with core, very conspicuous and at 606 broken up and veined with calcite. About 620 very fine grained.
50. Feldspathic melaphyre. Adv. d 1. 620-704 (78)
 Amygdaloid conglomerate, a little perhaps near 620. A sludge near 669, therefore more trap. In one case the seams at 64° to the core are faulted by those at 26°, *the southerly side being thrown down*, if we assume that the 64° seams are really parallel to the bedding. The bed is much veined, specked and disturbed.
 49 & 50 are bunched by Meuche quite naturally and perhaps correctly.
51. Feldspathic melaphyre. Adv. d 1. 704-748=41 (38)
 There is a feldspathic amygdaloid with pink and white amygdules to 733, then there is a decomposed feldspathic trap which near 745 becomes finer grained and redder, leaving the feldspar more porphyritic in appearance. The seams at the top are at 20° and 52° to the core and nearly perpendicular. Near the base a set at 35° and 55° at right angles to each other are conspicuous.
52. Feldspathic melaphyre. Adv. d 1. 745-775=34 (32)
 There is a well-marked red and white amygdaloid to 761; it is then grayer and finer grained, veined (20°) trap to 771.
53. Sandstone and amygdaloid conglomerate. Adv. d 1. 779-866=87 (77)
 (Meuche 775-784, and then -934)
 Epidotized with specks of pyrite and laumontite passing into a brown sandstone at 783. White seams at 68°, but the dip appears to be steeper, at 59° to 52° against the core. It passes into a conglomerate of dark

amygdaloid fragments and red matrix. In one case lines of white bubbles in mud dip 52°, in another place dips from 35° down to 68° all against the core were noted. The dip from the horizontal is certainly not less than 42°. This is the same type of bed as 29, 33, 38 above, but the associated beds seem more feldspathic. They resemble the beds above Conglomerate 6.

54. Feldspathic ophite 4 mm. Adv. d 1. 866-994=128 (119)
 Somewhat amygdaloidal at first, specked and veined.
 Several times the seams more nearly perpendicular to the core at 56° to it and probably nearly parallel to the dip are faulted by seams more nearly parallel to the core at 38° or so to it, so that if we assume the latter to be more nearly vertical and the hole we remember plunges to the south, the S. side is thrown down, exactly as in Belt 50. By 902 it is rather massive, 2 mm. feldspar, and there appears a faint mottling. The grain at:
 945, 950, 959, 992, (970 Meuche) feet is perhaps
 3-4, 2-4, 3-5, 2-3, 4 mm.
 Toward the base joints are at 21.5° and 68.5° quite persistently, the latter probably parallel to the dip, i. e., at 46° to the horizon.
55. Amygdaloid conglomerate and brecciated amygdaloid. Adv. d 1. 994-1040=54 (50)
 There is only a little real amygdaloid conglomerate apparently. 54 & 55 bunched by Meuche.
56. Feldspathic ophite. Adv. d 1. 1040-1279=131 (122)
 Amygdaloid, black and white, with vein matter to 1059, then pink and white laumontite to 1106. Trap feldspathic and laumontitic with seams at 37°. At 1131-1138 and 1143 it is epidotic and slightly amygdaloid. The grain at 1204 is probably as coarse as 5 mm. Toward the base it is finer and altered brown olivine, 1-2 mm. conspicuous. The seams at 26°-29° are very well marked, also at 16°, 36°, 58°, 90°, etc.
57. Feldspathic melaphyre. Adv. d 1. 1279-1559=280 (260)
 The amygdaloid is well-marked maroon and white with calcite and laumontite to 1299; seams parallel to bedding at 59° and at right angles to it at 29° to the core. Under it it is epidote to 1314, specked and reddish 1316, epidotic to 1322; toward 1335 it begins to look fine grained red and porphyritic and epidotic. The 22° joints are prominent and there is faulting along them. The trap is slightly glomeroporphyritic with 1 mm. feldspar and not mottled toward the base, from 1507 down the brown altered olivine spots become more conspicuous. The joints at 22° respectively 31° and 59° are conspicuous. There are also seams at 15°. The seams at 59° to 51° appear to run with the dip. A bed not ophitic and so thick ought to be an identifiable horizon, or is the hole going through this formation quite obliquely?
58. Feldspathic melaphyre. Adv. d 1. 1559-1902=343 (321)
 Red and white amygdaloid brecciated to 1591, at base epidote and prehnite with copper perhaps; seams nearly parallel to (at 50° from) core; also at 16°, 31°, 41°, 45° and 51°. The trap below is fine grained feldspathic with chlorite blotches and laumontite seams.
 Seams at 18° to 22° are nearly parallel and at 75°. Those at about 15° and 75° occur more than once. The laumontite seams at 36° to core, about vertical, are quite frequent.

¹But see Appendix.

§ 26. MASS MINE. (Pl. XIV, Fig. 52.)¹

Immediately adjacent is the Mass mine, one of the oldest. Extensive exploration and mining have developed cross-fissures here as in the Michigan and Adventure. These are probably not exceptional. Merely more work has been done here. The map shows a sharp change in strike of the Knowlton and lower beds on this property comparable to that between the Baltic and Trimountain. So far as one can judge this does not equally affect the uppermost beds.² With a little intercalation of older data we have a complete section from above the National sandstone. There are numerous maps and plans of the working of this mine on the Survey files, which show particularly well the displacement on cross-fissures. One fissure runs across the formation, dips to the northeast and throws the northeast side to the northwest about 30 feet. Plate XV exaggerates it. (File 15-6.) Explorations have followed along the Evergreen bluffs, the "Ogima" and "Mass" lodes through Section 6 to the "Nebraska" lode (that is, the Butler) on Section 13 and a conglomerate, the "Nebraska" or "Caledonia" (No. 8) which is exposed in the Lake, Mass and Adventure drilling 1,100 feet southeast, outcrops on the side of the Flint Steel River in Section 12, T. 50 N., R. 39 W.

Here the bluffs overlook the profound pre-glacial transverse valley, largely filled with drift, which the Flint Steel River occupies. Here there is a gap of nearly half a mile without exposures. There is quite a little difference in strike on the two sides and the strike also veers in approaching the valley so that one may suspect that it occupies a fault, or perhaps better a kink or crushed zone in the strata, for there is no indication of any large displacement. At the same time it must be remembered that in passing to the next (the Rockland section) we do pass a gap which we cannot certainly bridge.

Mass Mine Cross-Section (Fig. 52). The location and relation of the drill holes is given in the annual report of the company for 1907, and a cross-section showing somewhat of their relative elevation. The elevations are referred to bench mark probably about 1025 A. T. or 423 above Lake.

The highest hole geologically is 9. Then the others follow in the order: 9, 8, 5, 7, 1, 2, 3, 4, 6. There was a gap between Holes 9 and 8, which are above the Knowlton lode and No. 5, at the time of my examination which I completed from other sources. No. 5 begins immediately below the Caledonia or Nebraska conglomerate, and No. 7 parallels it for 200 ft., there being an outcrop of the same conglomerate not far (about 300 ft.) from No. 7.

¹Plate XIV and Fig. 52 are in envelope. By an oversight the number to Mass drill hole No. 1, occurring between Nos. 5 and 2, does not appear in Fig. 52.
²This suggests that disturbance and upheaval were going on at the same time as the lava flows,—an altogether likely supposition.

The dip of the formation is about 43° (B shaft to 14th level); steeper below, due to disturbance?

For correlation with the Adventure holes, see the record of the latter just given.

Mass drill hole 9. At an angle of 45°, nearly at right angles to the beds, near the middle of Sec. 34, T. 51 N., R. 38 W.

The direction is so nearly perpendicular to the beds that distance along the hole may be taken to be true thickness.

1. Ophite, feldspathic 3 mm. d 9. 10-43 (60+)
2. Ophite 3 mm. d 9. 43-105 (62)
Amygdaloid d 9. 43-59
brecciated, with black fragments and white cement 43-50, then trappy and chloritic -56, then epidotic 59.
At 60, 69, 70 ft. the augite grain is
1, 2, 2-3 mm. respectively, then finer.
Seams are at 16° to core and less.
3. Ophite 2 mm. d 9. 105-161 (56)
Amygdaloid, black and white d 9. 105-114
At 123 and 131 ft. the augite grain is
1-2 and 2 mm. respectively.
Laumontite seams at 8° to core, chlorite at 80°.
4. Ophite 2 mm. d 9. 161-224 (63)
Amygdaloid d 9. 161-178
with calcite and laumontite amygdules and brownish base to 171, then greenish to 178.
At 188 and 201 ft. the augite grain is
1 and 2 mm. respectively, then from 210 distinctly finer. At 207 is a ½-inch calcite-laumontite seam parallel to the core.
5. Amygdaloid conglomerate?
Not separable from amygdaloid below.
6. Ophite 3.5 mm. d 9. 224-320 (96)
Amygdaloid and amygdaloid conglomerate with maroon fragments; laumontite, calcite and hardened clastic or mud matrix to 237, brecciated to 242 16 ft.
The trap is fine grained with fissures nearly parallel to core.
At 262, 292, 299, 307, 315 ft. the augite grain is
1, 3-4, 2, 1-2, 0.5 mm. respectively.
7. Ophite 1.5 mm. d 9. 320-360 (40)
Amygdaloid d 9. 320-340 20
Trap d 9. 340-360
Epidotic to 342, then fine grained ophite 1-2 mm. at 350.
8. Ophite 4 mm. d 9. 360-463 (103)
Amygdaloid d 9. 360-370
Calcite, chlorite, prehnite, perhaps a trace of copper.
Trap d 9. 370-463
At 405, 415, 434, 452 ft. the augite grain is
3, 3-4, 3-4, 1-2 mm. respectively.
9. Sandstone d 9. 463-471 (8)
Light, quartzose, calcitic with epidote seams. Seams across the core, parallel to the dip, are normally faulted by others at oblique angle to it,

which *may* be northward trending nearly vertical faults, throwing the east side to the north.

There are some amygdaloid pebbles so that it passes toward amygdaloid conglomerate near 471.

10. Amygdaloidal melaphyre d 9. 471-527 (56)
Amygdaloid, weathered, trappy at first d 9. 471-513. Fine grained, brecciated, at end epidotic 509; black and white with laumontite and epidote crystals to 513.
Trap mainly d 9. -527
Somewhat brecciated, with chlorite amygdules, somewhat glomero-porphyritic at base.
11. Amygdaloidal melaphyre d 9. 529-598 (69)
Amygdaloid d 9. 527-559
Brecciated conglomerate to 529; epidotic, more or less amygdaloid to 535; red with calcite and epidote toward bottom -559.
Trap fine grained, grows coarser and speckled 1 mm. 589, then an amygdaloid streak, but continues fine grained and brecciated to 598.
12. Ophite, feldspathic 3 mm.+ d 9. 598-795+ 200+
Amygdaloid d 9. 598-608
Full of clasolitic matter, cf. amygdaloid conglomerate. There is also an amygdaloid streak between 676 and 692.
Trap d. 9 608-795
Plainly mottled, somewhat feldspathic; the rate of increase is low like the trap above the Forest conglomerate.
At 613, 621, 635, 650, 750 the grain is
1, 2, 2, 3, 3 mm.
If, as I suspect, this is the heavy trap just under the old Minnesota Powder house this hole laps Michigan No. 21 (1907), and this is Michigan No. 21, from 0-222.
13. will be Mich. 21 222-327 Powder House vein and foot=105 (75)
14. " " " 327-349 Amygdaloid conglomerate and foot of 13
= 22 (15)
= 30 (21)
15. " " " 349-379 = 22 (15)
15.A " " " 379-401 = 19 (13)
16. " " " 401-420 Copper bearing amygdaloid and trap
= 14 (10)
= 19 (65)
17. " " " 420-434
18. " " " 434-525
by scaling from old map about (186) (214)
19. " " " 19 525-464 ab (46)
20. " " " 19 464-420 ab (36)
21. " " " 19 420-320 the Rockland or National sandstone ab (70)
22. & 23. " " 19 320-0 Mass d 8. 17-119 ab (256)
24. " " " the Calico lode and foot (Mine sections about (100) to (125)
Mass d 8. 119-234
25. the Minnesota conglomerate. Mass d 8. 234-290 (56)
At the Michigan about (64)

Mass drill hole 8. At an angle of 45° at right angles to the formation about 2640 ft. across the strike from the Evergreen Bluff 470 ft. North, 150 ft. W. of the

S. $\frac{1}{4}$ post of Sec. 34, T. 51 N., R. 38 W. and is at an elevation of about 1254 A. T. (652.4 Above Lake). From B shaft in Knowlton lode 2654 ft. across the strike and 1898 ft. S. W. along it.

It thus should take from the Minnesota down and should also lap the upper part of the Adventure section and the Michigan Hole 21.

There were 17 ft. of overburden.

22 & 23. Feldspathic melaphyre d 8. 15-119 (104+)

The rock begins in a chloritic massive trap, rather fine grained,—less than 1 mm. There is a seam at 24° to the core, perhaps a vertical nearly northerly jointing. Along about 56-66 there are irregular pseudoamygdules and at 60 a banding at 56° to the core with a seam of clasolite (or amygdaloidal conglomerate) with amygdaloidal specks, below this at 80 is a faint mottling (2-3 mm.) of augite or feldspar, coarser, 3 mm. at 93 and at 113 finer. It may be there are two flows represented but the contact is not well-defined, and generally above the Calico comes a heavy ridge, marking 5 mm. trap of the feldspathic ophite type.

24. The Calico lode and foot, feldspathic melaphyre d 8. 119-234 (115)
Amygdaloid d 8. 119-125

Amygdules green and white, prehnitic and red bordered and white. There are also yellow epidotic spots with chlorite amygdules.

Trap. Feldspathic, mottled, with rare amygdaloid spots, and pink laumontitic seams at 17° to 11° $\frac{1}{8}$ from the core; also dense green (datolitic) seams.

