

CHAPTER V.

DETAILED STRATIGRAPHY.

§ 1. INTRODUCTION.

A general summary of the Geological Column of the Keweenaw is given in Chapter I, § 7, and in the Report for 1908, pages 30 to 38. The column or succession of beds is illustrated by Figure 4 in this chapter. We may proceed at once to consider the detailed sections. In Chapter I we took up the order of succession first with the Lower Keweenaw and the lower part thereof,—the Bohemian Range Group. It seems to me best in this chapter to follow a geographic order, and begin at the end of Keweenaw Point and go thence westerly, in general with the hands of the clock and with the sun around Lake Superior, since the sections explored in the different regions vary and overlap the different divisions more or less. It may be well, however, to run briefly over the different divisions and indicate in what regions they occur.

The Lower division, the Bohemian Range group with conglomerates and felsites at its top, extends from the part so carefully studied by Hubbard on the south side of Keweenaw Point near the mouth of the Montreal River, T. 58, R. 38, past the Mendota section (Fig. 26) almost all along the range, though often heavily masked by drift. The Torch Lake section shows but very little of it and it may be that where the Keweenaw fault uplift is much split it is absent altogether. The South Trap Range coming around from the south end of Lake Gogebic, and lying south of the Duluth South Shore and Atlantic Railroad seems to be wholly in this group. I judge that it is developed in Wisconsin and Minnesota, but does not appear on Isle Royale. I think that the Mamainse section is largely in this group.

The Central group is that found everywhere. Most of the sections are in it. (Fig. 24 et seq.)

The Ashbed group is very continuous, yet little drilling has been done in it outside of Keweenaw County. South of Atlantic the only drill section exposing it well is that at the Winona. Apparently from the Ontonagon County line toward the Porcupine Mountains it contains genuine felsites which are absent elsewhere. I do

not think that the Mamainse felsites are of this age, but rather earlier. There seem to be, really, but two epochs of felsitic intrusion. The only sections that show it well are those at Copper Falls (Fig. 30), Eagle River (Fig. 34), Calumet and Tamarack (Fig. 36) and Isle Royale (Fig. 56). The Arcadian (Figs. 41 and 42) and Winona (Fig. 50) shows something of it and it is exposed around Rockland (Fig. 52).

Structurally, the Upper Keweenaw might begin here, but it has been defined as not including any effusives. So defined, the "Outer" or uppermost of the Copper Harbor conglomerates becomes its base, and the Upper Keweenaw fringes the north side of Keweenaw Point from less than half a mile from the end to the north branch of Agate Harbor (broken by Copper Harbor), reappears about five miles west of Eagle River and about one mile northeast of Gratiot River and occupies the coast up to Oronto Bay. (See Report for 1908, Fig. 3.) Its upper member, the Freda sandstone, is frequently exposed, but only where uplifted by the Porcupine Mt. faulted anticlinal (see Annual Report for 1908, Pl. 1) are the lower members exposed along shore, and in the interior where there are numerous exposures which may be attributed to the Copper Harbor conglomerates, the Lake Shore traps are rarely found. They, indeed, seem to be absent for part of the way between Portage Lake and the Porcupines, where the base of the Upper Keweenaw has not been accurately located. Above the Lake Shore traps there are really no signs of igneous activity. That is one reason for my belief that the Upper Keweenaw is closely allied with the overlying Upper Cambrian Lake Superior Sandstone. This agrees with Irving's general statement,¹ although in describing the Porcupines he mentions (p. 223) a heavy dike of olivine diabase on Section 26-51-44 which, if it occurred, would be an exception to this rule. But at the point indicated there is only the emergence of a great fault with gritty beds of the None-such indurated so as to look exceedingly like an igneous rock,—from a boat, for instance. Since the original notes and specimens have been lost one cannot say how the mistake occurred. Probably² Irving did not visit this place himself.

The Eagle River group probably interdigitates with the Great Copper Harbor conglomerate by the dropping out of its upper trap beds. The Copper Falls (Fig. 30), Eagle River (Fig. 34), Calumet (Fig. 36), the workings of the Hancock mine, the Black River section (Report for 1906, Pl. 33) are the best sections.

¹Monograph V, U. S. G. S., p. 152.

²Loc. cit., pp. 3 and 4.

The Copper Falls conglomerates, Great, Middle and Outer, and Lake Shore traps have been but little explored and few of the diamond drill sections indicate them. They are best exposed in the Porcupine Mountain district. The heaviness of these conglomerates and the variety of pebbles they contain indicate to me a very considerable unconformity.

§ 2. END OF KEWEENAW POINT. CLARK-MONTREAL (FIG. 23).

On the end of the Point the beds run fairly continuously from west to east, tending southeast at the tip, though traversed by veins nearly at right angles to them, with which are associated faults nearly at right angles to the formation with small throw. These faults, on the whole, strike more northeasterly than they would were they just at right angles to the strike and the east side is often thrown south. (See Keystone Location 30, T. 57 N., R. 27 W.). The explorations seem to have been almost exclusively confined to the veins and to the horizon just below the Greenstone, the Allouez.

The beds are best shown at the end of the Point (where the dip is about 23°), and opposite Copper Harbor, where the upper beds were described in the very earliest report³ and again by Irving⁴ and Hubbard.⁵

We have the following section according to Hubbard (p. 63 and Pl. IV) assuming the Greenstone to be 1,270 feet thick, (its breadth of outcrop of about half a mile combined with a dip of 31° to 35° and its thickness in the Mandan section all point to a thickness of over 1,000 feet).

Outer conglomerate	(1000 feet ⁶) (half a mile of 23° dip)
Upper Lake Shore Traps	(1062 to 1100)
Middle conglomerate	(200 to 700)
Lower Lake Shore Traps	(400 to 550)
Great conglomerate	(1200 to 1250)
Eagle River group	(1308) (Irving 1,417)
Ashbed	(2000) } (Irving 1543)
	3270?
Greenstone?	(1270) } (Irving 1200)

Some drilling above the Greenstone up here would be desirable, though the flat dips are against easy mining. From the foot of the

³See Foster and Whitney.

⁴Monograph V, U. S. G. S., pp. 186-187.

⁵Vol. VI, Pt. II, Chapter II and Chapter III, §§ 8 and 9.

⁶Thicknesses in parentheses, (25) for instance, refer always to true thickness at right angles to the dip.

(Greenstone to the north shore of Breakfast Lake a section was drilled by the Calumet and Hecla Mining Company, whom I have to thank heartily for permission to examine the cores and especially for the results of the cyanide tests for copper. The detailed section follows, and is illustrated by Figure 23.

Calumet and Hecla section on Clark property N. from Breakfast Lake $\frac{1}{4}$ mile west of the East line of Sections 8 and 5, T. 58 N. R. 28 W. See Figure 23 (In envelope).

Sections by W. J. Penhallegon, and notes of A. C. Lane.

The section gave an average tenor of copper as follows		
Hole 1.	943 ft. into	5.1199 ⁶ ave.
2.	597 " "	1.185 "
3.	445 " "	3.01 "
4.	432 " "	2.032 "
5.	424 " "	4.385 "
6.	581 " "	47.037 "
A.	236 " "	2.62 "
7.	360 " "	5.425 "
8.	641 " "	18.12 "
9.	378 " "	15.655 "
	5,037	104.5889 ave.
		.02

But there was a certain amount of duplication and overlapping which should be allowed for as it materially affects the results. On the other hand, nothing less than .01% was estimated, so that an average of .0025 may easily have been ignored.

Closer figures could be obtained by taking the content for each bed, and multiplying by the thickness, did it vary with different beds and remain constantly high for some, but it does not. The average is not very different from that obtained in Holes 1 and 2 at Mamainse. Unless mentioned the sludge is reported as .00 copper. On the whole there is more copper in the upper beds. The distribution seems rather associated with chlorite seams than bedded lodes.

Clark drill hole 9. On the "Greenstone" 5739 feet north of Breakfast Lake and 106.84 feet above it (288.01 above Lake Superior) about 1250 paces N., 500 W. in Section 8, T. 58 N., R. 28 W. The dip of the hole is 66° 30' to the south, i. e., so nearly at right angles to the beds that true thickness is obtained at once, though the dip appears to be really about 26°.

1. Ophite, the Greenstone d 9. 12-34 (72)

An ophite growing finer at 24-30; 0.09 copper

2. Conglomerate, the Allouez No. 15 d 9. 34-82 (48)

It is basic especially below 76 and there are pebbles of ophite as well as felsite. It is mainly fine grained. The dip varies from being at right angles to the drill core about 6° to 7° indicating a possibility of a dip just that much more or less than 23° 30'; at 31-37 the copper content is 0.07, 37-43, 0.19, at 43-62, 0.03, at 64-82, 0.07.

3. Feldspathic melaphyre (46)

Amygdaloid d 9. 82-87 = (5) at 82-83, 0.06, at 83-85, 0.07 Cu

Amygdaloidal trap d 9. 87-91 = (4), at 85-99, 0.05 Cu.

Feldspathic trap d 9. 91-128 = (37), at 99-102, 0.05, 102-107, 0.09, at 107-117, 0.59, 117-120, 0.71, at 120-122 0.64 Cu.

⁶Total obtained by multiplying the percentage of copper in various samples by the number of feet which the sample represented.

4. Melaphyre (17)
Amygdaloid d 9. 128-130 (2), at 122-130, .08 Cu.
Amygdaloid trap d 9. 130-145 (14); at 130-153 trace Cu.
The trap is coarse amygdaloidal except the last foot at 145.
5. (8)
Amygdaloid d 9. 145-150
Chloritic amygdaloidal trap d 9. 150-153 = 3
6. Amygdaloid d 9. 153-154 = 1, 153-154 0.03 Cu. (8)
Coarse amygdaloidal trap d 9. 154-161 = 7 (79)
7. (59)
Amygdaloid d 9. 161-166 = 5
Amygdaloidal trap d 9. 166-173 = 7
Trap d 9. 173-220 = 47
Coarsest between 177 and 206, chloritic and white flecked with pseudoamygdaloid spots at 175-184, trace Cu.
8. Top of Mandan ophite? 138 (101?)
Ophite 8 mm?
Amygdaloid d 9. 220-223 = 3
Amygdaloidal trap d 9. 223-228 = 5
Trap d 9. 228-271 = 43
Amygdaloid d 9. 271-273 = 2
Trap d 9. 273-321 = 48
The amygdaloidal trap is a very coarse amygdaloid, the first trap feldspathic and faintly mottled, at 255-273 and 363-375, trace Cu.
The second two feet of amygdaloid is a poor chloritic amygdaloid with forms that look like pseudomorphs of phenocrysts. At 284 it is coarser and irregular and from 305-312 there appears to be a mottling 5-8 mm. across. This is about the point where the big Mandan ophite should appear. What has become of the rest of it? Is it cut out by faults?
9. Melaphyre (34)
Amygdaloid d 9. 321-323 = 2
Trap d 9. 323-355 = 32
The amygdaloid is chloritic.
10. Melaphyre
Amygdaloid d 9. 358-360 = 2
Trap d 9. 360-368 = 8
The amygdaloid is crushed; the contact uncertain.
Porphyritic melaphyre
Amygdaloid d 9. 368-375 = 7
Amygdaloidal trap d 9. 375-390 = 15
The trap is a coarse, chloritic amygdaloid and shows one big porphyritic feldspar crystal. Clark d 8. 260-304, also Clark d 8. 304-401. This does not look like the top of No. 8 particularly. I strongly suspect a fault. The mottling at 305-312 feet is not at all likely in so small a flow and I think that the lower amygdaloids may be streaks in the trap, for the samples when examined were mouldy and not easy to study.

Clark drill hole 8. 642 feet south of No. 9, i. e., 5097 feet north of Breakfast Lake and 44.75 above it (225.92 above Lake Superior); about 1025 paces N. and 500 W. of S. E. cor. of Section 8, T. 58 N. R. 28 W. The dip of the hole is 65°, i. e. practically at right angles to the bed. The dip to Hole 9 may be 26°, to Hole 7 26.5°. It is physically 62 feet below No. 9 and geologically should be between

300 and 400 feet below. The big ophite in which it begins would seem to be the Mandan ophite, which comes usually not over 300 feet or so below the Greenstone. If we assume this to be the last bed reached in No. 9 there must be an unusual number of beds between this and the Allouez, and a dip of over 33°. If, on the other hand, we suppose the apparently coarse mottling reached at No. 9 at 305-312 feet to represent the Mandan ophite and cf. d 9. 305-312 with d 8. 75-91, the dip would be only about 20.3° and we should have to suppose also that Hole 9 crossed a fault in its lower part striking N. E. and throwing the E. part S., and was separated by that from Hole 8. The weight of probability seems to be that the first bed in Clark d 8 is the Mandan ophite No. 8.

- (138?)
8. Ophite, the Mandan ophite 10 mm. 229
Amygdaloid d 8. 25-30 = 5, at 25-33 0.03 Cu.
Chloritic amygdaloidal trap d 8. 38 = 8
Trap d 8. 38-254 = 216
The amygdaloid is brecciated and prehnitic. The trap markedly mottled, at 75, 91, 131, 153, 192, 223, 230, 254 feet they are
5, 7, 9, 10, 10, 8, 4, 0? mm. across
9. } Cf. Clark d 7. 40-46
to } Porphyritic melaphyre
11. } Amygdaloid d 8. 254-260 ? = 6
Trap d 8. 260-304 = 44
Poor samples of amygdaloid
The trap shows one small feldspar phenocryst (Cf. d 9. 375-390) and the feldspar ground is rather coarse, while there is no conglomerate at the base there is in No. 7 at a corresponding point (Clark d 7. 40-46), being the first of three such belts which also are represented here.
12. Ophite 5 mm. (97) (624)
Cupriforous amygdaloid d 8. 304-314
Trap d 8. 314-394
The amygdaloid is red and white with copper and prehnite. The lower amygdaloid trap is faint and occasionally has forms suggesting porphyritic crystals. The trap is fine grained and compact to 327, then at 360, 378, 386 feet shows mottles
5, 3, 2 mm. across.
Cf. Manitou f. 31
Amygdaloid d 8. 394-401 = 7
This is well marked,—probably base of bed above.
13. Amygdaloid conglomerate d 8. 401-438 (37) (651)
Thick, well-marked, with red sediment and black scoria, and black and white amygdaloid fragments. Cf. Clark d 7. belt at 126 and 46. It belongs evidently to the Houghton conglomerate set.
14. Ophite 2 mm. (55) (704)
Trap d 8. 438-493 = 55
The mottles are: at 460 and 470 feet.
2 and 1-2 mm. across.
The relations of trap to amygdaloidal conglomerate are as in Nos. 2 and 3 and 8 and 9 of Clark drill hole 1.
At d 8. 483-494 0.03 Cu in the hanging of the porous bed.

15. Amygdaloid conglomerate d 8. 493-517, (24)
At 494-503 0.05 Cu; 503-521 0.03 Cu. (728)
Like the Bed 13. Somewhere near the Montreal lode.
16. Trap d 8. 517-522 (733)
17. Melaphyre (33)
Amygdaloid d 8. 522-531 = 9.
Amygdaloidal trap d 8. 531-555 = 24.
At 548-560 trace Cu.
The amygdaloidal part is red and white, the trap is fine grained and all streaked with amygdaloid to the end. The contact at the base is not plain and this is probably a gush of the underlying flow.
18. Ophite 6 mm. (113+17?) (130)
Trap d 8. 555-666+
From d 8. 555-586 it appears fine grained.
At 590, 597, 605, 620, 656, 666 feet the mottles are
2-3, 3, 4-5, 5-6, 3, 2 mm. across.
At 560-570 .25 copper.
570-580 1.12 "
580-597 .07 "
597-614 .06 "
614-646 tr "
646-651 .04 "
651-668 .02 "
Correlating d 7. 40, 120, 165, 180, 268 ft. with
d 8. 401, 493, 522, 555, 610 ft., the differences
361, 373, 357, 375, 342,
average 364. The dip will accordingly be $30\frac{1}{2}^\circ$. The general horizon is unquestionably that of the Houghton conglomerate and the Montreal lode. We may also compare d 7. 165-180 with d 8. 401-438.
Below the Allouez conglomerate (896) ft.
" " Houghton " (241)? ft.
- Clark drill hole 7.* 652 feet south of No. 8, i. e. 4445 north of Breakfast Lake, and 11. 57 feet above it (192.74 above Lake Superior), about 775 paces N. and 500 W. in Section 8, T. 58 N., R. 28 W. The dip of the hole is 65° to the south. Being 33 feet physically lower than No. 8 it should be about 300 feet geologically lower, and should certainly lap it extensively. The correlations above are satisfactory but imply a dip of $30\frac{1}{2}^\circ$. Such a sudden increase suggests a fault. A northwesterly fault throwing the east side down south between 8 and 7 would apparently steepen the dip.
The record is:
Overburden (40)
13. Amygdaloidal conglomerate d 7. 40-46 d 8. 401 (6)
Perhaps the Houghton conglomerate 9 or the crushed top of the ophite below.
14. Ophite 4 mm. (74)
Amygdaloid d 7. 46-49 = 3
Trap d 7. 49-120 = 71 d 8. 438-493
The mottles appear at 57, 66, 86, 91, 107 feet
They are 1, 2, 3-4, 3, 1 mm. across
Cf. Clark d 8. 438-493

15. Amygdaloidal conglomerate d 8. 120-126 d 8. 493 (6)
It is brecciated. Cf. Clark d 8. 401-438. Both are amygdaloidal scoriaceous conglomerate and have a heavier ophite above than below, and an amygdaloid conglomerate 60 feet below.
- 16 & 17. Cf. also d 11. Ophite 1 mm. (39)
Cupriferous amygdaloid d 7. 126-133 = 7 (119)
Trap d 7. 137-159 = 26 d 8. 522
Amygdaloid d 7. 159-165 = 6
The amygdaloid shows copper and prehnite. The mottles are at 133 and 145 feet, 1 mm. Cf. Clark d 8. 304-401. This cupriferous amygdaloid is not far from the horizon of the Montreal lode and may be it.
17. Amygdaloid conglomerate Clark d 7. 165-180 = 15 d 8. 522 (15)
Cf. the Montreal lode, also Clark d 8 and d 12; possibly a vein breccia. (124)
18. Ophite 5 mm. (119)
Trap d 7. 180-299 Cf. d 8. 555-668: fine grained to 186, at 188 mottled;
at
228, 252, 268, 277, 295, 297 feet the mottles are
3, 5, 5, 3-2, 2, 1 mm. across.
Note the replacement of amygdaloid by amygdaloid conglomerate. This is the only bed at all comparable with that of the base of 8. Cf. Manitou 41. (243)
19. Ophite 3 mm. (60)
Brecciated amygdaloid d 7. 299-326 = 27
At d 7. 299-316 0.01 Cu
At d 7. 316-325 trace
Trap d 7. 326-359 = 33
At 337, 345, and 350 feet the mottles are
1-2, 2-3, and 1 mm. across, then finer.
The breadth of this zone of amygdaloid allies it with the amygdaloidal conglomerates. (303)
20. Ophite 3 mm. (41 + 30?) (71)
Brecciated amygdaloid d 7. 359-374 = 15
At d 7. 357-368 0.01 Cu
368-376 0.03 Cu
Trap d 7. 374-400 = 26
The amygdaloid is red. The trap mottling increases to the end;
at 380, 391, 400 it is
1, 2, 3 mm. across (374)

Clark drill hole 6. 745 feet south of No. 7, that is 3700 feet north of Breakfast Lake and 1.62 feet above it (182.79 above Lake Superior), i. e. about 500 paces N. and 500 W. of S. E. cor. of Section 8, T. 58 N., R. 28 W. The dip of the hole is to the South at an angle of 60° . It is about at right angles to the beds, and should be about 320 feet below No. 7, which is about 10 feet higher. If we correlate the top of this with the top of the other the dip will be about 30° . There is an uncertainty of full 20 feet.