At 202 there is a 3 mm. mottling on a gray ground which lower down becomes finer and vaguer and under the lens specular iron ore is distinct.

25. The Minnesota conglomerate d 8. 234-290 (56)

From 234-238 a dense mud, marbled in shades of brown, (volcanic?). (This also occurs in the Caledonia and other conglomerates; cf. Adv. d 6. 211) passing into sandstone and amygdaloid conglomerate. The sand grains are mainly less than $\frac{1}{8}$ mm. The dip is not less than 76° to 79° against the core. From 249 on is conglomeritic with plenty of sand. The scattered pebbles are generally brown felsite, sometimes white, and the matrix is sometimes calcite.

26. Feldspathic ophite d 8. 290-405 (115?)
Amygdaloid d 8. 290-295

Irregular blotches, with calcite and chlorite.

At 302, 323, 253 to 361

1-2, 3, (faint) 4 to 5 mm.

There are seams at 90° and at 26° to the core, and epidotized bands toward the base at 0° and at 59°. (At 397 some sandstone misplaced by drillers?).

27. Brown sandstone d 8. 405-408? (3) (118)

Dip nearly at right angles to (up to 80°) the core.

Cf. Arcadian 67.

This does not match Conglomerate 6 exactly.

28. Feldspathic ophite d 8. 408-460 (52) (160)

Amygdaloid d 8. 408-417

Well-marked white amygdules on a rather granular ground, with considerable epidote and a little chlorite.

Trap d 8. 417-460

At 427 there is faint 3 mm. mottling, at 443 epidote seams.

29.	Amygdaloidal melaphyre d 8. 460-471	(11)	<u>(171)</u>
	Amygdaloid d 8. 460-468		
30.	Amygdaloidal melaphyre d 8. 471-504	(33)	
	Amygdaloid d 8. 471-478		
	White amygdules with gray epidotic or brown matrix, then trappy and fine grained.		<u>(204)</u>
31.	Doleritic melaphyre d 8. 504-625	(121)	
	Amygdaloid d 8. 504-518		
	It is seamed at 59° and less angles to core; it is amygdaloid in spots to 542, and from 538-564 broken with signs of faults sloping 80° to 73° against core. Then the trap is rather massive, in streaks doleritic with 2-3 mm. feldspar, and at 594 2 to 3 ft. of epidote.		<u>(325)</u>
32.	Amygdaloid conglomerate d 8. 625-643	(18)	
	Yellow and buff, much epidotized.		<u>(343)</u>
33.	Feldspathic ophite 8.643-730	(87)	
	Epidote at 663; at 706-708 is epidotic again.		
	At 663, 668, 683, 704 ft. there appears to be a grain of 1, 2, 3-4, 1-2 mm.		<u>(430)</u>
34.	Amygdaloidal feldspathic melaphyres d 8. 730-909	(179)	
	From 733-739 is yellow epidotized amygdaloid, then after a little trap, with no defined contact, there is amygdaloid again to 757 with clasolitic streaks of sediment and brecciated spots and white amygdules, then is all rather fine grained specked, quite often fractured at 59° to the core and nearly parallel to it. From 1 to 2 mm. grain, it becomes finer and broken at the base.		
35.	Feldspathic melaphyre d 8. 921-1100	(179)	<u>(609)</u>
	Amygdaloid		
	Brecciated, red, then epidotic d 8. 921-927		
	Trap d 8. 927-1100		
	This is at first quite fine grained with minute green feldspars on red ground, like Beds 1-4 of the Adventure cross-section (Holes 2 to 4) above the Knowlton. Toward the center or between 984 and 1033 the feldspar may still (as at 940-984) be 1-2 mm., but there is also a vague 2-3 mm. mottling; toward the base the porphyritic appearance comes out again. At 1091-1096 there is a little red sediment (clasolite). Toward the center columnar joints at 8° to 11° occur.		<u>(788)</u>
	This might be Adventure Bed No. 1 or Adventure Bed No. 5, but as we find no correlate to 32 we infer the former or a bed above. There would then be a gap of at least 400 ft. to the Knowlton lode uncovered as follows:		
36.	Feldspathic melaphyre	(104)	
37.	Feldspathic melaphyre	(40)	
38.	Feldspathic melaphyre	(58)	
39.	Feldspathic melaphyre with copper bearing amygdaloid	(200)	
		<u>(402)</u>	<u>(1190)</u>

For the beds of the mined zones we have, say:

40.	Knowlton lode and foot trap	42	
41.	Merchants lode and foot trap (Piscatqua?)	39	
42.	Mass ¹ lode and foot trap	77	
43-44.	North Butier lode and foot trap	102	
45-46.	Butler	70	
47.	Ogima lode and foot trap	210	
		<u>540</u>	<u>(1730)</u>

Or, L. E. Emerson gives a section for the Ogima bluff:

40-42.	No. 1. Mass mine lode, Knowlton or N. Mass and foot		
	Horizontal 228 at 47° dip		(164)
43.	2.	50	(36)
44.	3.	80	(58)
45.	4. Lode worked (Butler) & foot		
	Ogima mine vein	65	(45)
46.	5.	42	(30)
47.	7. to Evergreen	280	(209)
		<u>755</u>	<u>(542)</u>

According to Dr. C. Rominger (Vol. V, Pt. I, p. 149) a 1400' tunnel gave at the Mass mine:

40.	Knowlton vein	10-15	
42.	Mass	120' S. of Knowlton	(86)
45.	Champion or Butler 15-20	90' S. of Mass	(209)
47.	Ogima 5'-6' wide	90' S. of Champion	(65)
	(or "Ogema," p. 150).		
48.	Evergreen 4-40 ft. wide	260' S. of Ogima	(187)
		<u>760</u>	<u>(547)</u>
			(515) ft.
[48].	The Evergreen and foot is 12 of the Adventure section, and the beginning of the Lake	Adv. d 5. 40	(60) (1790)
49.	Amygdaloidal melaphyre is 13 of the Adventure section		(68) (1858)
50.	Feldspathic ophite 14 of the Adventure section		(267) (2125)
51.	The Caledonia conglomerate (8) is 15 of the Adventure section and 7 of the Lake	d 5. 375-419	(44)
			<u>(439)</u>
			(2149)
	Total below base of Minnesota conglomerate No. 25		
52.	Feldspathic melaphyre is 16 of the Adventure say		(124)
53.	Amygdaloid conglomerate is 17 of the Adventure and 9 of the Lake; cf. Adventure 19 also		(50)
54.	Feldspathic melaphyre is 18 of the Adventure and 10 Lake (cupriferous)		(72)
	Clasolitic sandstone, etc., 97? is 19 of the Adventure?		(18)
55.	Feldspathic ophite is 20 of the Adventure and 11 Lake		(41)
56.	Conglomerate (6) is 21 of the Adventure and 12 of the Lake (74)		
		<u>(818)</u>	<u>379</u>

¹Another lode has recently been called Mass at times.

Sealing from the 1907 report (840)
 Computed below for top of 5, just below it (874)

Hole 5 accordingly would, if it were not for the considerations below, begin not below No. 8, the Caledonia, but No. 6, the next conglomerate below. The drill shanty of No. 5 stood on a conglomerate outcrop. But next below No. 6 come heavy ophites well shown in many sections (at the Victoria and at the Adventure), and the base at the Adventure is peculiarly pumiceous. In both respects beds at the beginning of No. 5 Mass differ from those directly under 6, but are more of the type of the feldspathic group above. Faults shown in the map throw the S. W. side to the S. E. and thus bring the Evergreen nearer Hole 5, so that Hole 5 really begins with No. 52.

Mass drill hole 5, 70° (25° or so from being at right angles to the dip and at right angles to a strike of 38° 45' E.). Elevation 2.2 above datum 1027 A. T. From B. shaft it is 1102 feet across the strike to the S. E. and 6110 ft. along the same. Add 180 to length of hole to bring it on level with B. shaft and subtract 62 from the distance from the lode gives 1040 ft. which, at a dip of 43° would give (710) feet thickness below the Evergreen lode. To this must be added $180 \sin (70 + 43 = 67^\circ) = (164)$ ft. Thus the beginning of Hole 5 should really be some (874) ft. below the Evergreen lode, were it not for displacements and inaccuracy in possible determination of strike and dip. As a matter of fact it begins just in No. 52 under No. 51, about (439) ft. below the Evergreen judging from its associations, the difference (371 ft.) being easily accounted for either by a veering of the strike (371 ft. in 6110 would be not over 3° 30') or faulting, or both. Depth along hole must be reduced by multiplying by $0.92 = \sin (70 + 43^\circ)$

52. Feldspathic melaphyre d 5. 28-145 (108+)
 Cf. Adventure 16 (124 to 100)
 Lake 8

At the beginning epidotic feldspar 2 mm. long, at 112 ft. 2-3 mm. long with strings or bombs of amygdaloid showing that it is not far from the top of the trap. There are frequent breaks at the beginning at about 56° to the core, toward the base seams at 26° and 12° and 78° to the core. Toward the base it appears amygdaloidal with a red base with feldspar laths showing up to 3 mm. long, and calcite amygdules with an epidote border.

53. Amygdaloid conglomerate (No. 7?) d 5. 148-170=22 (20)
 d 2. 718-742

At 148 ft. is a hardened red argillite (cf. 56) with a dip against core of $63.5^\circ = \tan^{-1} 2:1$ indicating a dip of 46.5°. The colors are maroon to buff; it shades into an amygdaloidal conglomerate with maroon pebbles containing white amygdules and epidotic cement.

This does not appear at the Adventure. Cf., however, Adv. d 5. 661-679 which is probably a clasolitic crack running down from this horizon.

54. Feldspathic melaphyre d 5. 170-222=52 (48)
 d 2. 742-810?
 Adv. d 5. 543-593

Amygdaloid d 5. 215

Fine grained and chloritic amygdaloid to 194; coarse grained, light gray epidotic amygdaloid with chlorite and calcite amygdules -215. At 215 the feldspar is 2-3 mm. long, then it becomes finer grained and redder.

55. Melaphyre d 5. 222-250=68 (62)
 Amygdaloid d 5. 222-236

White amygdules on maroon ground, contact dips about 68° (tan -1 5:2).

Trap. Fine grained, greenish, all full of shear planes that make an apparently coarse texture.

56. Sandy conglomerate (6) d 5. 250-353 41+ (58)
 Lake d 2. 879-918
 Adv. d 5. 710-784

At the beginning, as often, cf. (25) and (53) is about 1 ft. of fine dark mud above the regular conglomerate. Numerous seams at 63.5° (tan -1 2:1) are nearly parallel to bedding; other dips measure 56° (tan -1 12:8) 57° (tan -1 11:7). All along are occasional pebbles, but much sand.

The interval between this and the conglomerate above (265) ft. or so agrees very closely with that at the Lake (259 ft.) and not badly with that in Adventure d 5 (291 ft.), and the intervening beds can be identified with the Lake very well. So far the section matches the Adventure and Lake.

57. Ophite d 5. 358-421=63 (57)
 Well-marked amygdaloid d 5. 358-390=32

The contact 350-353 is well marked with small white pebbles and also black ones, and it remains a *strong* amygdaloid to 376; then comes an epidotic amygdaloid blending into decomposed and seamed trap to 390. This is a distinct ophite.

At 388, 394, 410 ft. the augite grain is
 1, 2, 1-2 mm. respectively

Is this Adventure (24) d 5. 847-932? It doesn't at all look like it, and the pumiceous beds 22 and 23 are absent. Cf. the seams at 250 ft. and Adventure belts 38 and 39 at 5. 1243. It more resembles Adv. 22.

58. Ophites and faults d 5. 421-688 (245?)
 Amygdaloid d 3. 421-429 (to 443 doubtful) (140?)

The rock along here is much disturbed, full of laumontitic slips and seamed at 36° (tan -1 5:7) and 45° (tan -1 5:5) to core, and chloritic at 59° (tan -1 5:3) to core. Near 491 may be a main seam nearly parallel to the drill core, which continued more or less to 561. By 508 it is more settled, a 2 mm. ophite?, but there are a good many pink seams to 530. then more massive faulting ophitic with red specks of altered olivine. Toward the base a set of chloritic seams perpendicular to each other at 63.5° (tan -1 6:3) and 26.5° (tan -1 3:6) to the core may be parallel and perpendicular to the dip. Then the seams at 45° to the core may have a steeper hade, say 25°. There is a faint sign of 3-5 mm. ophite mottling 562-621, but it is clear that no such thickness as (245) feet of undisturbed trap could occur without a much coarser structure than exists. It doesn't seem at all probable that the bed is struck very obliquely¹ and is very much thinner, the indications of dip in it and the beds above and below do not point that way. The alternative is that it is extended by faulting or is a mere fractured aggregate of trap.

From this point on the Mass section does not at all match the Adventure. We cross a great strike fault probably.

59. Amygdaloid conglomerate d 5. 688-689 1 ft.
 There is clasolitic red matrix also in the Amygdaloid below.

¹Confer, however, what is said in the Appendix as to the possibility of southerly dips along here. Were the dips south it would be cut obliquely.