20. Overburden 25 feet (303)
 Ophite d 6. 3 mm.
 Trap d 6. 25-55? (30+41+?)
 Begins coarsest, at 25 and 50 feet the mottling is 3 and 1 mm. across.
 This might equally well be the base of 18, or in case of faulting, higher beds,
 but the beds below would not match. (374)
 (10?)
21. Amygdaloid ? d 6. 55-62
 At 53-71 0.03 Cu
 Trap d 6. 62-65
 This is quite likely not independent, only a gush of the overlying. The
 amygdaloid is brecciated and not well-marked, the trap fine grained. (384)
 (19)
22. Amygdaloid conglomerate d 6. 65-84
 At 71-93 0.02 Cu
 Cf. at the Mandan d 1. 648-668 268 ft. below the Montreal lode (403)
 (145)
23. Ophite 7 mm.
 Trap d 6. 84-229
 At d 6. 123-153, 177-203, 219-229 a trace Cu.
 At 100, 110, 117, 163, 171, 210 feet the mottling appears to be
 2, 3-4, 3, 5, 7-8, 3 mm.
 This reminds one of the big flow a hundred feet or two above the Calumet
 conglomerate, T 5f 49, and 1124-1174 below the Allouez at the Mandan. (548)
 (57)
24. Ophite
 Amygdaloid d 6. 229-232 = 3
 At d 6. 229-304 trace Cu
 Trap d 6. 232-286 = 54 (605)
 (18)
25. Cupriferous amygdaloid d 6. 286-292 = 6
 Trap d 6. 292-304 = 12
 It may well be that this belongs with the flow below, being separated
 merely by a brecciated belt. (623)
 (74)
26. Feldspathic ophite
 Brecciated belt d 6. 304-307 = 3
 Trap d 6. 307-378 = 71
 At 327 trace Cu., 335-355 0.01 Cu
 367 trace Cu.
 Trap from d 6. 311-358 rather feldspathic and fairly coarse; at 355 the
 mottles are 2 mm. across. (697)
 (67)
27. Amygdaloid d 6. 378-379 = 1
 At 378 0.05 Cu
 Trap d 6. 379-444 = 65
 At 395 0.01 Cu; at 409-438 0.01 Cu
 The trap coarsely amygdaloid, then ophitic to 387 (764)

28. Brecciated amygdaloidal conglomerate d 6. 444-448 (4)
 This is, I presume, the Calumet conglomerate.
 Cf. Mandan d 1. 901-920
 Base below base of Houghton conglomerate. (768)+
 The uncertainties of correlation of the different holes at the level of the Mandan
 ophite and Houghton conglomerates are so great that a hundred feet or two
 might readily be added to or subtracted from this. (31)
29. Amygdaloidal trap d 6. 448-468 = 20
 At 449 and 467 trace Cu
 Coarse amygdaloid at d 6. 468
 Trap d 6. 468-479 = 11
 from the base of the Houghton conglomerate (799)
 (127)
30. Ophite 3 to 4 mm.
 Amygdaloid d 6. 479-490 = 11
 At 479 0.01 Cu
 Trap d 6. 490-607 = 117?
 At 521 and 573 feet the mottles are
 2 and 3-4 mm. across.
 At 496-513 0.01 Cu; at 532 0.01 Cu; at 548 and 560 0.03 Cu; at 588
 0.02 Cu; at 602 0.03. Cu. (926)
- (31.) Brecciated cupriferous amygdaloid d 6. 607-617
 { at 607 0.64 Cu.
 at 623 0.055
 at 633 0.26
 at 634 5.46
 at 636 1.89
- Trap d 6. 617-636
 The trap is fine grained and rather brecciated, too. This ophite is thicker
 than the grain would warrant, one would think, and the brecciation of the
 amygdaloid below and the amount of copper lead me to suspect a little
 faulting, a northeast fault throwing the east side down to south, or a north-
 west fault throwing the east side up to north.
- Clark drill hole 5.* 931 feet south of No. 5, i. e. 276 feet north of Breakfast Lake
 and 6.44 feet above it (187.51 above Lake Superior). The dip of the hole is like
 3 and 4, 60°, practically at right angles to the beds, and it should be 390 to 460 feet
 (according as the dip is 25° or 30°) lower than drill hole 6.
 Overburden, sand, gravel and broken ledge 55 feet
- (30) Ophite (80+) (92+)
 Trap d 5. 55-133
 Looks fine grained and reddish, weathered at 58, then coarser
 At 88 and 123 feet the mottling is
 3 and 1-2 mm. (926)
 (126)
31. Ophite 5 mm.
 Amygdaloid d 5. 133-169 ? = 33
 Poor, with intercalated streaks of trap to 169 where is a heavy fissure of
 laumontite.
 Trap d 5. 169?-251
 At 200-246 0.02 Cu

At 176, 186, 195, 205, 226, 236, 246 ft. the mottles are
2-3, 3-4, 4, 8 faint 2-3, 1-2, 1 mm.

Below the Calumet conglomerate, (284)

Below the Houghton (1052)

Below the Allouez (1203)

32. Ophite 6 mm. (121)
Amygdaloid d 5. 251-271 Calumet amygdaloid?
At 246-266 0.03 Cu
At 266-284 0.065 Cu
Near horizon of Calumet and Osceola lode, but an abnormally heavy foot trap.
Trap d 5. 271-372
At 284-310 0.01 Cu, at 310-350 0.02
The ophitic texture is unusually well-marked down to pinhead size.
At 278-289, 295, 300, 305, 315, 316, 350,
1, 2, 2, 3, 7x2 and 4, 6, 1-2,
360, 364 ft
1, . 0.5 mm.
33. Amygdaloid d 5. 372-373
Trap d 5. 373-379
At 356-379 0.01 Cu
Perhaps part of the next flow
34. Feldspathic ophite 4 mm. (91)
Amygdaloid d 5. 379-381 = 2 (1264)
At 379-386 0.00 Cu
Brecciated, red and white
Trap d 5. to 388 7
Amygdaloid d 5 388-391 = 3
Trap d 5. 391-470 = 79
At 386-430 trace Cu
430-450 .01
450-460 00
460-474 trace
Coarser feldspathic ophite. Coarsest at about 423 to 435 when the augite prisms attain 7 x 2 mm., then finer.
- (35.) Amygdaloid d 5. 470-473
Well-marked amygdaloid with calcite and copper.
Note that this does not show much in the sludge which is influenced mainly by trap above.

Clark drill hole A. 544 feet south of No. 5. 2225 feet north of Breakfast Lake, and 31.64 feet above Breakfast Lake. 212.81 A. L. S. Dip of the hole 51° to the north.

Overburden about 20 feet

31. Ophite
Trap d A. to 190
32. Ophite
Amygdaloid d A. 190 (Calumet amygdaloid?)
At 190-206 0.04 Cu; at 225 0.03; at 236 0.03; at 239 0.06.
Trap d A. to 239

Clark drill hole 4. 773 feet south of No. 5, i. e. 1996 feet north of Breakfast Lake and 9.14 feet above it (190.30 above Lake Superior). The dip of the hole is, like 3 and 5, 60°.

Overburden about 18 feet

33. Ophite
Trap d 4. 18-43(?)
At 18-28 0.02 Cu
Begins broken up for two feet and at 30 feet a 2 mm. ophite? (97)
Ophite
34. Amygdaloid 43-50 (?)
At 28-64 trace Cu
Trap d 4. 50-140
At 64-67 0.02 Cu
121-146 trace (1264)
35. Doleritic ophite 12 mm. (247)
Amygdaloid d 4. 140?-160.
At 121-146 trace Cu
Trap d 4. -367
At 171-198, 227-260, 328-351, 357-370 traces Cu
At 253, 299, 317, 346, 363 ft.
10, 10, 12, 5, 1-2 mm.
Doleritic streaks occur at 253 and 256-260 which may represent the welding together of two flows.
It is coarsest at about 317,—and there are chlorite seams.
The grain is irregular. Cf. Empire b 35 (d 2. 199-360), also Manitou 3, Belts 51 to 54, just above the Kearsarge conglomerate.
Below supposed Osceola (369) ft. (1511)
36. Kearsarge amygdaloid?
Amygdaloid d 4. 367-375
Fine grained, with porphyritic crystals and copper in large amygdules.
Trap d 4. 375-386
37. Wolverine sandstone d 4. 386-397 (10)
At 385-400 0.06 Cu
Red sandstone and shale at first at 84° 20' to core, passing at 391' into fine grained conglomerate, and at base there is a much disturbed transition to trap. At first this was taken to be the Kearsarge conglomerate and certainly the overlying ophites and distances to Calumet conglomerate, Osceola amygdaloid conglomerate, etc., agree, but the Kearsarge group seems largely cut out of the section. Presumably the faulting displacements grow greater to the south as we approach the area of disturbed felsite intrusions described by Hubbard. The grain of the doleritic ophite above 12 mm. at apparently only 50 feet from the margin is altogether too coarse, and is, to my mind, decided indication of a fault. 35 may be over the Kearsarge or it may be Manitou 3, flow 66 in part. Such a fault (if a nearly vertical fissure) would, however, imply a horizontal displacement or throw by which the lower part of the section was moved north 1400 feet or a strike fault with a dip steeper than 30° and a very considerable uplift of the lower part and drop of the upper.
Of so large a cross-throw there should be more evidence in the topography

than there is. The Montreal River valley may well mark the course of some such strike faults.