60. Amygdaloidal melaphyre d 5. 689-731 (38)
 Amygdaloid d 5. 689-698
 Brecciated, and with clastic red matter to 712, then slightly more massive but brecciated to about 716; at 712 changes to chloritic amygdaloid, at 726 to 731 becoming red with porphyritic green feldspar as so commonly at the base of feldspathic melaphyres. This is a type of rock found more commonly above 6.
 At about this point the angle of the hole changes to 60°. The reduction factor ($\sin^{-1} 60^\circ + \text{dip}$) is probably .97 or so, almost negligible.
61. Feldspathic melaphyre and faults d 5. 731-1182 (440)
 Amygdaloid d 5. 731-751
 This is gray amygdaloid with coarse 3 mm. somewhat glomeroporphyritic feldspar, specked, broken up and seamed, but getting more massive with hard white seams of datolite or quartz; at 818 there is a faint 1 mm. mottling, from 841 to 908, 2-3 mm., the mottles certainly never reaching 3 mm. It seems to grow finer after 968. Seam at 774-844 at 76° and 63.5° ($\tan^{-1} 4$ to 2:1) of laumontite at 49°; strong seam at 1125-1136 of chlorite, calcite and laumontite at 22° with core. If, as is quite possible, they are nearly vertical, from the direction of drag, one would say the north side had been moved down. Other seams are at 63.5° ($\tan^{-1} 2:1$) 51° and 45° ($\tan^{-1} 4:4$), then 1164-1182 the porphyritic marginal facies once more; at 1182 more sliding and a sudden jump to a 3-4 mm. ophite.
 The general type of Bed 61 seems to be rather that of beds above Conglomerate 6.
62. Faulting between 1125 and 1182 especially.
63. Ophite 4 mm. + d 5. 1182-1263 (110+) (80)
 Top faulted off.
 At 1182, 1220, 1240, 1262 the augite mottling grain is
 3-4, 2-3, 1-2, 0.5 mm. respectively.
64. Ophite 4 mm. d 5. 1263-1362 (96+)
 Amygdaloid, perhaps amygdaloid conglomerate -1291
 At 1319-1343, 1352-1362
 3, 4, mm.
 Then comes another slip fault and a fine grained specked trap.
65. Feldspathic melaphyre d 5. 1362-1391? (29?)
 This is fine grained and seamed at about 63.5° ($\tan^{-1} 2:1$) to core.
66. Red sandstone with tufaceous base d 5. 1391-1418 (20?)
 Cf. d 1. 394-430=36 (31)
 Dips on the sandstone against the core run from 39° to 68° averaging 52° ($\tan^{-1} 1:1, 4:5, 5:3, 5:5, 5:2, 5:4, 5:3$). This would mean a dip either of 58° to 68° or else nearly horizontal. In either case it is probably abnormal and due to drop near a large fault, which effect is also seen near 1543. The abnormal thickness of some of the beds above may also be due to abnormal dips so that they were struck transversely. Similar phenomena are found in Michigan holes at a similar horizon in the south part of Sections 14 and 15. At 1413 is the end of the red sandstone and there is fine marbled brown mud. Cf. 56. It shades, by a tufaceous base for the first few feet more into fine grained stuff with prehnite amygdules. If this corresponds to Adventure Belt 29 and Conglomerate 5 it is extra

- far away from Conglomerate 6. Has not the hole traversed a more southerly trending fault, which has thrown the east side south?
67. Feldspathic melaphyre d 5. 1418-1494=76 (65?)
 The amygdaloid shades into the tufaceous bed above, then becomes dense and dark,—black with red bordered amygdules scattered irregularly to 1444, seams at 59°, both near top and bottom and at 1483 probably nearly parallel to dip. Then a fine grained feldspathic trap to 1480. Then a coarse open amygdaloid, the new flow probably not until 1494.
68. Feldspathic melaphyre d 5. 1494-1543=49 (43?)
 Cf. 1. 430-443
 Amygdaloid
 Marked with red and white amygdules and black matrix -1505
 Trap
 Massive, toward base finer and feldspar (1 and 1-2 mm. long) appear more porphyritic on a fine ground. Cf. also No. 65.
69. Sandstone d 5. 1543-1591=48 (39)
 d 1. 443-478 (to 500) (28)
 Very well banded with round grains, unusually like Eastern sandstone. Dips are 54° against core but noted two or three times ($\tan^{-1} 6:4$) 52°, 56°. A seam about parallel to the core shows a drag in the bedding. Cf. Conglomerate 4
70. Ophite 2 mm. d 5. 1591-1611+ 20+ (48)
 d 1. 500-560=60
71. Amygdaloid, black and white.
 Then very well-marked ophite, the grain increasing from 0.5 to 2 mm. at the end. The ophitic mottling is very prettily marked in this bed both here and in Mass No. 1. Cf. also Adv. Bed 34.

Mass drill hole 1. A vertical hole 6660.9 feet along the strike S. 38° 45' and 2906.7 feet at right angles to the lode from B. shaft, elevation-98.7, i. e., about 927 A. T.

The distance at right angles to the strike from 5 is accordingly 1804.7, and to bring them to the same elevation one must add 100 ft. to Mass No. 1. At a dip of 60° to 70° for every 100 ft. depth on Mass 5 one must take from 35 to 50 ft. from its distance from Mass 1. Mass 5 1611 may, accordingly be taken at 1805- (225+450) =1135 from Mass d 1; its depth below the top of Mass 5 is 1570 ft. If then we correlate Mass 5. 1611 with Mass 1. 500 we have a dip of 41° ($\tan^{-1} \frac{1570-(500+100)}{1135}$) which is plausible enough, as an average dip, though the dips actually noted in the sandstones seem so much greater. In that case the faulting would flatten the dip.

If we suppose d 5. 1611 correlates with d 1. 430 the dip would be 42.5°. If the ophites at the top of d 1. are altogether below 5, as is in some ways likely, the dip would be over 52° which is very possibly true in the particular block in which the top of 1 and bottom of 5 are. The overburden was very heavy, 128 ft., and it must be remembered that the Van Orden brickyard also put down a hole¹ over 200' in clay.

There is only 550 feet difference along the strike.

Unless we have a dip of over 46° (or faulting) the conglomerate and sandstone of No. 2 should appear in No. 1. The only possible, by no means certain, correla-

¹Report for 1903 p. 184.

tion is of d 2. 63 and d 1. 590 which is strengthened by the abundance of iron oxide in d 2. 406-585 d 1. 946-1000+. This correction would mean (making no allowance for faults) a dip of only 24° about that noted in the sandstone at d 1.

443. On the whole it seems best to take different factors to get the true thickness derived from the dips in the hole in the sandstones.

Cf. also Adventure 1.

(70?) Ophite d 1. 128-198=70

Gets finer from 2-3 mm. to $\frac{1}{2}$ mm. at 198.

(71?) Ophite 3 mm. d 1. 198-329=131

This is a very pretty, well-marked ophite varying from 3 mm. down to $\frac{1}{2}$ mm.

Amygdaloid probably faulted out.

At 198 it is fine grained, red seamed.

At 206, 217-289, 289, 295, 316, 329 the grain is
2.5, 1-3, 3, 2, 0.5, contact

From 217-289 are very many pink laumontite seams parallel to the hole.

It does not seem to be badly disturbed below 289 and the rate of increase A=about 1:15 does not seem abnormally slow so that it is probable that the hole is *not* cutting the formation very obliquely.

? Ophite 2-3 mm. d 1. 329-394=65

Amygdaloid d 1. 329-333

Red, white and green, then not so marked and at 337 massive fine grained trap, but from 339-343 fine grained and amygdaloid in spots (bombs).

At about 350, 360, 376, 382 ft. the augite grain is
2-3, 1, 1, 0.5 mm. respectively

769? Red sandstone d 1. 394-430

Very red, much faulted; dip if the core is vertical 66° ($\tan^{-1} 1.76$). It is much seamed and broken; the transition at the base is not a normal but a faulted one. The probabilities are that this is a faulted block of the same sandstone as 69.

Fault at d 1. 433. Cf. Conglomerate 5

68? Trap d 1. 430-443=13

Fine grained, greenish specked trap.

69. Sandstone d 1. 443-478=35 (31)

Seams less disturbed, dips about 26° to 28° (average of 5 observations $\cot^{-1} 2.05$). Cf. Conglomerate 4?

70. Amygdaloidal melaphyre d 1. 478-495=17 (15)

With small irregular amygdules and white seams at 45°.

71. Ophite 2 mm. d 1. 495-560=65 (58)

Clasolitic amygdaloid or amygdaloid conglomerate -500.

Trap is a very prettily marked ophite, coarsest at 529.

At 508, 529 feet the grain is

1, 2 mm. respectively, and the mottling can be seen clear down to less than half a millimeter. It matches very well with the bottom bed of No. 5. This is so marked an ophite that the slow increase of mottling would suggest more of a dip and that the thickness was really only about 30 ft.

72. Ophite d 1. 560-590=30 (27)

Amygdaloid with pinkish amygdules.

Trap rather fine grained but with mottles up to 1-2 mm. At the base

is a well-marked calcite seam which seems to wipe out the base of the trap and perhaps another bed shown in d 2. 1963 ft.

73. (in d 2?) 44?

74. Conglomerate and sandstone d 1. 590-699=109 (97)
d 2. 63-207=176

Pebbles of fine grained felsites and traps dominate; red rock (augite syenite) occurs, amygdaloid pebbles occur; largely sandstone; bedding in conglomerate 45° in sandstone 70°, 64°, 80° against core, i. e., dipping 26° or less. At the base is a fine flecked or marbled mud just as in d 5. 1413, brown clouded with lighter. We find this also in the Adventure Bed 23, and in d 2. 189.

Cf. both Adventure Belts 23 and 29.

75. Ophite 2 mm. d 1. 699-760=61 (54?)

Amygdaloid d 1. 699-704

Red and white, like that at 495.

Trap

The mottles are about 2 mm. at 723 ft. The increase in grain is abnormally low. Is there not a decided dip close to the fault at 760 nearly parallel to it? At 760 there is shearing and the laumontite crystals filling the seam which is at 68° seem to show drag.

(52)

76. Ophite 2-3 mm. d 1. 760-900= (125)

Amygdaloidal somewhat down to 795; at 830 2-3 mm., then finer grained.

77. Melaphyre d 1. 900-1000+ (120)
d 2. 406-585

Amygdaloid d 1. 900-946

Brecciated, not very amygdaloid, like a conglomerate in spots.

Trap d 1. 946-1000

This is dark, rather fine grained with chlorite seams nearly parallel to the core, granular, massive, with altered olivine and an appearance as though it would run high in iron, in this respect resembling d 2. 406 and d 2. 263-294.

Numbers 74, 75, 76, 77 match fairly well in Holes 1 and 2. In all cases they are greater in Hole 1 by about 25%. This may be due to a difference in the angle at which the holes cut them. The flows beneath the conglomerate (74) all have a rather peculiar character in not being as ophitic as one would expect for their size and in showing plenty of altered olivine.

This character also reappears in the trap in Hole 3, but I do not find anything just like it above or in the Adventure section.

Mass drill hole 2. Vertical, just about in line with Mass d 1 and 6, 661.3 ft. S. 38° 45' W. along the strike of the Evergreen lode from shaft B. and 3850 ft. from the lode southeasterly at right angles thereto. Elevation (10.3) 1035 A. T., or 109 above d 1, and 943 ft. from it at right angles to the strike. It should therefore lap it unless the dip is more than 49° ($\tan^{-1} 109-19-(0-1000)$). The dips on the sand-

stone near the top are from (51.5° to 50°, against the core) 40 to 38.5°. Such dips would make Mass d 2. 0=Mass d 1. 740. This is not possible but the correlation of Mass d 2. 63 with Mass d 1. 590 is quite possible.

Now we find at Mass 2. 171 a white seam making an oblique angle of about 49°, and we also find signs of slip in Mass 1. at 760, so that it seems best to charge the difference to the faulting and suppose that the dip is really about 40°. The reduction factor would then be .77.

The overburden of drift is only 19 ft.

73. Ophite d 2. 19-63=44+

At 34, 44, 62 ft. the grain is

2-3, 1, 0.5 mm. respectively as observed, but the mottles are not plain.

74. Conglomerate d 2. 63-202=139 (107)

Conglomerate—little core—69 ft.

Amygdaloid conglomerate 128-136 ft.

Pebbles amygdaloid and felsite with hematite.

Sandstone at 50° (tan⁻¹ 5:4, 6:5, 6:5) against core, i. e., 38.5° to 40° dip. There is also a seam at 40° to core and oblique to bedding. From 185-189 the red mud filling dips at 41.5°, then grows less and less.

75. Feldspathic ophite perhaps d 2. 202-294=92 (70)

The amygdaloid blends with the base of the conglomerate.

At 218, 263 the grain is 1-2, and 3 mm. faint.

The trap has a peculiar hackly fracture, and much iron oxide; reddened altered olivine and feldspar are conspicuous. It resembles Bed 78 in this respect.

76. Melaphyre d 2. 294-406=112 (86)

Amygdaloid. Brecciated d 1. 294-323. Then there are seams at about 45°, and faulting perhaps, then rather more massive to 353 ft., then a dark amygdaloid with red lines of breccia and small white and green amygdules, with a trace of prehnite and copper, then an irregular trappy amygdaloid to 406 ft.

77. Melaphyre d 2. 406-585=156 (120)

d 3. 26-116

d 1. 946-1000+

Amygdaloid d 2. 406-429

With white and pink amygdules, mottled with calcite and epidote blotches and iron oxides. Altered olivine specks and (probably primary) hematite up to 1 to 2 mm. are a feature; also the fact that it is not plainly ophitic.

Mass drill hole 3. At 49° to S. E. It is 7360.4 feet S. 38° 45' from shaft B. and 4281.9 at right angles thereto. The elevation is 1024 A. T. (-0.9), i. e., 11.2 ft. below Hole 2, so that to reduce to the same level we must take that much from the running measurements of 2. As they are 432 ft. apart across the strike if we correlate 3.0 with 2. x the dip is $\tan^{-1} \left(\frac{0-(11-x)}{432} \right)$ and if there is no correlation it must be $\tan^{-1} 585+ -11$, more than 53.5°. But there is no necessity for such a dip since we may

432

well correlate: No. 77. Mass 2. 406-585+ (a little)

with Mass 3. 26-116

This would imply a dip of 43° or so, just about at right angles to the hole and very similar to the dip found probable for 2, and only 4° from the somewhat doubtful dip derived by correlation with No. 4. There will then be no reduction factor, the distances along the hole are thicknesses.