38. Feldspathic ophite (1542)
 Trap d 4. 397-450+
 At 400-416 trace Cu
 416-450 0.01 Cu
 At d 4. 397-398 much disturbed, specked and decomposed to 406.
 Much seamed in various directions; parallel to the core, at 40° to the core and at 60° nearly at right angles to the other, and also parallel to the dip?
- Clark drill hole 3.* 754 feet south of No. 4, i. e. 1242 feet north of Breakfast Lake, at 15.77 feet above it (196.94 feet above Lake Superior). The dip of the hole is steeper than in No. 2 (60°). As it is 2458 feet south of No. 6 and 14 feet higher, it should be from 1100 to 1270 feet lower (according to the dip assumed) or 592 to 800 feet below the bottom of it and 573 below the Houghton. The feldspathic glomeroporphyritic character of the top at d 3. 130-140 reminds one, however, of beds below the Kearsarge, those exposed in Manitou 7 d 6 S., Nos. 89-91. In that case the heavy bed above, No. 35, might also be compared with Manitou 7 b. 80 or 82.
- Overburden, sand and gravel 22 (1543)?
 (38) Feldspathic ophite or melaphyre (112+ ?)
 Trap d 3. 22-140
 At 22-37 trace Cu
 The trap gets finer from 112 on and from 130-140 is markedly glomeroporphyritic. Cf. Manitou d 7. b 59 (1655)
 39. Feldspathic ophite 141
 Brecciated veined (amygdaloid ?) d 3. 140-143
 Amygdaloid trap d 3. -156
 The trap is a chloritic feldspathic ophite, coarsely amygdaloidal
 Trap d 3. -281
 At 185-213 0.02 Cu
 213-230 trace
 230-324 0.02
40. "Amygdaloid" d 3. 281-287 (1796)
 "Trap" d 3. 282-294 (13)
 1. Amygdaloid conglomerate 9
 "Amygdaloid and sandstone" d 3. 294-303 (1818)
 "Trap" d 3. 303-306 3
 (42.) Feldspathic ophite (1821)
 Amygdaloid d 3. 306-310
 Trap d 3. 310-467
 At 407-433 trace Cu
 433-453 0.02 Cu
 453-467 trace
 Equivalent to d 2. 13-248 presumably
 If No. 37 were the Kearsarge conglomerate, Manitou 3 b 5 6, this would be Manitou 3 b 6 6.

Clark drill hole 2. 500 feet north of the Breakfast Lake datum and 27.02 feet above it and 208.19 feet above Lake Superior. Its dip is 52°.

A correlation of Hole 1.199-206-218 with 2.467-487 seems close, also

1.152	2.421
1.110	2.378
1.84	2.353

No. 2 at 32 feet would be on a level with the beginning of No. 1 and 466 feet from it.

The dip to be inferred would be 30° $\frac{1}{4}$ (302?)

42. Doleritic ophite 7 mm.
 Trap d 2. 13-248;
 At 108-143 and 240-256 trace Cu
 The hole begins at 13 in a coarse mottled (6-5) ophite and at d 2.20 is dolerite which, we assumed, corresponds to d 3.380. This would make the top of this flow about correspond to d 3.281-306, thus making d 3.306-467 and d 2. 13-248 one thick flow.
 At 13, 32, 35, 50, 233 feet the mottling is
 4-5, 5, 7, 7, 2-3 mm. respectively
 But the augitic mottling is scanty; the doleritic streaks frequent and coarser toward the center. Doleritic seams occur at 20, 22, (with 2-3 mm. feldspar) 31, (3 mm. feldspar) 38, 48, 50-53, 117-118 feet. It is heavily seamed with laumontite at 62-67; at 38 is a minute speck of copper.
43. Feldspathic amygdaloidal melaphyre 52
 Amygdaloid d 2. 248-257 = 9
 At 240-292 trace Cu
 292-311 0.02 Cu
 Amygdaloidal trap d 2. 257-300 = 43
 Beginning in a red, fine grained, chloritic amygdaloid, then at 256 veined, brecciated, siliceous, then (from 257 on) coarse feldspathic with grey and white amygdules at first, then coarsely feldspathic, with green amygdules and a doleritic appearance,—coarsest at 272, then growing finer.
44. Feldspathic melaphyre (glomeroporphyritic ?) (53)
 Amygdaloid d 2. 300-302
 At 292-329 0.02 Cu
 Markedly fine grained, then coarser calcitic.
 Trap d 2. 302-353; cf. Hole 1-78.
 At d 2. 308 seamed and possibly with porphyritic crystals (10 mm. or so). Beside that 1 to 2 mm. feldspar on red ground.
 At 325 $\frac{1}{2}$ greenish, chloritic, altered.
 At 328 a prehnite copper seam.
 At 339 prehnite seams and the rock is specked to 356.
 To 351 reddish feldspathic.
 Cf. Manitou 7. b. 90.
- (45) Feldspathic melaphyre (25)
 Amygdaloid d 2. 353-370 with white, then green, irregular amygdules like d 2. 300.
 Amygdaloidal trap d 2. 370-378 (cf. 1 to 104).
 Feldspathic with chlorite amygdules, inclining to doleritic type.
- (46) Amygdaloid d 2. 378-388; d 1. 104-112 (43)
 Well-marked to 382; with maroon base and small white amygdules changing to coarse feldspathic with chlorite amygdules.
 Trap d 2. 388-421; d 1. 112-152
 Coarse feldspathic

- (47) Amygdaloid d 2. 421-425; d 1. 152-166 (46)
and
(48) Red and white, with seamed laumontite contact becoming chloritic and coarser at base.
Trap d 2. 425-467; d 1. 166-199
49. Sandstone and amygdaloid conglomerate d 2. 467-487; d 1. 129-218 (20);
All along from d 2. 453-496 a trace of copper, and at d 1. 216 trace
Dark brown to red with fragments of black and white amygdaloid at first not very abundant. The bedding is practically perpendicular to the hole. There are also seams at 23° to core perhaps about vertical that fault the sandstone bands a few millimeters. There is more and more enclosed amygdaloid toward base.
- (50) Amygdaloidal ophite (80)
Amygdaloid d 2. 487-490 = d 1. 218
Of same type as the pebbles in the bed above.
At d 2. 482-496 trace Cu
Trap d 2. 490-493
Amygdaloid d 2. 492-511
At d 2. 482-521 trace Cu
Trap ? d 2. 511-514.
Amygdaloid d 2. 514-540.
Trap d 2. 540-567
At d 2. 538-560 trace Cu.
The amygdaloid is of the same type as the pebbles in the conglomerate above. The bottom trap is a fine grained ophite, with mottles at 554 feet $\frac{1}{2}$ to 1 mm. across.
Beds 51, 52, and 53 are found only in drill hole 1
- (54?) Ophite $\frac{1}{2}$ mm ? (31?)
Amygdaloid d 2. 567-573 = 6
Trap d 2. 573-598 = 25
The amygdaloid is well-marked but many of the amygdules are empty; at 573-598 is $\frac{1}{2}$ mm. mottling.
Amygdaloid d 2. 598-600.
- Clark drill hole 1.* 15 feet north of Breakfast Lake and 31 feet above it, i. e. 184.27 A. L. S. Dip of hole 52° to S.
- (44) Feldspathic ophite (10 +)
Trap d 1. 68-78 = d 2. to 353
Begins coarse with 1-2 mm. feldspars
At 74 feet is a seam.
Toward the base it grows fine grained and in a way glomeroporphyritic.
45. Glomeroporphyrite 26
Amygdaloid d 1. 178-94; d 2. 353-370
Poor, red, with small porphyritic crystals
Trap d 1. 94-104; d 2. 370-378
Feldspar and chlorite conspicuous
46. Feldspathic ophite (48)
Amygdaloid d 1. 104-112; d 2. 378-388
Grey, markedly brecciated (108-110), coarse with porphyritic crystals of feldspar
At 113-128 0.03 Cu
128-148 0.02 Cu

- Trap d 1. 112-152
in No. 2 hole none
Chloritic, angular, doleritic; toward 134-144 coarsest, feldspathic slightly ophitic.
47. Porphyritic melaphyre?
Amygdaloid d 1. 152-166 = 14
Fine grained, with small, white amygdules on red ground, and also what appear to be pseudomorphs of altered feldspar.
Trap d 1. 166-189
Cf. Beds 116 to 123 of the Manitou section.
48. Amygdaloid d 1. 189-196
Well-marked, and at 193 $\frac{1}{2}$ almost conglomerate, with small amygdules, chlorite and laumontite and calcite.
Trap d 1. 196-199 = 3
Fine grained black
Quite probably not a separate flow.
49. Sandstone d 1. 199-206 = 2. 467-487
Amygdaloid and amygdaloid conglomerate d 1. 206-218 brown, then red, with amygdaloid 204-6 and at base a conglomerate of chloritic grains; angle with hole 11 $\frac{1}{2}$ °, probably indicating a dip near 26° rather than one of 48°. In many respects d 1. 152-206 resembles d 4. 367-397.
Amygdaloid or amygdaloid conglomerate from d 1. 206-218 evidently corresponds to the lower part of d 2. 467 to 487.
50. Amygdaloidal melaphyre. (59)
d 1. 206-218 may be amygdaloidal top of 50 or bottom of 49
At 199-216 trace Cu.
Trap d 1. 218-227 trap, fine grained prehnite amygdules, porphyritic.
Amygdaloid d 1. 227-228, marked, but with small amygdules.
Amygdaloid and trap d 1. 228-236
Amygdaloid d 1. 236-241
Trap d 1. 241-243
Amygdaloid d 1. 243-245
Amygdaloid d 1. 245-259
Trap d 1. 259-265
51. Amygdaloid conglomerate d 1. 265-275 (10)
Red matrix and dark amygdaloid pebbles.
In No. 1 this was not noticed and the question whether it is a fault breccia might be raised.
52. Trap d 1. 275-282.
53. Amygdaloid d 1. 282-289.
Strong with small white (calcite) or pink laumontite amygdules.
Amygdaloidal melaphyre d 1. 289-295.
54. Ophite, faulted, 3 mm.
Amygdaloid d 1. 295-301.
Like d 1. 282-289
Clasolitic amygdaloid d 1. 301-304
Amygdaloid d 1. 204-325
Trap d 1. 325-437.
At d 1. 364-376 and at 399-410 0.03 Cu, evidently connected with the chlorite seams.
At d 1. 346 the mottles are white and red.

- At 337, 341, 346, 351, 358, 364 feet the mottles are:
1, 1 to 2, 1 to 3, 2, 3, 1 to 2 mm., then from 367-398 heavily seamed with chlorite, and mottled about the same, 2 mm.
At 412 and 420 feet the mottles are:
2 to 3, and 3 mm. and at 430 an interesting piece of core shows a seam with 2 mm. mottles on one side, ½ mm. on the other.
Cf. d 2. 573-598. Then it is fine to end.
At d 1. 410 to 425 trace Cu.
55. Amygdaloid d 1. 437-440.
At 425-444 0.03 Cu.
Hard, very minute amygdules, light red.
Amygdaloid trap d 1. 440-457.
Compact, with minute amygdules.
56. Amygdaloid d 1. 457-459.
Trap d 1. 459-468.
Same type as at d 1. 437, peculiar, epidotic and siliceous, passing into a regular porphyrite, with small 2-3 mm. green altered feldspar laths on a red ground, like the Ashbed type.
Cf. Manitou b 90-91 and 116-117 and Central mine belts 97-115 which are 1577 to 2975 feet below the Wolverine sandstone
2773
4350 5748 ft. below the Houghton conglomerate.
57. Amygdaloid d 1. 468-470.
Trap d 1. 470-490.
58. Feldspathic ophite 5 mm. (133)
Amygdaloid d 1. 490-499.
At first brecciated and clasolitic (like amygdaloid conglomerate) then chloritic.
Trap d 1. 499-622.
Feldspathic, growing coarser.
At 520, 540, 560, 619 feet the mottles are
2, 4, 5, 2? mm.
At d 1. 590-609 0.02 Cu.
59. Feldspathic ophite. (37)
Amygdaloid d 1. 623-630.
Coarse, poor, calcitic.
Trap d 1. 630-660.
Reddish, with laumontite seams.
60. Feldspathic melaphyre. (72)
Amygdaloid d 1. 660-669.
Trap d 1. 669-732.
Feldspathic, with chloritic seams and a bomb.
61. Melaphyre. (15)
Amygdaloid d 1. 732-738.
Trap d 1. 738-747.
Dark green. Is this a sign it is near a fissure?
Note the Cu; at 720-765 0.02 Cu.
62. Ophite 5 mm. (111)
Amygdaloid d 1. 747-750.
Trap d 1. 750-858.
At 794-807 0.03 Cu.

- 807-813 trace Cu.
At 770, 787, 790, 811, 830-838, 847 feet the mottles are
2-3 mm, 5-7, 5, 5, 3, 2 mm.
63. Sediment shading into red amygdaloid conglomerate d 1. 858-860.
At 842-858 0.02 Cu, though none was reported from 858-936.
64. Feldspathic ophite 3 mm. (78)
Amygdaloid d 1. 860-863.
Trap d 1. 863-938.
Seamed d 1. 863-866. At d 1. 876, 2-5 mm. mottles; at 897-900 probably an altered seam, but like those puzzling amygdaloids above, looks felsitic, red and white speckled.
65. Sandstone d 1. 938-943
An amygdaloid conglomerate or clasolite.
All sandstone d 1. 938-940.
At 939-961 trace Cu.
With amygdaloid d 1. 940-943.
66. Trap d 1. 943-947.
67. Epidotic seam and fine grained, doubtfully a new belt d 1. 947-950
Mottled trap d 1. 950-960.
68. Scoriaceous top d 1. 960-961. 32
At 961-972 0.02 Cu.
Amygdaloid d 1. 961-965.
Trap d 1. -992. (15)
69. Amygdaloid d 1. 992-996.
At 972-984 trace Cu.
Trap d 1. 990-1007.
70. Scoriaceous amygdaloid or amygdaloid conglomerate d 1. 1007-1012
At 1001-1011 0.02 Cu.
On the whole Manitou 7-5 and 6-5 correspond to Clark 3 and 4, and Manitou 7-8 and 9 S, with feldspathic smaller beds to Clark Hole No. 1.
Seamed d 1. 863-866. At 876 2-5 mm. mottles.

The lowest beds of this Clark-Montreal section should outcrop about 1,600 feet south of Breakfast Lake. It is just about a mile from Hole 1 to the Bohemia conglomerate at the center of Section 22, T. 58 N., R. 28 W., from which point Hubbard had studied the cross-section pretty carefully. Assuming the dip to be 30°, this would give 2,640 feet, of which Hole 1 covers 1,012, leaving unexplored thereby 1,628 feet and probably more, as according to Hubbard, the Bohemia conglomerate dips nearer 54°. In this interval should be the horizon of the Arcadian-Isle Royale lodes. The beds of Hole 1, feldspathic ophites, are, in fact, not unlike the belts of the Arcadian section, Holes 4 and 22, belts 76-83, just above the Isle Royale. In the interval are some outcrops but no continuous section has been made. No conglomerates or sandstones are known. The lower 200 paces contain traps and conglomerates and we then have, using Hubbard's letters and Plate III of Vol. VI, Part II:

O. Felsitic conglomerate	20 paces	37 ft.	
N. Melaphyre one or more thin beds	50 paces	93	130
M. Felsitic conglomerate	240 paces & less	84	214
L. Felsite, spherulitic Sp. 17037	330 paces	615	829
Mt. Houghton felsite.			
K. Conglomerate	20 paces	37	866
(K, M and O merge and make up the Bohemian conglomerate, loc. cit. p. 28) No. 8			
J. Felsite Sp. 17036 A, amygdaloid	50 paces	93	959
H. Conglomerate and breccia of felsite at top, and basic or amygdaloid conglomerate at base, No. 7?	25 paces	46	1004
G. Felsite porphyrite Sp. 17039, amygdaloid	40 paces	74	1078
F. Conglomerate, amygdaloidal. See Plate III b.	10 paces	18	
E. Porphyrite, Sp. 17033, amygdaloid, andesitic, microlitic	60 paces		112
D to B. 9 melaphyres with amygdaloid or amygdaloid conglomerate tops. These amygdaloid conglomerate tops under Conglomerate 6 are marked also around Portage Lake. It will be noted that they grow more massive. They are respectively about			
	20 paces	37	1115
	15 paces	28	1143
	15 paces	28	1171
	40 paces	74	1245
	15 paces	28	1273
	20 paces	37	1310
	30 paces	56	1366
	70 paces	130	1496
	60 paces	112	1608
A. Heavy ophite: continues through to Mt. Bohemia. Cf. the Mendota section, and the Mabb ophite.			100+
Total?			

§ 3. EMPIRE. (See Fig. 24 in envelope.)

The next section in order is that of the Empire, about $3\frac{1}{4}$ miles west. The beds above the base of the Greenstone are probably about as before. The Greenstone and Allouez conglomerate were just missed in the drilling, but are placed in Figure 24 from my field notes and observations on the grain of the Greenstone at its nearest exposure in the bluff north of the section.

The section is not far from the Old Iron City vein of Whitney, Hill and Stevens. There was a "Manitou" on Section 8 and a "Cape" on the west part of Section 7, working cross-veins just below the Greenstone.

Abstract of Empire Section.

Missed Allouez conglomerate.

1.			
2.	1. 28-37		
3.	105-175	Felds. Oph. Faulted (8 mm.)	
4.			
6.	1. 295-365	" " " (7 mm.)	
7.	77	" " " (5 mm.)	
8.	1. 451-462		410
9.	1. 462-548	78 Oph. " (7 mm.)	
10.			
11.			
12.	Houghton 1. 629-643		585
13.	Oph. (1-2 mm.)		
14.	Aeg.		
15.	Oph. (2-3)		
16.	Aeg.		
17.	?		
18.	Aeg.		
19.	Oph.		
21.	Montreal 193		
20.	Aeg. & O. (6 mm.)	(140)	
21.	Oph.	(68)	
22.	Oph.	(85)	
23.	Aeg?	(43)	
24.	Oph. (7 mm.)	(130)	
25.		(63)	
26.	Calumet conglomerate 4.	600-606	M. f. 44
28.		710	
30.	Feldsp. Oph. (7 mm.)	(140)	320
	Gap in section.	M. f. 49	300 feet? Including perhaps Osceola Am.
31.	Osceola?		
32.			
33.			
35.	Dol. Oph. (7-10)	(141)	
38.	Kearsarge conglomerate		424'

39.		744
41.	Sediment	
42.	Dol. ophite	(162)
43.	Epidotic sandstone	
45.		
47.		
48.		
50.	Ophite 2.1091 (160+)	455
	Gap in section in which is Wolverine and Kearsarge Amygd.	
51.		(400+)
52.	Congl. 5. 715-720	1020
53.		