Overburden 26 feet.

77. Melaphyre, very olivinitic d 3. 26-116 90+

This is all trap with dark specks of altered olivine, and much iron oxide. There is no notable change in grain. It is very much like the trap in the last two boxes of Mass 2. Cores break square across with a few chloritic seams at only 15° or so with the core. Near d 3. 114 there are seams at 20° and 59° to the core.

78. Melaphyre, olivinitic d 3. 116-305 (189)

Amygdaloid, showing a little copper.

From 114-116 slightly amygdaloid and seamed,—base of the flow above but from 116-134 is a well-marked red and white amygdaloid. Trap d 3. 134-305

This is at first fine grained, then granular with iron oxide and altered olivine abundant, feldspar 1-2 mm. long, not conspicuous, and augite mottling very vague.

79. Melaphyre, olivinitic d 1. 305-347 (42)

Amygdaloid d 1. 305-311

Not well-defined, somewhat glomeroporphyritic. In the trap, which is like that above, the brown specks are conspicuous.

80. Feldspathic melaphyre d 1. 347-637 (290)

Amygdaloid, poor d 1. 347-351

The trap is coarse, reddish, feldspathic, feldspar 2-4 mm. There are chlorite specks. About 371 are numerous laumontite seams parallel to the core and at 20°, columnar joints?

81. Feldspathic melaphyre d 3. 637-679 (42)

Amygdaloid d 3. 635-669

Poor, contact ill-defined, perhaps about 642 ft.

Trap d 3. 669-679

With white specks, and chloritic and calcite blotches and 2-3 mm. flesh colored feldspar.

82. Sandstone and conglomerate d 3. 679-910 231

Fine grained (less than 1 mm.) mottled a foot or so at top (exomorphic contact); cement calcareous; dips practically at right angles to the core at 74°, 78°, 80° with it; at 686 a red shale, then more conglomeritic. Thence to 806 conglomerate with fine grained felsite pebbles, some amygdaloid, and calcareous cement, then more sandy.

There are occasionally lighter and blotched red and gray streaks with calcareous cement. A dark brown, fine grained sandstone at about 875 ft. makes an angle of 86°, and so do bands of tuff fragments.

The last few feet are amygdaloid conglomerate, and I suspect near the base. The dip can not be over 13° from being at right angles to the hole,—probably much less.

This very heavy sandstone and conglomerate with the peculiarly heavy and coarsely feldspathic trap just the second bed over it should be a well-marked and identifiable horizon.

No. 4 is said to have struck it in the first 10 ft. though none was saved. The dip would then be very nearly 37°, supposing that Mass 3 is within 10° of being perpendicular to the dip. This is fairly close to dips otherwise obtained, the average deviation from right angles to the hole, which is at 49°, being 12°.

This may be conglomerate 3, and probably is, since it can hardly be the repetition of any bed above.

Mass drill hole 4. At 46.5° to the S. E. Located 7351.7 ft. S. 38° 45' W. of B. shaft and at right angles there to across the strike from the Evergreen lode 5486.8 ft. or 1205 ft. across the strike from 3. Elevation (69.2) about 1094 A. T. The dip (correlating with d 3) is about 47°. The average of drill core observation on a sandstone at 384-541 ft. is about 15° from being at right angles to the core. There may be 4% reduction but not more.

- Overburden 73
83. Ophite 2 mm. (44)
Trap d 4. 73 to 117
Begins at the transition from amygdaloid in red seamed trap.
At 80, 91, 102, 113 ft. the augite mottles which are well separated are 1-2, 2, 2-3, 1 mm. respectively.
It is much seamed with laumontite and prehnite and a trace of copper.
84. Ophite 3.5 mm. (92)
Amygdaloid d 4. 117-143
Irregular, brecciated and trappy, with laumontite and red fragments and calcite amygdules, and greenish, maroon or pinkish ground.
Trap d 4. 143-209
At 143, 148, 153, 158, 172, 186, 193, 199
1, 1-5, 2, 2, 3-4, 2-3, 1-3, 1½-0.2 mm. in bands.
The irregularly banded grain in this ophite is notable.
Sp. 3.199 was taken for section.
85. Ophite (29)
Amygdaloid d 4. 209-233
Very well marked, brecciated, red and white (like that at 117 ft.) to 226 ft., then about 231-233 sediment and amygdaloid conglomerate or clasolite, seams at about 35° to core (tan - 1 5:7) brecciated.
Trap d 4. 233-238
Presumably a gush of the underlying flow.
86. Ophite 3.5 mm. (87)
Amygdaloid d 4. 238-247
Pink and white, laumontitic
Trap d 4. 247-325
At 260, 264, 272, 280, 309, 316-325 ft. the grain is 2, 2-3, 3, 3-4, 1, black aphanitic respectively.
87. Ophite 3 mm. d 4. 325-384 (59)
Top is a red seamed breccia from 325-370
At 332, 359 the grain is 1-2, 3 mm., then finer.
88. Sandstone and conglomerate d 4. 384-541 (157)
Sandstone with angles against core 67°, 74°, 67°, and white seams (nearly perpendicular). At about 449 feet a breccia seam. It is quite massive brown, with long cores—at about 472 is a foot of conglomerate but it is mainly sandstone to 513, then there is a conglomerate with a variety of pebbles (beside felsite, labradorite porphyrite, quartzite, light pink, *granitic*, dark and amygdaloidal.) It passes then into amygdaloid conglomerate at about 522 ft. with black and white amygdaloid scoria and maroon mud matrix full of fine white seams at an angle of about 70° to the core parallel to dip?
89. Ophite 8 mm. d 4. 541-716=175 (175-to 164?)
Amygdaloid d 4. 541-549
Below 549 is fine grained and brecciated, with amygdaloid spots.

- Trap d 4. 549-716
At 586, 621, 634, 644, 656-664, 676, 682, 690, 706, 716 ft.
3, 5-6, 8, 7, 6, 3-4, 3, 3, 1, 0 mm.
The rate of increase A is about 1 in 11 ft. or so, quite normal for an ophite. It might pass for the Mabb ophite.
90. Ophite d 4. 716-760+ 34+
Amygdaloid d 4. 716-727
With some clasolitic matter, verging on amygdaloid conglomerate.
Trap d 4. 727-760
Specked to 74°.
At 748, 760 feet which is the end of the hole the grain is 1-2, 2-3 mm. respectively.
Hole 4 is characteristically ophitic as Hole 3 is not.

Mass drill hole 6. At 45°. Location 7737.8 ft. S. 38° 45' W. of B. shaft and at right angles thereto across the strike 6.306.4 feet. Elevation (42.2) 1067 A. T. It is accordingly 822 ft. from 4 and about 27 feet lower. No. 6 starts in with a 3-4 mm. ophite which breaks nearly perpendicular and parallel to the core which might be No. 90 perfectly well and this would allow a dip as flat as 53°. Flatter than this it can hardly be. No reduction factor seems necessary.

- Overburden 52; first core at 74 ft.
90. Ophite d 6. 52 to 92 to 106 (40) (to (56)?)
Trap 3-4 mm. grain? breaks parallel and perpendicular to core.
At about 92 ft. it is finer with amygdaloid spots.
At 106 ft. the grain is 3 mm., and is somewhat seamed perpendicular to the core, and at 23° and 20° and 57° to the core, those at about 20° looking like bedding.
91. Melaphyre d 6. 92-135
Seamed, slightly amygdaloidal. About 132 ft. more so.
Seams at 24°, 8° and 20° to core.
92. Sandstone and conglomerate d 6. 135-168 33
Small felsite pebbles with calcite cement.
There is also much dark red sandstone dipping 70° against core.
There is also a seam dipping in the same sense relative to the hole, but at only 24°, 18.5°, etc.
At 156-159 ft. the dip is 51° against the core with joint seams perpendicular thereto.
In case of a seam dipping the same way against the hole as the bedding but more nearly parallel to hole there seems to be a down drag of the upper side.
93. Melaphyre d 6. 168-192
Amygdaloid d 6. -178
Fine grained, seamed, and prehnitic.
Trap is fine grained and decomposed.
- From 192-195 is part Jacobsville sandstone, part Keweenawan sheared together.
94. Jacobsville and Eastern sandstone d 6. 192-622
This is a friable sandstone nearly white to light pink, with the grains more exclusively quartz, usually ½ to ¼ mm., more rounded and larger

than in the Keweenaw sandstone; the dips against the core usually about $\tan^{-1} 51^\circ$ probably about horizontal at 225 ft. 50° to 38° , at 262 ft. 38° , or 35° , seams parallel to core are perpendicular to dip. At 302-323 32° quite persistent (probably 13° to the S.), at 393-478 51° , at 495 apparent dip makes angle of 74° with core, say 29° dip, and is faulted by seam nearly at right angles at 51° to core, a normal fault; at 598 to 622 at 51° with seams at 26° . Probably the last part dips about 6° to the north.

The two conglomerates 88 and 92 might perhaps match those close under the Lake lode and 82 or thereabout, might be the Lake lode. Cf. also Adventure 29.

§27. MICHIGAN AND ROCKLAND. (Pl. XIV, Figs. 52 and 53.)

Beyond the Mass is a wide valley occupied by a transverse river, the Flint Steel, which runs in a pre-glacial gorge cut down like Portage Lake through a mantle of Paleozoic sediments now removed. It is overlooked on the east by Caledonia Bluff (named after an early mine). For half a mile there are no exposures. On the south side of this bluff is a conglomerate named after it. There is a considerable swing in the strike just here and (since there may well be a displacement) the possibility of an error in correlations. Moreover, a slide fault such as is known to exist in the Minnesota mine might well stop or change the amount of its displacement here so that one part of the section might match closely and another part be displaced. At and near Rockland, there are, however, exposures frequent enough to make up a fair section and this is being supplemented by S. Brady and C. M. Haight, respectively, the able agent and engineer of the Michigan mine. And as the Nonesuch sandstone and the felsite is exposed we can patch together a section of all the higher beds down to Bohemian Range group.

FREDA SANDSTONE. Base exposed in Section 4, T. 50 N., R. 39 W., extending thence north ten miles to Ontonagon. The dip in Section 4 is 40° . Along shore the dip is slight. The thickness can only be guessed and Chamberlin's remarks on the building out of sandstones may apply² judging from the Montreal and other sections. However the thickness is not less than (5000)

The base has holes after stellate groups of crystals like the Fontainebleau calcite pseudomorphs.

NONESUCH GROUP. Greenish black chloritic sandstones or fine grained conglomerates with the red and green granules not much more than a millimeter across. (400)

¹Plate XIV and Figs. 52 and 53 are in envelope.
²Geology, Vol. II, pp. 192 and 262.

COPPER HARBOR CONGLOMERATES. The total section from here to the felsite is very much less than on Black River and the Porcupine Mountains and one is tempted to suppose that the Lake Shore traps have dropped out entirely. They seem to thin also in going from the Mount Bohemia focus to Portage Lake. In that case one conglomerate may include the Outer, the Middle and the Great Copper Harbor conglomerates. There is, however, a covered interval in which the Lake Shore traps may occur. There is about, however, of exposed coarse conglomerate (10 inch pebbles). (75)

Dark mottled sandstone. (75)

Conglomerate 850, dip 44° or 42° , on Section 8 in the railroad cut. (600)

Some old maps indicate on unknown grounds (probably old trenches) a narrow band of (Lake Shore?) trap, of thickness not over. (200)

—below the railroad exposure, followed by as much conglomerate more. (600)

This would reduce the gap at present unexposed of about (1000) feet to only 200. (200)

This 1,750 feet is not unlike that found on the Montreal River at about an equal distance from the Porcupine Mountain or Chipewewa felsite.

ASHBED AND EAGLE RIVER GROUPS. This is followed in Section 8, T. 50 N., R. 39 W., along the railroad track by a rather imperfect succession of beds of Ashbed type as follows (cf. Black River 6 e)

1. Conglomerate basic and sandy
2. Amygdaloid (120)
Trap
3. Possibly all amygdaloid conglomerate (88)
Amygdaloid conglomerate (30) (128)
4. Fine grained trap with flow lines (30)
5. Amygdaloid conglomerate (50)
6. Fine grained trap (Ashbed type?) (20)
7. Amygdaloid conglomerate (50)
8. Amygdaloidal porphyrite (20)
Trap with flow lines, felsites (44)
9. Amygdaloid conglomerate (30)
10. Labradorite porphyrite, 4 mm. feldspars (40)
11. Banded felsite porphyrite covered and
Quartzose amygdaloid and
fine grained black trap like the Minong (140)

12. Amygdaloid conglomerate of "Ashbed" type with red sediment and marked amygdaloid "bombs" (28) (700)

Estimates would make this total 1,200! Probably there are small, overlooked unexposed gaps.

Next comes the Chippewa felsite, which also on Section 9 shows this series of fine grained traps and amygdaloid conglomerate over it. (See Ss. 19655 to 19660 not all of felsite.)

Its thickness is there (500) to (350)
Total Ashbed group (2200) to (1050)

CENTRAL GROUP

Close below comes a 3 mm. ophite

Then a conglomerate with 8 inch pebbles, some basic, many felsite. This conglomerate can be traced in Section 8 very well, also in Sections 9 and 10. I identify it with the Allouez No. 15. Scattered in the south part of Sections 8 and 9 are outcrops of ophites and amygdaloids which partly, but not continuously, fill in the gap to the Rockland Creek section of about 2000 feet or (1375)

It is noteworthy that this belt which has been the scene of much work in Keweenaw County has hardly been touched here. Then follows a nearly continuous section of Rockland Creek which was once trenched out and made continuous by B. F. Chynoweth. Of this creek a transit survey and careful section was made by P. S. Smith and W. V. Savicki (File 14-18, Ss. 19412 to 19459). The dip is 40° to N. 32 W. An abstract is as follows:

Down to first conglomerate (250)

Conglomerate down 3 feet of sandstone, then felsitic and at base amygdaloid conglomerate. Near the north line of Section 11, dip 40° on the creek, also 3000 feet north of the south quarter post of Section 10. It is also said by Fuller in 1897 to have been exposed a few feet northeast of the south quarter post of Section 9.