The Empire section of Keweenaw Copper Co. is on the north and south line in the old "Empire" and Wyoming mining properties 1500 paces west in Section 14, T. 58 N., R. 28. W.; The 0 of the section is on the Greenstone Range at an elevation of 572 A. T. From notes furnished by the engineer, A. H. Sawyer, examination of the cores and trip of Aug. 1907., by A. C. Lane, Contractors Longyear and Hodge.

Empire drill hole 1 is on a flat 450' above Lake Superior and is 700' south of the N. line of 14, 2000' N. of Montreal River. No. 1 seems just to have missed the base of the Allouez conglomerate, which is thus 600 or 700 feet farther south than indicated on Plate IV of Volume VI, Part II.

It is 700 ft. south of the section 0, while at about 3+98'3 of the section the mottling is 10 mm., rapidly increasing as we go up a 26° slope, to say 35 mm., at 176 to 200' N. of the road which is 154' N. of the hole, i. e. 350' south of 0 of the section. On the other hand the grain shows that the hole could have but barely missed the conglomerate. The dip of the correlation of the Houghton conglomerate is 25°, which agrees well with 26° found N. of Breakfast lake. The reduction factor from depth to thickness is .906

1.	Melaphyre	(16)
	Trap d 1. 9-28 = 18	
2.	Ophite	(70)
	Amygdaloid d 1. 28-37 = 9	
	The amygdaloid is coarser from 29-33, and brecciated perhaps at 31	
	Trap d 1. 37-105 = 68	
	The trap shows 3-4 mm. mottles at 99	
3.	Ophite (shattered)	(64)
	Amygdaloid d 1. 105-107 = 2	
	Trap d 1. 107-175 = 68	
	This shows at 128 a 5 mm. mottling, at 160 8 mm. (?), and remains a coarse feldspathic ophite to 167, when it passes a fault, and is suddenly finer.	
4.		(25)
	Amygdaloid d 1. 177-185 = 8	
	Trap d 1. 185-204 = 19	
5.	Ophite	(36)
	Amygdaloid d 1. 204-209 = 5	
	Trap d 1. 209-244 = 35	
	At 230 has 3 mm. mottles?, at base brecciated.	

5.	Amygdaloid d 1. 244-250 = 6	(46)
	Trap d 1. 250-295 = 45	
	The hole crossed at 280 a vein at an angle of 30°	
6.	Ophite, feldspathic	(64)
	Amygdaloid d 1. 295-312 = 17	
	Trap d 1. 312-365? = 53	
	The trap has 7 mm. mottles at 335, 4 to 5 at 355, while at 357 there are signs of a slide and finer grain.	
7.	Feldspathic ophite	(77)
	Amygdaloidal trap passing into feldspathic ophite d 1. 365-409 = 44	
	This may be part of the bed above, disturbed by faults	
	At 404 is a prehnite seam.	
	Chloritic amygdaloid d 1. 409-415 = 6	
	At d 1. 423 is a marked seam with a slip at 45°	
	Trap d 1. 415-451 = 36	410
	Mottles up to 5 mm.	
8.		(10)
	Amygdaloid d 1. 451-456 = 5	
	Trap d 1. 456-452 = 6	
9.	Ophite	(78)
	Amygdaloid (poor) d 1. 462-476 = 14	
	Trap d 1. 476-548 = 72	
	Seams at 45° to core; at 491 7 mm. mottles, at 520 5 mm.	
	Apparently partly cut out.	
10.	Amygdaloid d 1. 548-554 = 6	(32)
	Amygdaloid trap d 1. 554-576 = 22	
	Fine trap d 1. 576-583 = 7	
	The whole group of beds above or at least 8-10 seem to represent the Mandan ophite disturbed by faults with a steeper dip than the beds, i. e. about 45°.	
11.	Ophite	(42)
	Amygdaloid d 1. 583-584 = 1	
	Trap d 1. 584-629 = 45	
	Brecciated, 1-2 mm. mottles. Cf. Clark 8. (see p. 176) 254-304, No. 12.	
12.	Houghton conglomerate.	(13)
		(585)
	Amygdaloidal conglomerate d 1. 629-643 = 3. 60 to 73. The dip according to this correlation is 24.5°. Dark red, brecciated. Cf. 750 feet at the Delaware, 576 at the Mandan & Medora d 12. 540, 689 feet at the Central.	
13.	Ophite	(37)
	Trap d 1. 643-683 = 40 and d 3. 73-108 = 35	
	Mottles 1 to 2 mm.	
14.	Amygdaloid conglomerate? First below Houghton. See brecciated (0 to 16), amygdaloid below.	
15.	Ophite	(62)
	Amygdaloid, brecciated d 1. 683-686 = 3	
	Trap d 1. 686-751 = 65	
	Cf. d 3. 108-183 (14 and 15) = 75	
	The mottles are 3 mm. at d 1. 722 feet, and 2-3 mm. at d 3. 152 feet.	

- 16 to 18. Amygdaloid conglomerate. Second below Houghton (41)
Brecciated d 1. 751 to 796 = 45
There is a speck of copper at 793. This heavy bed corresponds to 16, 17 and 18 in No. 3. Is this the Montreal lode or the one above?
19. Ophite (55)
Trap d 1. 796-855
Coarsest at 833. Total below the Houghton conglomerate. 212 (193)
20. Ophite, the Montreal and foot.
Brecciated amygdaloid d 1. 855-860
Trap d 1. 860-907
All ophite up to 5 mm. across.
- Empire drill hole 3.* 303 above Lake Superior on flat at foot of well-marked terrace front. 1625 feet S. of beginning, i. e. 925 feet S of Hole 1. Dip 90°. Dip of beds about 25° as before, though the correlation with the Houghton conglomerate in No. 4 would give nearer 30°. Reduction factor about 0.82 to 0.88.
- (9 or 11) Ophite
Trap d 3. 22-60 = 38
Getting finer from 5 mm.
12. Houghton conglomerate 60-73, greenish massive at top, then dark red and black amygdaloid conglomerate.
13. Ophite (32)
Trap d 3. 73-108 = 35
Specked, decomposed, original weathering? to 78', mottles at 83 and 100 feet are 1 mm. across.
14. Amygdaloid conglomerate. First below Houghton. (16)
Brecciated d 3. 108-126 = 18 (48)
15. Ophite (52)
Amygdaloid trap d 3. 126-133 = 7 (101)
Trap d 3. 133-183 = 50
Mottles are 2, 3-2, and 2 mm. at 144, 152 and 170 ft. respectively.
16. Amygdaloid conglomerate? Second below Houghton.
17. Ophite (33)
Brecciated amygdaloid d 3. 183-193 = 10 (134)
Amygdaloid trap d 3. 193-200 = 7
Trap d 3. 200-219 = 19
Mottles at 207 1 mm.
18. Amygdaloid conglomerate? Third below Houghton.
19. Ophite (62)
Very brecciated amygdaloid d 3. 219-226 = 7
Skeined amygdaloid trap d 3. 226-231 = 5
Trap d 3. 231-287 = 56
At 265 is a seam dipping 25°-26°, then it is finer with mottles 2-3, 2, and 1 mm. at 261, 271 and 280 feet respectively.
Total below Houghton conglomerate 214 = (195) ft.
20. Montreal lode ophite. Fourth below Houghton
Brecciated amygdaloid d 3. 287-311 = d 1. 855-860 = d 4. 12-47?
Ophite d 3. 320+ = d 1. 860-907+40+ = d 4. 47-168
This is a marked ophite. Cf. Clark d. 6. 84 to 229? In the Manitou 3 section it is (224) feet from the base of the Houghton conglomerate to the Montreal lode and it is the third below the Houghton. On Manitou

- 7 it is supposed to be only (150) from the top of the Houghton, with a heavy ophite beneath. At the Medora d 12. 743, d 2. 277, d 1. 350, d 9. 365, d 3. 339 are the depths to the top of a fairly persistent amygdaloid with a good-sized ophite beneath,—something like 200 below the Houghton.
As d 3. 73 = d 1. 643 and d 3. 287 = d 1. 855, the almost identical length of the holes of the same thickness of the beds would indicate almost the same dip. (335)

Empire drill hole 4 is at 2067 of the section 542' S. of 3. Its elevation is 282' above Lake Superior. Dip 90°. The dip of the bed is probably 25° to 30° and a reduction factor of .88 may be nearly right. The Montreal lode correlation implies a dip of 28.5° and that with No. 2 Hole 29°.