Total distance of base from base of Conglomerate 15 in Section 10 at 42° dip, breadth 2400, or thickness (1650)

This conglomerate is identified as the West Minnesota conglomerate in the older maps. (See Fig. 52.) It is rather coarse and just above it is a very fine grained compact, dark trap of the Minong trap type, somewhat suggestive of the Ashbed group. Below it the Rockland Creek section continues, showing laumontitic and black traps and blue amygdaloids. The following is the record:

Second important conglomerate of Rockland Creek section.

Base is below base of conglomerate above (870)

Base is below base of conglomerate (15) (2920)

The creek section continues for about 700 feet but on a rising grade so as to expose only about (File 15-31 and 14-18) (435)

	Talus		
50.	Breccia, light matrix, dark trap and amygdaloidal fragments, considerable epidote	112	(82)
49.	Moderately coarse grained trap with quartz, feldspar and epidote, like No. 48 except coarser	10	(6)
	Talus	104	(70)
	Same as No. 48	5	(3)
	Talus	102	(70)
48.	Very fine grained dark trap, very compact. Minong type		
		48	(32)
	Talus	23	(13)
	Very fine grained dark trap, much jointed, fragments angular, evidences of slipping. Exposed in pit overlying conglomerate		(294)
	Conglomerate, rather coarse	60	(45)
	Talus	10	(7)
47.	Fine grained brownish amygdaloid, amygdules filled with quartz, calcite and epidote	20	(12)
	Talus	113	(79)
46.	Moderately coarse grained amygdaloid, amygdules filled with quartz, calcite and some prehnite; carries some free copper		
		58	(37)
	Talus	23	(14)
45.	Moderately fine grained greenish trap, with quartz, feldspar, and augite recognizable	10	(6)
	Talus	23	(14)
44.	Dark amygdaloid, amygdules filled with quartz, calcite and epidote, some cavities show fine quartz crystals	50	(30)
38.	Moderately coarse grained greenish trap. Contains some laumontite		
38A.	7-foot band of amygdaloid. Trap weathering to a conglomeritic appearance. Not persistent and lies about the center of belt No. 38		
		105	(56) (300)
37.	Light grayish green amygdaloid trap, amygdules filled with quartz, calcite and prehnite. Shows traces of free copper. Some slickensiding		
		103	(65)
36.	Light grayish trap. Foot contact more amygdaloidal. Amygdules often showing fine crystals of quartz	13	(7)
35.	Moderately coarse grained brownish trap. Much iron stained		
		60	(33)
34.	Very fine grained dark greenish amygdaloidal trap. Amygdules filled with quartz, calcite and epidote	47	(33)
33.	Coarse grained reddish diabase. Much iron stained. Becomes more amygdaloidal near hanging base	5	(3)
32.	Reddish amygdaloidal trap with rounded amygdules filled with epidote and calcite. Matrix shows augite needles		
		28	(17)
	Talus	28	(12)
31.	Light colored greenish amygdaloid becoming more trappy a few feet from foot contact. Amygdaloid filled with quartz and calcite		
		23	(15)

30A.	3-foot band of much decomposed trap, which weathers to a conglomeratic appearance	5	(3)	
30.	Moderately coarse grained brownish trap, showing some small amygdules filled with quartz, calcite and epidote	35	(15)	
	Talus	50	(40)	
29.	The 3 feet next to foot is an amygdaloid. Amygdules filled with calcite and laumontite. The bed then merges into a very fine trap	110	(77)	(320)
28.	Fine grained amygdaloid gradually merging into a trap. Amygdules filled with epidote and quartz	25	(17)	
27.	Very fine grained dark trap with a one-half inch brownish band running through it	38	(22)	
	Talus	230	(165)	
26.	Dark brownish green amygdaloidal trap with moderately fine grained irregular amygdules filled with epidote and quartz.	5	(4)	
25.	Weathered specimen of amygdaloid from dump presumably from pit which overlies conglomerate. None found in place. Amygdules filled with epidote and calcite	15	(10)	
	Conglomerate rather coarse	32	(23)	(297)
24.	Moderately fine grained brownish amygdaloid. Amygdules filled with epidote and calcite	28	(20)	
	Talus	80	(58)	
23.	Fine grained, compact, dark greenish trap with 6-inch band of amygdaloid near center, walls indeterminate, reddish amygdules	53	(63)	
	Talus	10	(8)	
22.	Fine grained greenish trap with small irregular amygdules filled with quartz and calcite	45	(23)	
21.	Same as No. 16	8	(6)	
20.	3-foot band of trap merging into No. 21	3	(3)	
19.	Amygdaloid	95	(67)	
18.	1½-foot band of trap merging into No. 19	2	(1.5)	
17.	Fine grained greenish amygdaloid often merging into trap. Amygdules filled with calcite and laumontite	8	(4)	
16.	Moderately coarse, brownish amygdaloid. Amygdules filled with laumontite. Similar to No. 14			
15.	Rotten, brown trap, showing augite, feldspar and quartz	16	(10)	
	Talus	15	(4)	
14.	Moderately coarse grained brownish amygdaloid. Amygdules filled with laumontite	5	(4)	
	Talus	35	(25)	
	South line of northeast ¼ of Section 10, T. 50, R. 39			
51.	Coarse grained diabase, showing crystals of feldspar, quartz, and augite and considerable epidote	10	(7)	

52.	Light greenish amygdaloid, irregular amygdules filled with quartz and calcite	35	(25)	
53.	Rather decomposed, dark greenish diabase. Much iron stained on weathered surface	25	(18)	
	Talus	20	(15)	
54.	Rather fine grained, dark gray amygdaloidal trap. Amygdules filled with calcite and laumontite	5	(3)	
	Talus	5	(3)	
55.	Decomposed brownish trap. Similar to No. 15	40	(27)	
56.	Very fine grained dark brown trap. Much iron stained on weathered surface	30	(24)	
57.	Moderately coarse grained. Rotten amygdaloidal trap with small amygdules filled with calcite and laumontite	7	(5)	(435)

The next conglomerate reported is one exposed by a well in Agent Brady's yard in Section 15, on the outskirts of Rockland. (See map, Pl. XIV.)

Base below base of last conglomerate (1480)

Above the heavy 7 mm. feldspathic ophite in which drill hole 21 begins this is probably not more than (750)

This 7 mm. ophite is a rather heavy bed which makes a continuous ridge on which the Powder House stands and we may refer to it as the Powder House ophite. It runs continuously from the drive up to the mine to the southeast corner of Section 10. Here it seems to be slightly displaced to the south, but then may be followed practically to the center of Section 11.

Old and new sections are frequent from below this point. Taking the mine records and my notes of drill hole 21 we continue.

1. Powder house 7 mm. ophite, faintly mottled, one epidote "bomb" with some fine copper at 20 feet, from 44 to 105 3-8 mm. mottles, at 120-138 about 7 mm. faint and irregular mottles, then growing finer. The top of drill hole near top of bed.
Probably Amygdaloid (18)
Trap d 21. 0-222 (162) (180)
2. Feldspathic ophite (78)
Amygdaloid Powder House vein d 21. 222-234 (10)
Brown and white, irregularly streaked
Trap d 21. 234-327 (68)
Feldspathic, very faintly ophitic, about 4 mm. at 250, growing finer
3. Amygdaloid conglomerate and amygdaloid d 21. 327-349 (16)
4. Amygdaloid d 21. 349-360 (8) (22)
Trap d 21. 360-379 (14)
Fine grained, speckled

5. Amygdaloid d 21. 379-400 (15) (21)
 With sediment dipping at a little more than 45°, also (56)
 epidote and copper, especially about 383 for five feet sprinkled through
 this and the trap
 Trap 400-408 (6)
6. Amygdaloid conglomerate? d 21. 408-430 (16)
7. Trap d 21. 430-525 (70) (86)
 Specked to 430, coarsely amygdaloidal to 458, then feldspathic, faintly
 ophitic, seams dip about 50°.
8. Amygdaloid d 21. 525-534 (7)
 Cold gray epidotic, carries a few specks of copper. Here we pass to
 the record of Hole 19 from the 12th level horizontal 520-504

 Hole 19 record scaled, which agrees substantially with an old record
 by George D. Emerson.
 Trap d 19. 504-462 (33) (40)
9. Ophite
 Amygdaloid d 19. 462-456 (3)
 4-foot vein carries some copper
 Trap d 19. 456-416 (29) (32)
10. Rockland¹ or National sandstone d 19. 416-306 (80)
 Base below base of last known conglomerate about (1100)

The Michigan mines steepens in dip in the A and B shafts from 46° 36' at the surface to 55° at the 17th level. From the 10th to the 12th it is 52°, thus the Bee shaft carried down at an even slope is in the hanging at the 12th level where the drill hole starts. The "Branch" or Rockland vein,—a fissure—approaches the "Calico lode" and is now being developed at the Bee shaft. At the north end near the C shaft it is 135 feet from the "Calico" but meets it to the south and downward, at the C shaft about the 6th level and crosses it and is in the foot, and is full of small faults that throw the east side south. The chutes of better rock are said to pitch toward the Ontonagon River.

The National sandstone and Minnesota conglomerate have been traced continuously in mine workings and exposures across from Section 15 into Section 16, T. 50 N., R. 39 W., and across the railroad track (File 15-1) where the dip is about 53.5° to N. 28.5° W.

The last section between them close to the Creek shaft toward the river is:

National sandstone	60
To amygdaloid	90

¹Rockland seems the older name, being used in George D. Emerson's 1859 report. But Broughton's map uses the term National sandstone, from the National mine, and that is more current.

- To another amygdaloid 74
 To epidote 112
 To amygdaloid 100
 To Minnesota conglomerate 134
 In the north end of the adit at the Bee location we have this section (File 14-41). The strike is N. 20 W. The cross-cut tunnel is near north.
11. Trap 0-246 at right angles to strike from north end of tunnel.
 At 115 seams 2" wide, dip 40° drifted on
 Amygdaloid 246-251, width 5', dip 49° ("North Amygdaloid")
 With heavy copper, now worked.
 Trap 251-327
12. Amygdaloid vein (to test pit?) 10 feet, dip 36° 327-337.
 Calico lode? 368-374. Amygdaloid vein 8 feet, dip 55°.
 Trap with numerous seams.
 At 400, 8-inch seam parallel to strike, dip 37°, at 430 8-inch, dip 37° E. of N., at 443 8-inch, dip 65° to N., at 457 8-inch, dip 55° to E. of N., at 463 6-inch, dip 34° to W. of N., at 472 4 to 6-inch, dip 35° just parallel to dip of formation.
13. Beginning of south end of cross-cut tunnel 520-526
 Along this there was a drift for 310 feet on the so-called "contact" or "south" vein. The adit into it was 165 feet farther west and showed the following bed:
14. Minnesota conglomerate 31
 Sandstone 57
 Foot and drift to a total of 200 feet.
 Thence to the north end of the south adit on Section 15 (see Pl. XIV) is about 1250 feet by (File 15-26) (920)
 Allow Beds 15 to 28 to correspond with the Mass section. (Fig. 53)
29. Black trap at N. end (1090)
30. Mass lode (presumed) 0-10 (220)
 Dip 46°, carries copper
 Dense gray trap 10-380
 6-inch parting, carrying copper with 44° dip
 18-inch parting, carrying copper with 35° dip
 3-inch parting, carrying copper with 32° dip
 Then brownish and gray, "felsitic",—i. e., very fine grained
 Below Minnesota conglomerate (1310)
31. Butler lode (presumed) 380-425 (Cf. File 15-26) (57)
 Trap 425-485
 See Plate XIV. Upon this there was considerable work done. (1367)
32. Amygdaloid d 19. 485-492 (Ogima lode?) (80)
 Trap d 19. 492-605 (1447)
 Early maps show conglomerate 50 paces north and a conglomerate 100 and a lode 830 paces south of the southeast corner of Section 15. The uppermost of these should come close below this section, and if Bed 31 is the Butler lode we should have (cf. the "Adventure" section).
33. Evergreen lode and foot, Adventure 12 (83) (2030)
34. Amygdaloidal melaphyre (71) (2101)
35. Feldspathic ophite (7 to 8 mm. faint) (267) (2368)

36. Caledonia conglomerate (Adventure 15) No. 8 probably underlain by brown sandstone. It will be noticed that here as there, no *known* conglomerate comes above it up to No. 14. But on the other hand there are unexplored gaps and the "Butler lode" may not be such. The distance as above given is greater than at the Mass (2149) but not much in such a patched section. A cross-fault may reduce the unexplored gap.

Below, the section is more or less exposed in bluffs on Sections 13 and 14 and on a hill known as the "South" or "Third Brother" on Section 21-22, south of the railroad. Owing to the cross-faults, however, the correlation is not sure. On Section 13 the crest of the bluff is made of a heavy 5 mm. feldspathic ophite with greenish bands that dip 62° to 66°, but underneath comes a narrow belt of red sandstone and shale with well-defined 33° dip, then amygdaloid and faintly feldspathic ophite with 40° bands to the base near the railroad track.