- Surface 12
(20) Montreal lode ophite d 4. 12-168 = 3. 287+ (137)
The well-defined mottling is respectively
1, 1½, 2, 2-3, 3, 8x3&4, 4, 5, 6 mm.
at 50, 55, 58, 70, 82, 87, 90, 99, 107,
5, 4-5, 5-6, 4-5, 2, 1, ½, mm. at
111, 120, 141, 136, 147, 158, 164 feet, indicating a rate of increase of something like 1 mm. in 10 (9) feet, or 1 : 2,750 = .00036. From 12-47 it is fine grained specked with a little copper at 19 feet, amygdaloidal and ophitic, evidently the eroded top of a flow.
21. Ophite (66)
Amygdaloid d 4. 168-171 = 3 (398)
Poor, brecciated red and white.
Trap d 4. 171-243 = 72
The trap is fine grained brecciated to 180 where the mottling begins to be noticeable. It increases to 218, then becomes finer and is beautifully developed.
22. Ophite (84)
Poor amygdaloid d 4. 243-256 = 13 (482)
Trap d 4. 256-338 = 82
Coarsest about d 4. 301-313
23. Amygdaloid conglomerate? (43)
Brecciated belt d 4. 338-386 = 48
This is a broad brecciated and amygdaloid belt. It is not distinctly conglomeritic, but too thick for a normal amygdaloid. This with the heavy ophite below represents a persistent coarse ophite. Medora d 1. 648-835 (7 mm.); d 3. 653 to 812, M. d 3. 620-749 (7 mm.) Clark flow 23.
24. Ophite (126) (524)
Trap d 4. 386-530 = 144 ?+
Irregularities in grain seem to indicate disturbance. It is coarse close under the brecciated belt. The mottles are respectively
7, 4 to 8, 3 to 4, mm. across at
447, 449-492, 490
It is finer about 530-537 but there is no well-marked amygdaloid, but fine trap. (650)
25. Ophite (63)
Trap d 4. 530-537
d 4. 537-600

Coarsest at 569 feet, with 4-5 mm. mottles. The top is a fine grained veined ophite.

A bed about 60 feet thick over the Calumet occurs in the Medora and Delaware sections, and in the Central Mine, where it is also No. 25; at the Clark Montreal it is No. 27. (705)

26. Calumet conglomerate (6)
 Conglomerate d 4. 600-606
 At d 4. 601 felsitic. There is copper in the conglomerate and in the hanging (710)¹
 At the Central the distance base of Houghton to base of Calumet is 815
 At the Delaware (Manitou) " " " " " "
 Calumet is 745
 At the Medora " " " " " "
 Calumet is 710
 At the Clark Montreal " " " " " "
 Calumet is 728
27. Foot of Calumet conglomerate. Ophite (69)
 Brecciated d 4. 606-620 = 14
 Trap d 4. 620-682 = 62
 Cf. M. 2. S. 88-172, at Calumet 109 ft. thick, Medora d 10. 194-245?, Clark 6. 448-479.
28. Feldspathic melaphyre (111)
- 29? Poor amygdaloid d 4. 682-688 = 6 (180)
 Trap d 4. 655-805 = 117
 The trap is generally fine grained, from 722 seamed and at 733-742 brecciated, only faint ophitic. There may be a contact at 733; cf. M. d 3. 2. S. 244-250, Clark d 6. 479-607. At Calumet, too, the next 160 feet are sometimes, not always, counted together.
30. Feldspathic ophite. "Calumet amygdaloid" and foot? (140)
 (320)
 Amygdaloid d 4. 805-813 = 8
 813-948 = 135
 From 817 on some ways many laumontite seams. The mottles are respectively
 3, 7, and 1 to 2 mm. at
 845, 880, and 940
 below which it is fine grained and specked. Cf. M. d 3. 2. S. 334-459, Clark d 6. 607+. At Calumet it is 130 feet thick.
31. "Osceola" and foot ophite, or more probably Calumet.
 Amygdaloid d 4. 948-970
 Brecciated, poor, chloritic.
 Is this the Osceola or Calumet amygdaloid? The hanging of the "Osceola" lode at the Manitou in d 7. 1. S. is also about 320 feet below the Calumet conglomerate. Cf. Clark d 5. 251-271. A correlation with the first belt of Empire hole 2 would imply a dip of 29°, but a steeper dip is probable, in which case one stout bed of ophite may be omitted.

¹Plus 50 feet faulted out?

Empire drill hole 2 is at 3700 feet on the section, 950 ft. S. of the Montreal River, and 262 above Lake Superior,—30 feet above the bottom of Montreal River. Dip 90°. Dip of beds 29°?+ To reduce the depth to thickness multiply by .88. But there are some reasons for believing that the dips are considerably steeper at the bottom of the hole. So that below the Kearsarge conglomerate we assume a dip of 38.5° and multiply by .78 (320)

- Surface 27 feet.
31. Osceola amygdaloid and ophite foot (54)
 Brecciated amygdaloid d 2. 27-32 (374)
 With prehnite, calcite, copper.
 Trap d 2. 32-88
 A feldspathic ophite coarsest (3-5 mm.) about 51
 Cf. Clark d 5. 271-372.
32. Melaphyre (20) (394)
 Amygdaloid d 2. 88-93
 Trap? brecciated d 2. 93-111
33. Feldspathic ophite (64) (458)
 Amygdaloid?
 Minute green chloritic amygdules, a red amygdaloid with glomeroporphyritic feldspar.
 Cf. Medora d 1. 567
 Trap d 2. 111-184
 Chloritic, feldspathic, when coarse faintly mottled.
 Seams perhaps parallel to the bedding.² Dip 35° to 45°
 Cf. 32 and 33 with Clark 33 d 5. 372 to 470. Both have alternations of amygdaloid at the top, and a coarse feldspathic ophite beneath. (458)
34. Melaphyre (13) (471)
 Amygdaloid d 2. 184-194 = 10
 Trap d 2. 194-199 = 5
 Very probably only a gush of the underlying.
35. Doleritic ophite (141) (612)
 Amygdaloid d 2. 199-210
 With seams of calcite and copper. Cf. the lode at the Clark 4. 35.
 Amygdaloidal trap d 2. 210-216
 Trap d 2. 216-360
 At 244 are big seams and the trap is doleritic, coarse but only faintly ophitic. At 254 the mottles appear to be 6-8 mm., and at 320 7-10 mm. across, then finer. There are laumontitic seams at 320. Cf. Mandan d 10. 784-925? (925-1009 too small?), cf. Clark d 4. at 317 with this at 320. Does the shattering shown have something to do with the accumulation of the copper
36. Melaphyre (28) (640)
 Amygdaloid d 2. 360-374
 Cf. Medora d 10. 1098.
 Trap d 2. 374-392
 Very probably not an independent flow.

²A dip of 45° would make other distances correlate much better, and is probable.

37. Feldspathic doleritic ophite (87) (727)
 Amygdaloid d 2. 392-399
 Trap d 2. 399-491
 The amygdaloid seems to dip at 14° to 18°, but the dolerite and other seams in the trap at 22.5° to 45°.
 Cf. Mandan d 10. 1149-1220. Clark d 4. 388-
 The distance from this, the top of the Kearsarge, to the "Osceola" hanging (31) is about 407 feet which is small either compared with the Mandan or the Clark-Montreal sections. The large ophite 35, a persistent bed, is not as thick as its mottling would lead us to expect, but it is seamed and presumably some is cut out.
38. Kearsarge conglomerate (17)
 Conglomerate and red sandstone d 2. 491-510 = 19 (744)
 The apparent dip is 20°
 Cf. Fig. 29, M d 3. 4. S 121. While this thickness is much less than in the adjacent sections, it would take a dip of only 37.5° to make the thickness between the Calumet and the Kearsarge conglomerate the same as at the Manitou, and there are some independent reasons for believing this likely.
39. Feldspathic melaphyre (119)
 Trap d 2. 510-517
 Amygdaloidal trap d 2. 517-527
 Trap d 2. 527-619
 A brecciated vein at 551, faintly ophitic and feldspathic 558-610.
40. Melaphyre d 2. (37)
 Amygdaloid d 2. 619-630
 Trap d 2. 630-656
 From d 2. 645-656 specked and weathered.
41. Sediment
 Sedimentary breccia 656-658 under well-marked contact at 656. At 686 there is a red clasolite making an angle of 20° with core, evidently filling a nearly vertical fissure extending down from this bed?
42. Doleritic ophite (162)
 Trap d 2. 658-820
 Coarse d 2. 701-807, then a big fissure with reddened and apparently finer trap to the end.
43. Epidotic sandstone:
 Yellow epidotic sandstone d 2. 820-824
 Cf. Fig. 29, M 3. 4. S. 324, Central mine 50³
44. Ophite
 Trap d 2. 824-854
 Epidotic, much fissured.
45. Amygdaloid d 2. 854-856
 Coarse
 Trap d 2. 856-881
 Fissured near d 2. 874, mottles 2 mm.
46. Amygdaloid d 2. 881-885
 Red and white passing into a glomeroporphyrite.
 Trap d 2. 885-971
 Coarse, at first amygdaloidal, then seamed feldspathic, toward the base finer, reddened with laumontite seams.

³Under the Kearsarge conglomerate some ways a tendency to clasolitic occurrences and feldspathic traps is well-marked. Cf. also Arcadian No. 76, a lower horizon.