The section is important as indicating flat dips. The feldspathic character is that of the Evergreen bluffs. The distance from the Minnesota conglomerate near the north quarter-post of Section 14, 2400-2900 feet, would indicate that the section exposed must be some (1700) feet below and near the top of the Bohemian Range group. At a dip of 35° the section would be continued by that of drill hole 22. The heavy sandstone conglomerate bed of Michigan d 22. 383 feet, must probably be Mass-Adventure bed 15 or 21. But the bed above can hardly be Adventure 14. Adventure beds 19 and 20 in Hole No. 5 at 661-669 (which also contain copper) may better be compared. But if Michigan d 22 does skip the Caledonia conglomerate No. 8 it must be very close under it, perhaps immediately. This we assume. At any rate it seems safe to assume that Michigan 22 is in the same general position geologically that it is topographically. Just where it is and just which side of the fault shown on Plate XIV near which it lies is a question. Drill hole Michigan 22 is supposed to be about 1865 feet south of the "Butler" lode as exposed near the quarter-post between Sections 14 and 15 and about 3500 from the Minnesota conglomerate. The Butler lode is, however, thought to be thrown 400 feet by an oblique fault which produces only 80 feet displacement at right angles to strike, and a fault line (see Pl. XIV), which runs nearly north and south and throws the Powder House 7 mm. Bed 1 to the south on the east side, must run near the hole and may disturb the correlations. Still other faults have been recognized by Haight. The elevation is (by barometer from bench mark) 410 above Lake Superior. It lies south of the railroad track and west of the road in Section 15. The dip of the hole is to S. 45°, the apparent dip of the beds at the surface (for it starts on the north side of a low outcrop) only 35°. Compare the flat dips found in the lower Mass section. The record is as follows:

MICHIGAN DRILL HOLE 22.

- | | | |
|-----|--|-------|
| 37. | Glomeroporphyrite d 22. 1-35 | (35) |
| | Cf. Mass 52 | |
| 38. | Amygdaloid d 22. 38-45 with copper at 40 | |
| | Trap with amygdaloid spots d 22. 39-54 | |
| 39. | Glomeroporphyrite | (104) |
| | Amygdaloid d 22. 54-67 | |

- | | | |
|-----|--|--------|
| | Dark | |
| | Trap d 22. 67-159 | |
| 40. | Clay seam. Fault? d 22. 159- $\frac{1}{2}$ -168- $\frac{1}{2}$ (Adventure 15 cut out?) | |
| 41. | Melaphyre (Adventure 16) | (54) |
| | Amygdaloid d 22. 168- $\frac{1}{2}$ -198 | |
| | Trap d 22. 198-214 | |
| | Broken | |
| 42. | Feldspathic ophite (Adventure 17) | (69) |
| | Amygdaloid d 22. 214-235 | |
| | Trap d 22. 235-283 | |
| | 1-2 mm. at 236-266; but little core, considerable copper from 266 down to 283 | |
| 43. | Conglomerate (No. 7?) | (5) |
| | Felsitic d 22. 283-288 | |
| 44. | Ophite (Adventure 19 and 20) | (100) |
| | Trap d 22. 288-378 | |
| | Reddish, full of calcite, with specks of copper, at 296-299 a vein of calcite without copper, with chloritic bombs, 1-2 mm. green feldspars, and chlorite amygdules (and the core jams badly, largely sludge) toward the base and near the conglomerate, perhaps amygdaloid, very chloritic, with numerous laumontite seams at 31° and 50° to the core; occasionally 1-2 mm. mottles. | |
| 45. | Conglomerate and sandstone (Adventure 21?) | (62) |
| | Upper contact at 45°, conglomerate 338-388 with copper, at 378' 6", then brown sandstone 388-400 with dip at 64° to core. A seam at 79° to core shows other seams parallel to the core but faulted by it and thrown into the acute angle. Assuming that this angle with the core is due to a flatter dip than that expected we may infer an upthrust or if the seams are like the Central mine-vein that they have been similarly displaced. | |
| | Amygdaloid well-marked gray d 22. 400- | |
| | No. 23 is vertical from the same point and while at the surface it shows a dip about as indicated 35°, the steeper correlations show steeper dips so that this must be near a fault. The south bluff shows exposures beginning at the railroad about 3150 feet from the Minnesota conglomerate, perhaps 1700 feet from and 250 feet below the Butler or the top of that ridge. It must be close to the horizon of d 22. | |
| 46. | Amygdaloid | (40) |
| | Ophite | |
| 47. | Amygdaloid conglomerate | (95) |
| | Ophite 4 mm. 165 feet | |
| 48. | Amygdaloid | |
| | Ophite | (155)? |
| 49. | Amygdaloid conglomerate with much sandy material | (10)? |
| | Strike N. 77° E. Total 250-300 paces, 450 feet | (300) |
| | This is a section like Mass beds 62-64, or the beds from Adventure 24 on. There are no outcrops farther south. It is covered by the great dissected clay plain at about 418 feet developed in Mass holes, 1, 2, 3 and 4. Here 200 feet and more of heavy clay overburden may be often expected. | |

§ 28. VICTORIA MINE. (Pl. XV and Figs. 53 and 60.)¹

The Victoria mine has been drilled and I have prepared a cross-section which is given in Figure 53 with some additions.

The cores were looked over by Mr. R. S. Schultz, Jr., the engineer, and Mr. Menche. A fine set of samples of the cross-cut, the cross-cut itself as well as the neighborhood in general were also examined so that there are some modifications of the section as printed in their annual report.

The upper part of the section, the Nonesuch shale, found on Section 11, T. 50 N., R. 40 W., Copper Harbor conglomerate beneath found through Secs. 14 and 15, and the felsite ridge with beds above and below in 13, 14 and 15, faulted in 13, are easily identifiable and are at similar distances apart and make an identifiable top. The Rockland Creek section may be matched by outcrops in Section 19, T. 50 N., R. 39 W. The dips seem to be steeper west of the Ontonagon.

At 1131 in the cross-cut is a pumiceous bed which with the sandstone below and conglomerate above from 991 to 1178 (142) feet can be correlated very probably with Adventure 5, Beds 21 to 23 (168-) feet, as it makes up a peculiar group. If so, the Forest conglomerate becomes that great datum plane, No. 8, the top of the Bohemia Range group. 1,900 feet above it we find no sediment to speak of, which also agrees. The bed immediately above is, however, much thicker than elsewhere, although Lake beds 5 and 6 are not so bad a match. About 1,628 feet northeast of the shaft is a slip which throws the east side 50 feet south.

A detailed section of the cross-cut follows, but later drilling is included in figure 53, from Mr. Schultz's notes. See also notes on the distribution of salt water in the mines.

The Victoria mine 19th level cross-cut section. Compiled from notes and surveys and examination of specimens collected by R. S. Schultz, Jr. E. M. The dip at this level is about 54° to 55°; presumably flattening somewhat to the north, since about 3600' N. a dip of 50° was obtained. Distances along the cross-cut are accordingly multiplied by .82 to reduce to true thickness. The direction of the cross-cut at right angles to the lode is N. 22° 50' W.

About 1760-1800 feet N. W. of (1400) feet above the shaft is a conglomerate. Cut in No. 3 Hole as shown in Fig. 53.

1. Ophite 3-4 mm. 480 to 570 + 30? (100)

The cross-cut goes into the trap of this from 480 to 570 feet from hanging wall of the lode, 650 from the shaft. It seems to be getting slightly finer (2 mm. mottles) and has occasional chlorite amygdules at the end, the coarsest part being at 550 to 540 (about 3 mm. mottles). One may infer that something more than 30 feet (25 feet) would be needed to reach

¹In envelope.

the top of the flow and the overlying amygdaloid. The rate of increase A is 1 mm. in 16 ft. The augite grain at 570, 560, 550, 540, 530, 520, 510, 500, 490, 480 ft. respectively seems to be 2, 2, 3, 2-4, 2, 1.5-2, 2, 1-2, 1, 0 mm.

The plagioclase laths seem uniformly small in 570, and at 490 they appear about 4 mm. long but somewhat thinner near the margins. At 510 the magnetite granules were about 2 mm. and the altered brown olivine, iddingsite, which shows well in 490 is about the same. Greenish chlorite fills the interstices and replaces the olivine. The specimen at 510 ft. shows a seam with pink and green laumontite and chlorite coating, that at 500 a face with a shining, transparent, glassy coat, hardness 5. There is also calcite and laumontite. Another face is more thickly coated with chlorite.

2. Ophite 8-12 mm. 480 to 183 (240)

The grain at:

480, 470, 460, 450, 440, 430, 420, 410, 400, 390, 380, 370

augite 0, 3(?), 2-3, 2-3, 3-4, 4-6, 4-5, 8, 7-8, 7-9

plagioclase 1.0, 0.8, 0.6, 1.0, 1.0, 1.0, 1.0,

olivine 0.4, 1.0, 0.6

360, 350, 340, 330, 320, 310, 300, 290, 280, 270, 260, 250 is

for the augite 8, 4-6, 4-7, 10-12, 6, 7, 7-10, 6, 4-6, 4, 3-4, 4-5

plagioclase 1.0, 1

olivine 1.0, 1, 1

240, 230, 220, 210, 200, 190

augite 3-5, 3-4, 3, 2, 1-2, 1-2?

plagioclase 1, 1.0

olivine 0.6

The augite is not very regular in grain and seems, e. g., at 330 to have a certain tabular habit and parallel arrangement. The chances are that it was not very uniformly heated and somewhat supersaturated for some reason. The rate of increase A appears to be about 1 mm. in (13) feet. The plagioclase and olivine are coarser than in the belt above, about uniform in size, 1 mm. or so.

It is on the whole massive and fresh, though of course the olivine is altered to reddish iddingsite (?); there are the usual joint faces and seams covered with dark green chlorite at 300, and 290, which also fills interstices and turns the feldspar light greenish; also laumontite in flesh colored fibres on seams and joints at 280, 270, 230, 220. In 440 epidote is notable; in 430 epidote, prehnite, chlorite and calcite in a 8 mm. seam, and bright scales of hematite.

3. Feldspathic melaphyre 183-136 (39+)

This melaphyre has a more pronounced amygdaloid and is probably a smaller flow though some part seems to have been removed by the big slip at its base.

The sample at 183 is very fine grained, with fibrous chlorite full of small pores, and quartz, epidote and prehnite, and probably is just the base of the overlying flow. That at 180 is a red amygdaloid with epidote and quartz amygdules, and feldspar laths of various sizes up to 1 mm. That at 170 is similar with some prehnite in the amygdules and less conspicuous feldspar.

That at 160 has fewer large, white, but more small chloritic amygdules. That at 150 has but small pores.

- The specimen at 140 is fine grained, with considerable feldspar (0.8 mm. long) and greenish decomposition spots.
4. Clay slip, at 136.
This slip is filled with a red unctuous fluccan clay, wet and easily taken out in the upper levels, dry lower down. It is met in cross-cuts from the 4th, 5th, 6th, 18th and 19th levels always at practically the same distance from the vein and may be a typical "slide" or strike fault.
5. Melaphyre 136-100? (25)
This is quite probably not a separate flow, but only a gush of the underlying.
Specimen 130 is reddish amygdaloid with abundant epidote and white prehnite (?).
Specimen 120 is somewhat epidotic with prehnite, the feldspar rather conspicuous on a reddish ground (6-8 mm.).
110 is specked with prehnite changing to chlorite.
6. 3 mm. copper bearing ophite. 100 or less north from hanging to 20 south from hanging (98)
It is in the foot of this ophite that the shattered zone called the Victoria lode occurs. It is noteworthy that minute quantities of copper seem to occur frequently in the trap, not the amygdaloids nor the lode proper. The lode relative to the Evergreen or I. R. lodes is said to be low in silver, high in arsenic. It is a distinct ophite.
The augite grain is at:
40, 30, 20, 10, 0 feet N., 5 ft. S. respectively
1?, 2-3, 2, 1-2, 1-? 1-?
This gives a rate of increase from the bottom of A=1 to 15ft.
But the amygdaloid top is extra heavy. There is possibly a 20-foot separate gush.
At 90 there is a brecciated amygdaloid, red fragments with epidote or brownish and calcite cement.
At 80 the amygdules are relatively few, and the rock is gray with feldspar.
At 70 the amygdaloid with amygdules of epidote and quartz and of calcite is marked.
At 60 it is a trap with apparently amorphous chlorite blotches with very possibly considerable prehnite, and with spangles of copper.
At 50 there is also pink prehnite with copper.
At 30 the altered olivine (0.4 mm.) the feldspar (0.6 to 0.8 mm.) and the whitish mottlings are common.
At 20 it is also prehnitic with copper.
At 10 while the gray trap looks fresh there is a seam of laumontite.
The hanging wall is fine grained ophite with 5 mm. chloritic blotches. It is said to be a fairly well-defined line throughout the mine and marked by shallow saucer-like depressions which remind one of those formed by the "cannon ball" or "onion" disintegrations of diabases. Even when the foot runs along fairly uniformly the hanging wall will occasionally run up into fairly sharp points making the width of the lode vary from 50 to 14 feet.
Five (5) feet S. of the hanging wall at the 19th cross-cut is still clearly a fine grained ophite; the joints coated with laumontite, a thorough trap, in this respect like the Baltic lode in many places.
The foot wall at 20 feet is an amygdaloid but shows no copper.

7. Amygdaloidal melaphyre. Ophite. (?) with trace of copper. 20 S.-88 (56)
The mottling is hardly visible. At 20, 30, 40, 50, and 60 it is a reddish amygdaloid. The amygdules are in the 20-foot specimen of epidote and quartz; at 30 they are more sparse, with chlorite and prehnite also; at 40 more chloritic with some red specks, which are more abundant at 50, where they have red borders with epidote or quartz centers; at 60 there is some prehnite; at 70 it is almost massive; at 78 it is 1 mm. ophite, fine grained, reddish with prehnite and specks of epidote and quartz; at 80 there are amygdules of epidote, quartz, and pink prehnite with a trace of copper.
8. Amygdaloidal melaphyre 88-118 30 (25)
This is probably connected with one of the flows above or below. The specimen at 88 is a fine grained amygdaloid of pink prehnite (copper) and red bordered amygdules of epidote and quartz. The specimen at 98 is grayer, but shows epidote and prehnite, while that at 108 is greenish gray and shows epidote and quartz. This may belong with the flow below but the grain of the latter does not point that way.
9. Ophite feldspathic, 5-7 mm. 118-528 (343)
It is peculiarly red and massive. An exceptional thing about this, if it be all one flow, as seems most likely, is the fine grain of the augite for the size of the flow, as may be seen by these figures:
distance 208, 218, 228, 278, 298, 318, 328, 338, 348, 358, 368,
diam. of mottles 1, 2, 2, 1, 2-3, 3, 3-5, 5-7, 6, 5-6, 4-6,
388, 398, 408.
2-3, 2, 2.
The rate of increase and decrease from 268 to 428 is about 1 mm. in 11 ft., quite rapid but at neither place does there appear to be a well-marked contact. This agrees well enough in grain with the ophite under the Bluffs on the Tremont location in the N. part of Section 35, but does not look so much like that on the creek. Plate XV.
At 118 the specimen shows amygdules with epidote and quartz, and prehnite and pink border.
At 128 the amygdaloid is red and with small amygdules.
At 138 the amygdaloid is gray, with partially red bordered amygdules, containing epidote, calcite, a trace of copper, etc.
At 148 the specimen contains occasional epidote and pink prehnite specks. It is possible that between this and 158 comes a flow contact, but I think this 158, which contains small amygdules of epidote and prehnite and calcite tablets, is but a bomb. At 168, 178 and 188 the specimens are distinctly a fine grained trap with chloritic flecks.
At 198 it looks a little coarser.
At 208 it is red, fine grained, perhaps a 1 mm. ophite.
The feldspar laths are on the whole usually small; at 218, 0.2mm; 228, minute; and at 248, 258, 328, 508, 518 ft. 0.6 mm. The grain is then only in general half as coarse as flow 2 above the lode.
Chlorite blotches at 248, chlorite and prehnite pores at 268.
Altered olivine may be 0.2 mm.
10. Conglomerate (8) mainly sandstone 528-668 (115)
The specimens are:
At 528 a dark brown sandrock, with granules of felsite mainly and a

poikilitic calcite seam, in contact with the trap which is brown for 3 mm., then greenish for 12 mm., then reddish.

At 538 the cement is yellow, epidotic, the pebbles of red felsite and quartz porphyry.

At 548 the cement is calcite, and the grains of felsite and darker stuff less than 2 mm. across.

At 558 is an amygdaloid with calcite and chlorite slips.

This may be from an intruded block, considered by L. L. H. a separate layer.

At 568, a brown sandstone with calcite cement.

At 578, rounded red pebbles, grains of felsite and prehnite, and a cement of sand and calcite.

At 588 and 598 grains 2 to 4 mm. and smaller, largely basic.

At 608 sandstone with bands coarser and finer, the coarser with calcitic cement, the finer dark brownish red.

At 618, there is a pebble of distinctly porphyritic feldspar porphyry.

At 628, 638, 648 a dark brown sandstone, respectively, less than 1 mm., 1-5 mm. and very fine grained.

At 658 the transition at the base is to an amygdaloidal conglomerate with calcite and laumontite amygdules and fine reddish brown cement.

On the whole the bed seems to be more sandstone than conglomerate, and on the whole finer toward the base. This last is also true of the bed from 998 to 1038. At the top is salt water,—Chapter VII, § 5.

This is the beginning of (530) feet in which there is a large proportion of sediment, 528-668, 998-1048, 1128-1188, and no very heavy trap which should therefore be a marked topographic feature. This is true. The Forest Conglomerate outcrops on the flanks of the hill on the road to the Norwich just S. W. of the Victoria mine location, and there is a fairly continuous valley, with a double ridge S. of it to the Lookout, a triangulation station of the mine survey.

The bed above also seems somewhat characteristic, being rather feldspathic.

11. Feldspathic melaphyre 668-788 (98)

In this bed the feldspar and olivine were probably relatively abundant.

The specimen at 668 is a decomposed amygdaloid with chlorite, epidote and calcite, the feldspar is 1 mm. long on a blue-gray ground.

Those at 678-688 a gray trap with 1 mm. feldspar, and at 688, 1-2 mm. augite.

Those at 698, 708 and 718, similar but look coarser, quite reddish, more so than flows 6-8.

Then at 728 one can see the red specks of secondary hematite after olivine.

In that at 738 the feldspar is 1-6 mm; there are white seams and red blotches of clay enclosures or altered olivine up to 8 mm. across.

In that at 748 the red specks are 2 mm., the general effect is 1 mm. granular; laumontite seams appear.

That at 758 has finer bands of reddish specks.

That at 768 has greenish feldspar up to 3 mm. tending to a glomeroporphyritic nature.

That at 778 has 1 mm. feldspars with specks of chlorite quartz and epidote.

12. Feldspathic melaphyre 788-828+ part cut out? (33+)

The specimen at 788 is amygdaloid, with epidote, quartz crystals, and chlorite, prehnite and traces of *copper*.

That at 798 also shows calcite, epidote, *pink prehnite*, and quartz.

That at 808 shows distinctly 1.6 mm. feldspar, 1 to 2 mm. augite and a green chloritic ground.

About 818 there is a slip, a branch of that at 890 feet (?), the one that cuts the shaft at the 14th level. ?

The specimen is a fine grained, massive, reddish trap with a greenish white joint seam and others parallel.

See notes on slip at 890.

13. Ophite 828-918+ part cut out (74+10?)

The alteration of this bed seems to be affected by the very considerable seam at 890 feet.

The specimen at 828 feet is a red amygdaloid, with greenish prehnite, small amygdules (2 to 3 to <10 mm.) not brecciated.

That at 838 shows very light small mottles $\frac{1}{2} \times 1$ to $1/5$ mm., on a gray ground, apparently decomposed augite.

The grain of the augite at:

838, 848, 858, 868, 878, 888, 898, 908 ft. seems to be respectively

.25, 1-2, 2, 2-3, 2-3, 2-3, 1-2 mm.

The rate of increase at A is about 1 mm. in 11 ft., and there is perhaps 10 ft. cut out.

14. Clay slip at 890, is filled with a regular red fluccan clay; dip 45° to 46° to S. Strikes S. 80° W. Passes through the plat of the shaft at the 14th level and strikes the 14th level next, there being a cross-cut of 70 to the level, about 200 W. of the same, dropping the hanging wall down about 10 ft. and temporarily impoverishing the lodé.

15. Feldspathic melaphyre 918-997 (73)

The specimen at 918 is a fine grained amygdaloid with epidote, chlorite, calcite (and prehnite?)

That at 928 is blotched and decomposed, greenish gray, with epidote, and abundant red feldspar and augite.

That at 938 is similar, coarser, feldspathic. (2 mm.? augite).

That at 948 is similar, with greenish seams.

That at 958 has 2 mm. feldspar, is full of yellow epidote with chlorite and quartz in small specks (microdruses).

That at 968 shows a speck of *copper*, in the dark chloritic blotches. The feldspar is greenish.

That at 978 and 988 has similar chlorite blotches. The feldspar is greenish.

16. Conglomerate and sandstone 997-1048 (41)

The contact at 997 shows trap on one side, epidotic cement, calcite felsite pebbles and minute veins of calcite crossing them.

The specimen at 998 has an epidotic cement, inch pebbles of not porphyritic felsite dominant, sand of quartz and felsite. There was some *copper* in the hanging.

Those at 1008 and 1018 show a dark sandstone with a few dark pebbles, of quartz and felsite grains <1 mm. round; light green joint seams.

Those at 1028 and 1038 show a change from a quartzose sandstone with calcite to a red argillite or shale. It is like the mud in the amygdaloid conglomerates, and it is not uncommon in this region for conglomerates to have such a base.

17. Amygdaloidal melaphyre 1048-1131 (68)
 The specimen at 1048 shows a red amygdaloid with calcite and prehnite amygdules.
 That at 1058 is decomposed, with pink and green blotches, and pink spots (laumontite).
 That at 1068 is fine grained with specks of quartz, chlorite and laumontite.
 That at 1078 is greenish white, with epidote and white specks.
 That at 1089 is a typical amygdaloid, with white and greenish amygdules on a maroon ground, disseminated epidote, calcite, prehnite, and probably a trace of copper.
 That at 1098 is full of small (1-3 mm.) white amygdules.
 That at 1108 is banded with bands of small white amygdules.
 That at 1110 is very amygdaloidal, with prehnite and calcite amygdules and much epidote in the gray ground.
 That at 1118 is a maroon amygdaloid with light greenish spots.
 That at 1128 is a perfect mass of small amygdaloidal pores, (some larger) approaching a pumice, while that at 1131 was a perfect pumice, banded and altered and full of white amygdules, with pink borders. There is a very dark base and a streak apparently of ash and sediment. This may belong with the bed below. Evidently this flow was laid down in the sediment 15 and 17 when the same were wet and the base was heavily steam laden. Something like it is found in the Torch Lake section south of Calumet.
18. Sandstone. 1134-1178 (33)
 The specimens at 1134, 1138, 1148, 1168, 1178, are all a dark brown sandstone, with a fine grained felsitic sand. That at 1138 is very heavy and dark.
19. Ophite 1188-1308 (98)
 The ophitic character is not plain especially at top. The specimen at 1178 shows the contact of a dark slate blue amygdaloid with white amygdules, while that at 1188 shows smaller white and chlorite amygdules.
 The augite grain at:
 1198, 1228, 1248, 1258, 1268, 1278, 1288, 1298 ft. appears to be perhaps
 2, 2?, 3-5, 3, 3-5, 2-3, 2, 1-2, 1 mm.
 The rate of increase A is perhaps 1 mm.:10 ft.
 The feldspar is only 0.4-0.6 mm.
 The specimen at 1198 shows the yellow-gray epidotic alteration.
 That at 1208 is brecciated with calcite and epidote.
 That at 1238 is laumontitic specked and seamed.
 That at 1248 has a chloritic joint and is laumontitic.
 The trap is generally reddish.
20. Ophite 1308-1438 (106)
 The specimen at 1308 is an amygdaloid of epidote and calcite on a dark maroon ground.
 That at 1318 is decomposed, slightly amygdaloidal with yellow ophitic ? mottles.
 That at 1328 is similar (Cf. 1198) with occasional large amygdules with prehnite, calcite and copper.
 The augite grain at:
 1318, 1328, 1338, 1348, 1358, 1368, 1378, 1388, 1398, 1408, 1418 ft. appears to be

- 0.5-1. 1.5, 2, 2-3, 4-5, 4, 7 faint, 5-8, 3, 2, 1-2 mm.
 The base is abnormal and the grain shows some irregularities. It is very apparently abnormally coarse toward the base. This may for some reason have been a little extra cool at the beginning of consolidation, or more likely its cooling retarded. The grain from the top down would be about 1 mm. in 10 ft. while from the base ?, which was probably hot when it rolled over it, would be 1 mm. in only 5 feet! There is no distinct amygdaloid beneath, and very likely 19 and 20 would be found to blend elsewhere.
21. Ophite underflow of 19? 1438-1569 (106)
 The specimen at 1438 is a decomposed epidote seam with quartz and large (40 mm.) poikilitic patches of calcite (luster mottled).
 That at 1448 is the same with curious red flecks on a yellow-green ground.
 1458 is a fine grained reddish trap with minute chlorite amygdules, and at
 1478 there are chlorite lined pores.
 The augite grain at:
 1468, 1478, 1498, 1508, 1518, 1528, 1538, 1548 ft. seem to be
 2, 2, 2, 3-4, 4, 2-3, 3, 2 mm.
 The rate of increase A at the bottom is about 1 mm. in 19 ft. It is notable that just as the bottom of 2 has grain increasing extra fast so that of 20 increases extra slow. This may be explained by a change of heat (or unequal initial heating) from the top of 20 to the bottom of 19.
22. Ophite 1569-1650 (68)
 The specimen at 1569 is a typical maroon amygdaloid with epidote bordered quartz and calcite amygdules.
 That at 1508 is more massive but has still a hackly fracture and a trace of copper, while that at
 1588 has quartz and epidote amygdules on a gray base, and in that at
 1590 they are in parallel lines; with epidote pores and a trace of copper; even that at 1598 is slightly amygdaloidal, porous and much epidotized.
 The trap is red and the augite grain at
 1608, 1618, 1622 ft. appears to be
 2-3, 2, 3 mm. respectively.

The work of Plate XV was done by A. H. Meuche in 1908, assisted by his brothers, Karl and Leon. Mr. R. E. Hore and I were in the area a few days. Mr. P. S. Smith and W. V. Savicki also did some work in 1900.

The horizon of the Forest conglomerate, No. 8, can be carried along easily to Section 34, T. 50 N., R. 40 W. Here there is a gap across the range and a wide swampy valley not over 500 ft. above Lake Superior. But two conglomerates can be found on the other side, the uppermost of which is pretty likely to be the Forest as indicated by Meuche. A fault throwing the east side to the south (like that on Section 13) is suggested and as well a turn of the strike more to the south from southwesterly. This brings us past the Old United States location to Section 4, T. 49 N., R. 40 W., whence it is but two miles to the old Norwich, the Copper Crown Just off the map (Pl. XV) in Section 20 a conglomerate dipping 32° is exposed in a stream about 400 paces north, 700 west of the southeast corner and the position of the felsite and the Ashbed group, can be located also.

An old map of the Canal lands (File 15-28) gives beside the Victoria section of

Plate XV. and the West Minnesota section, a section in Sections 3 and 33 with the following lodes, reckoning south from the west quarter-post of Section 33.

Amygdaloid	at 150 paces
Conglomerate	at 300-400 paces
Amygdaloid	at 600 paces
Road	at 950 paces
Lodes	at 1300, 1450, 1500, 1800 and 1850 paces

One of the two last is meant for the Forest conglomerate without doubt.

Also another at 2075 paces.

The same map gives a section from the Hamilton to the Norwich along the west line of Sections 1 and 12, T. 49 N., R. 41 W., as follows: beds at 0, 150, 250 (apparently the conglomerate of the section just mentioned) 1230, 1430, 1570, 1760, 1880, 2350, 2400, 2460, 2600, 2860,

§ 29. THE COPPER CROWN (NORWICH) MINE. (PL. VIII.)

Recently some work was done about six miles east of the Victoria on Sec. 11, T. 49 N., R. 41 W., especially in connection with old-time Norwich and Devon conglomerates, and the intervening territory was carefully worked up under the supervision of A. H. Menche with results shown in Plate XV.

A prospectus issued in 1905 shows five belts of amygdaloid with dip 46° - 56° . The company owned 1,000 acres, had two shafts, 75 to 100 feet deep and near the east shaft an adit. The bedded lodes were faulted by a lot of small 10 foot throws, the east side thrown north.

§ 30. PORCUPINE MOUNTAIN. (See Pl. IX, Report for 1908, and Fig. 54.)

Dr. F. E. Wright is making a careful study of the Porcupines and a preliminary map will be found in the report for 1908. The section from the base of the Freda sandstone to the Chippewa felsite is given with not much disturbance on the north side of the range. There is no olivine diabase in the Freda sandstone.

The copper deposit worked at the White Pine lies on the northeast side of a fault that strikes northwest. (See Pl. I, Report for 1908.) Near the fault the Nonesuch shales and grits are bent down toward it in approaching it from the north, and are then thrown down several hundred feet. The black shales themselves contain notable quantities of copper, but the most up to 5% is found in the sandstones beneath which are white or grey. The values run down as the red sandstone below is reached (exactly as noted by Weed in New Jersey).

Also and most interesting the values are practically gone on the lower dropped side of the fault, (see Fig. 54).

¹Plate IX is in envelope.

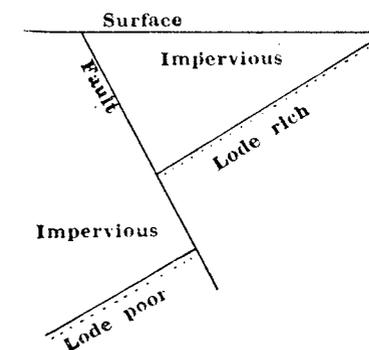


Fig. 54.—Faulting of the Nonesuch Lode at one point on the White Pine.

This might, of course, be well explained by supposing ascending solutions following the fault and then veering off to follow the contact between the pervious sandstones and impervious shales. If so, however, one would rather expect a mineralization down the fault line which has not yet been found. This explanation also takes no account of the fact that this particular formation is very widely mineralized,—near Lone Rock, Black River, almost everywhere that I have had a good look at it. We may also assume that the fault line acted simply as a clayey impervious shield to check circulation of any kind along the contact of slate and sandstone. The conditions are illustrated by the records of a number of holes put down by the Calumet & Hecla people.

Beneath this to the Lake Shore trap is clearly the Outer Copper Harbor conglomerate, of which over 200 feet is exposed. A knob of conglomerate is well exposed on Section 36 where the trail to Lafayette Landing turns northwest and a faulted ridge extends to the southwest. It is very coarse, and contains a lot of porphyrite pebbles, with labradorite, oligoclase and acid feldspar. It contains a few of amygdaloid, and occasional pebbles of breccia.

At a 27° dip there would be about (2800) feet
Quite likely as Irving says there is over (3000) feet or as
at Black River (6000) feet
The Lake Shore traps are about (400) feet
fine grained traps with coarse quartzose amygdaloid.

The lowest bed appears to be a 50-foot bed of feldspathic ophite with 1 mm. augite grain and 0.4 mm. feldspar laths. These seem to be three flows along the cliff. No melaphyre porphyrites or intermediate conglomerates show, nor are there any coarse ophites.

But they are mainly amygdaloidal ophites with grain less than 2 mm., and large coarse amygdules, round and white, with more laumontite than epidote. In all respects they resemble Division 4 of the Black River section¹ and there is clearly nothing like them at Rockland where the whole section between Nonesuch and felsite has greatly shrunk. This is the first of many indications that at the Porcupines was a volcanic focus. Beneath we come to the Great Copper Harbor conglomerate which occupies only part (just how much is uncertain) of the interval between the felsite and the Lake Shore Traps. It is certainly included in the interval between a point 1400 paces north 1600 paces west in Section 33 and the east quarterpost of Section 28, T. 51 N., R. 42 W., with flat dips, but we must wait for Wright's detailed work before bettering Irving's estimate of (1800) feet, which is probably a maximum, since on the Black River, 5 with 6a and 6b, which may also be included if the eruptive group 6a is not exposed, only amounts to 1850 feet.

Next follows the Ashbed series, exposed in Sec. 33, T. 51 N., R. 42 W., including one coarse ophite but characteristically feldspar porphyrites and porphyries and based on a heavy felsitic conglomerate which seems to be derived from the underlying felsite which forms the backbone of the Porcupines. This is bounded on the south by a great fault, along which are a mass of smaller faults. On Sections 3 and 4, T. 50, R. 44, the cut in the felsite boundary (Pl. VIII) is not due to a fold but to exclude an intrusive gabbro. Felsite intrusives were also discovered by Wright in Section 4. The very interesting relations here must wait for their full description until his work is ready for publication.²

It seems very probable that, as Irving thought, this main mass of Porcupine Mountain felsite is the same as the Chippewa felsite and that it is brought up by the fault shown in the map of the annual report for 1908,³ repeating the conditions of the great Keweenaw fault on a small scale. (See also Irving's sections⁴.)

The normal section should be found in T. 49 N., R. 42 and 43 W. but T. 49 N., R. 42 W. around Bergland has an extensive development of felsite and quartz porphyries, so that it required detailed study. Not only is there a great ridge of porphyry north of the Cascade River, as Rominger pointed out, occupying most of Sections 9, 10, 11, 12, 15, 16 and 17 and extending down into 19, 20 and 21, but as

¹Report for 1906, p. 430.

²See also Wadsworth's work for Longyear and Smith and Savicki's work. Ss. 19518-19703. Note books 157-159.

³The elevation of Little Carp Lake there given as 900 feet is that above Lake Superior. It should be 1602 above sea level.

⁴Monograph 5 and Figs. 1 and 2, Report for 1905.

Wadsworth notes there are similar rocks intrusive in a great belt of ophites (up to 8 mm. mottles) in Sections 26, 34 and 32, and 500 paces south of the south corner between 31 and 32. These intrusives are other signs of nearness to a volcanic focus. So too is the appearance of traps of the Keweenawan lapping up on the iron ranges south of Lake Gogebic.¹ They are many of them porphyrites rather than ophites, have flat dips, and might represent some of the Ashbed series, though if so there are marked differences, and the Black River section would suggest rather that they belong in the Bohemian Range Group.

Beyond the Porcupine Mountains comes the Presque Isle River described by Irving² and similar in section to that at Black River except that the north and south ranges of Keweenawan have not come together.

§ 31. BLACK RIVER. (Fig. 55¹) (Pl. 33 of Report for 1906.)

A detailed section of the Black River was given by Gordon in the 1906 report.² For convenience we may summarize it here with the nomenclature herein used, adding the section of sandstone on the Montreal Upper Keweenawan.

- | | |
|--|--|
| 1. <i>Freda</i> sandstone | (5000+?) on Montreal River |
| 2. <i>Nonesuch</i> shales | (500) |
| 3. <i>Outer</i> conglomerate. <i>Outer Copper Harbor conglomerate</i> | (5000) |
| 4. Lake Shore Trap. Five flows (35), (35), (115), (85) and (130) feet thick respectively | (400) |
| 5. Conglomerate just like the Middle or Great Copper Harbor conglomerate | (350) |
| 6. Mixed eruptives and sedimentaries | (5500) |
| | about 38 belts, about 3000 feet unexposed, with at least 7 sandstones and conglomerates 20 to 30 feet thick generally, down to the base of the Chippewa felsite but the lower eight beds are more felsitic, only Beds 20 to 24 being distinctly ophitic. We may divide this into |
| 6a. Six beds of melaphyre possibly belonging to the Lake Shore traps but probably to the Eagle River Series. | |
| Thicknesses, (60) + (90) + (180) + (90) + (180) + ? | (600) |
| 6b. Covered 1200=(Gordon's 16 and 17)= | (900) |
| | ends in conglomerate, perhaps largely conglomerate and sand- |

¹The scattered traps of what used to be called the South Range, rising from the Eastern sandstone begin at Silver Mt. and are exposed in Sec. 16 near by on the Ontonagon. They are shown on a map prepared by Denton for the Chicago exposition, and in a map in the report for 1901.

²Monograph V, U. S. G. S., pp. 208-220. See also Pls. XXI to XXIII and Pl. I of Report for 1908.

¹In envelope.

²P. 421 and Pl. XXXIII and illustrations.

stone. This is as far as the Great conglomerate could possibly come.

- 6c. Melaphyres Nos. 8 (40) and 19 (40), ophites 20 (75) and 21 (70); faulting; melaphyre (80) sandstone (30) dip 42°, ophite, conglomerate (20), melaphyre (25) melaphyre (25), melaphyre (25) melaphyre (60) melaphyre (20) melaphyre No. 31 (40) melaphyre (20) sandstone (25) dip 44°, 4 melaphyres (30), (70), (140)? feet. The Eagle River series may end here with from (835) feet thickness up.
- 6d. No. 38 gap unexposed for 900 feet, in which somewhere is probably the top of the Ashbed series; the beds are distinctly more felsitic.

Ashbed group

- | | | | |
|-----|---------------|---|-------------|
| 6e. | No. 39. | Conchoidal fracture porphyrite | (90) |
| | 40. | And 41 quartzless porphyries | (90) + (90) |
| | 42. | Sandstone | 30 |
| | 43. | Melaphyre | (45) + |
| | 44. | Unexposed | (170)? |
| | 45. | Sandstone | (20) |
| | 46. | Melaphyre | (70) |
| | 47. | Conglomerate | (100 +) |
| | | Unexposed, largely felsite perhaps | (1300) |
| 7. | 48. | Chippewa felsite | (500) |
| | | Below this within 200 feet are 5 mm. ophites so I do not hesitate to place this felsite here at the base of the Ashbed series, which in that case would be between 3500 and | (2500) |
| 8. | 50. | A sandstone. Under the Chippewa felsite; would then be the Mesnard. | |
| | 51 and 52 | are ophites | (80) |
| | 53. | An acid sandstone; would be the Allouez No. 15 conglomerate | (10) |
| | 55. | A felsite sandstone and conglomerate | |
| | 56 to 58 | are ophites | |
| | 59. | Is unexposed | |
| | 60 to 61 | are ophites | |
| | 63, 64 and 65 | are like Ashbed rocks | (900) |
| | | This is the end of nearly continuous sections, but down to 72 no sandstones are noted. | |
| | 73. | Is about 100 feet thick of sandstone like the Wolverine, about 17000 feet horizontally below the felsite at | (1300) |
| | 78. | About 1200 below is a feldspar porphyry of unknown thickness. 800 feet below this is unexposed. | |
| | 80. | Is the coarsest ophite seen with mottles up to an inch across. | |
| | 81. | Is another | |
| | | Below these ophites is 8500 feet unexposed in which it is more than possible that great strike faults like those that bound the south side of the Porcupine Mountains and Keweenaw Point pass so that it is | |

doubtful how much we need to add for thickness, if anything.

9. The porphyrites are much like (and may be considered provisionally equivalent to) the *Bohemian Range* group. There is a strong tendency toward coarsely porphyritic 30 mm. labradorite porphyrites. Felsite occurs and there are intrusive diabases as well as a gabbro sill. Ophites are rather the exception. Amygdaloid conglomerates occur. Down to the gabbro are 41 beds, and but little of the column unexposed Nos. 83-124 (4800)
- This group reminds me somewhat of the Ashbed group but is so different that I hardly think it can be a faulted repetition of the same. The presence of intrusives also suggests a lower position.
10. A 200 ft. gabbro sill is intrusive, coarsely granitic, not much like the Mt. Bohemia gabbro but more like the Bad River gabbro to the west.
11. Melaphyres and labradorite porphyrites occur below with but little sediment, numerous flows with well-marked contacts and pipe amygdules (125 to 187) 62 of them about (4500)
12. The basal sandstone has but 300 feet exposed, and not always that as the Neo-Huronian is unconformably overlapped by the Keweenawan. (300)

§ 32. MONTREAL RIVER.

The last section in Michigan in this section is that of the Montreal River and neighborhood. It will be found described by Irving¹ and some corrections by myself.² The noticeable thing is that we are back to a type of section like that at Rockland. The Lake Shore traps seem to be gone. The Outer and Great conglomerate are merged in one Copper Harbor conglomerate. We have:

Freda sandstone	(5000) +
Nonesuch shales and sandstone	(350) +
Copper Harbor conglomerate	(1200)
Twenty-six small beds of the Eagle River Group	(1212)

Nos. 2, 4, 8, 14, 22 and 26 are sediments, only 14 conglomeritic, the rest red sandstone and shale, showing that we are leaving their source. This is the end of the section on the river, but felsites, ophites and gabbros may be found farther south and west exposed here and there, the felsites near the D. S. S. and A. track, and as Irving remarks gabbros become more abundant, and the red rocks (gabbro aplites) associated with them.

The indication is clear that the Porcupine Mountains were a volcano, a center both of erosion and outpour late in Keweenawan history. But it was not the only center. Another was at Mt. Bohemia. The last outburst of Lake Shore Traps at the two centers seems to have been nearly simultaneous, though probably

¹Monograph V, pp. 226-229.

²Annual Report for 1908.