47. Ophite
 Amygdaloid d 2. 971-978
 Prehnitic coarse.
 Trap d 2. 978-1032 At 1012 4 mm. mottles.
48. Amygdaloid d 2. 1032-1043
 Red and yellow with trappy seams.
 Amygdaloidal trap d 2. 1043-1060
49. Amygdaloid d 2. 1060-1069
 Trap d 2. 1069-1091 (455)
 Seamed and coarsest about d 2. 1081-6
50. Ophite (160+) ? (615)
 Amygdaloid? d 2. 1091-1096
 Trap d 2. 1096-1144+ (1023)
 Mottling is 4 mm. at the end. This heavy ophite might be the bed in which Empire Hole 5 begins and if not, the dip is over 39°. If it is the same bed the dip is 38½° and at this dip its top below the base of the Kearsarge conglomerate would be (1091-510) 38½°, 455 feet. It can not be any lower bed in No. 5, as we can find no heavier bed in No. 2 with which to correlate the heavy bed at the top of Hole 5. A steeper dip would make this bed still nearer the Kearsarge conglomerate. At 45° for instance, the top would be only 350 feet below the same. At the Clark the only bed to connect with the top of Empire Hole 5 is that at the top of Clark Hole 2, 296-676 feet below the Kearsarge there. This is, I think, less than 100 feet from the Kearsarge amygdaloid.
- Empire drill hole 5.* 5200 feet south of datum 1500 feet S. of Hole 2. 270 above Lake Superior. Dip 90°.
- The dip of the beds is uncertain but there is no probable correlation with Hole 2 that will give less than 38.5°. The apparent dip of the conglomerate at 765 feet is 45°. The mean rate of increase of grain in the ophite below appears to be not over 1 mm. in 25 feet or less whereas it is usually 1 mm. in 10 to 15 feet, which would suggest even steeper dips. In that case the Kearsarge amygdaloid and Wolverine sandstone lie in an unexplored gap between Holes 2 and 5.
- | | | |
|-------------|---|-------------------|
| | Surface | (28) |
| (50) Ophite | Trap d 5. 28-156 ³ | |
| | The mottles are respectively | 7, 10, and 5 mm. |
| | at | 30, 60, 107 feet. |
| | | (615?) |
| 51. Ophite | 579, | (400±) |
| | Amygdaloid d 5. 136-151 | |
| | Trap d 5. 151-715 | |
| | Marked brecciated amygdaloid, with a much disturbed amygdaloid trap just under, spotted to 174. The mottles are respectively | |
| | 9, 15, 10-15, 5-10, 8, 3+, 1 to 2, 1 mm. at | |
| | 239, 370, 415, -454, 536, 575, 629, 686 | |
| | There are doleritic seams between 250-284 and at 300, a big prehnite seam between 454 and 497, numerous joints crossing the cores at 45° from 629 on. Cf. Medora d 6. 239-649 (12mm.) and also Manitou d 7. 5. S. 54-333 ³ with a little sediment at the base and 10 mm. mottles | |

also, another heavy ophite 333-552 just below. Cf. also Central mine 58. d 2. 442-498 = d 8. 42-314 with 59 & 60 sediment just below, and 311 feet below the Wolverine, and 12 mm. mottles. See also Arcadian Belt 68. Hole 2. 315'-464'+ (10 mm. mottles) Calumet and Hecla A. 193-273. This is uncertain. The prismatic augite form is often marked.

52. Conglomerate d 5. 715-720 5 1020

There is some felsite, but it is mainly amygdaloid conglomerate, much sheared, so that it is hard to tell shearing from dip—about 45°. This and the big trap above it would seem to match the Medora d 6. 652-657 best in position and association. Cf. also Manitou d 7. 5. S 333, and Franklin Jr. d 3. 535. The actual distance from d 2. 510 to d 5. 720 is 1513 feet, the thickness will vary according to the dip assumed; at 45° it will be 1215 feet at 38.5° 1100 feet at 29° 920 feet.

D 6. 657 is below the Kearsarge conglomerate at the Medora 1056 ft. Cf. Arcadian (76), as well as (69) which is (866+355) (1221) feet below the Kearsarge conglomerate.

53. Ophite
Amygdaloid d 6. 720?-724
Trap d 6. 724-789
The mottling reaches 5 mm.

This Empire cross section will cover just about the first mile south of the Allouez conglomerate (15), and should also show beside the beds of Section 14 those of the first row of forties in Section 23, leaving about half a mile to be explored down to the Mt. Houghton and the Bohemia conglomerate.

In this the dips will be steep, and they should be, for we have all the beds of Manitou-Frontenac 7, Holes 6, 7, 8 and 9, 2000 feet or so, to be crowded in, including the Isle Royale lode. ($2300 \div 2640 = \sin 60^\circ$)

§ 4. MANDAN¹ AND MENDOTA. (Figs 25 and 26.)

On Section 16 a couple of veins are indicated running into the Washington Copper Company lands, and on Section 17 on the east side are the fissures opened up by the Medora shaft of the Keweenaw Copper Company. Only a few belts just below the Allouez conglomerate have been proved up thus.

A much more complete section than any heretofore is that of the Mandan. This follows and is derived from notes of A. C. Lane and those of W. W. Stockly and A. H. Sawyer. This also runs north and south and the main section is close to the west line of Section 17, T. 58 N., R. 29 W.

Shortly east is a vein causing some displacement, shown by the drill records. On the coast east of Agate Harbor about 400 paces east of the west line is a vein striking nearly north and south,

¹Developed at the same time as the Medora and so referred to at times in my notes.

called by Whitney the Giraffe vein. It would be hardly a stretch of the imagination to connect this clear across the range with the Mendota vein of Mt. Bohemia² in Section 29, six miles south, and there would be but a slight bend needed. However, I think it quite as likely that there is a sharp displacement of it on a strike fault or slide somewhere near the Montreal River just as the vein of the Central mine is displaced under the Kearsarge conglomerate.³ Note the slide indicated in the section in Hole 4 at about 337 feet depth.

Mandan (Fig. 25 in envelope). Nearly N. and S. at right angles to strike. Mandan drill hole 14. Elevation 674.25. Surface 2 feet.

(19)⁴ (1) The Greenstone.

Trap d 1. -578

Trap not exposed, mottles much of the way too large for the drill core to show distinctly. Manitou b. 19.

At 2, 95, 100, 125, 156-182, 182-224,
20 mm., 25 mm., 35, 28-32, 40+, 30+,
329, 363
22, 20

- at 474, 497, 513-521, 542-554, 568 ft. mottles are:
+ 8, 6, 5-6, 4, 1-1/2 mm.+

At 18 is a seam with copper and prehnite, at 408 is a seam of prehnite at 72° to the core, at 454 at 69°. At 29 and 33 it is doleritic with feldspar 3 or 4 x 2 mm. and augite in large grains.

The core owing to the uneven hardness due to the augite crystals has a peculiar knobby appearance well shown at 95 ft. Porphyritic crystals of feldspar occur (but are rare) and may be as much as 10 x 2 mm. or 12 x 7 mm. at 189 ft.

This also is the first bed in Hole 13 to 202 feet. In the interior of the augite the feldspar is smaller and by patches of smaller feldspar with coarser between them is the ophite pattern brought out.

At 13, 95, 128, 138, 143, 151, 158, 168 to 170, the mottles are:

10-12 8, 7, 6, 6-5, 5, 4, 2-3 mm.

and at 177, 182, 187, feet they are:

1/2 to 1-1/2, 1 mm.

The rate of increase of diameter of the augite patches (A of Chapter IV) is one of the most rapid found—1 mm. in 8.5 feet, in 2.6 meters or .00032⁵

(20) (2) Allouez conglomerate

Absent in No. 14

in No. 13 202-220

²See report by F. E. Wright for 1908.

³Hubbard, Lake Superior Mining Institute, 1895, Pls. II and III.

⁴The side numbers in parenthesis in holes 14 and 12 refer to corresponding belts in Manitou 3.

⁵Cf. the results in Manitou 3 and on Isle Royale. The fact that the gradient is greater here may be connected with the fact that it is thicker. But it must be remembered that with large poikilitic patches of augite one would think one would oftener get small clipped off segments of the patches and so get the grain too small.

- (21) (3) Feldspathic ophite (13) 220-326
Amygdaloid d 14. 578-593 (14) (35)
with copper
Trap d 14. 593-616
Feldspathic ophite, amygdaloidal at top to 546 then finer
and darker.
- (22) (4) Feldspathic ophite. Hanging of Medora lode
Amygdaloid d 14. 616-621 (5) (53.)
Well-marked with calcite and pink and green amygdules
Trap d 14. 621-673 (48)
Feldspathic and coarsely amygdaloid at top, dark, finer,
more chloritic at base.
Base below base of Allouez (87)
This corresponds to the distance to the Medora lode from
the Allouez in the 7th level cross-cut. in the Keweenaw
Copper Co. mine on the Medora location, though there and
in d. 13 but one flow occurs.
- (23) (5) Medora lode and foot, feldspathic ophite
Amygdaloid d 14. 673-676 (3)
Well-marked with datolite and copper at 675 ft.
Trap d 14. 676-725 (45)
Faintly ophitic; at d 14. 700 seams at 45° to the core.
Distance from base of Greenstone 725-578 = 147 (136) ft.
- (24) (6) Ophite, the Mandan ophite 60+
Amygdaloid d 14. 725-727 (?)
With copper (Manitou lode?)
Trap d 14. 727-860+ (132)
At d 14. 860 6-7 mm. which would indicate 60 ft. more
at least. This I take to be the same as the heavy bed at
the top of Mandan No. 1 to 120 ft, and No. 12, 20 to 511
feet, with a dip to be inferred of 20°. But the dip at the
mine being 23.5° it is a question if this not due to faulting.
The distance in No. 14 is (136) between Greenstone and
this ophite in No. 13 is (126)
Comparing various sections and exposures it seems that there
are below base of Allouez to base of Mandan ophite (611)

Mandan drill hole 12. Is considerably to one side of main line of
section and is thrown by a fault probably.

- (19) The Greenstone ophite trap d 13. 0-202 (730+)
Described in connection with Hole 14
- (20) Allouez conglomerate d 13. 202-220 (17)
Absent in d 14. Dip 18.5° in a sandy streak.
- (21) Medora lode hanging (85)
and Amygdaloid d 13. 220-228 (7)
- (22) Poor to d 13. 228, then brecciated, with copper and preh-
nite; much very fine copper to 225
Trap d 13. 228-310 (78)
Doleritic at 256 ft.
Basal amygdaloid d 13. 310-317

- With Thomsonite in coarse scattered amygdules and
amygdaloid spots included in Medora lode.
- (23) Medora lode and foot. Strike N 87° 30' E; dip 23° 40' (21)
Amygdaloid d 13. 317-331 (14), (10+ in the mine)
Amygdaloid trap d 13. 331-338 (7)
- (24) Amygdaloid d 13. 338-343 (5)
Trap d 13. 343-352-½
Holes 12, 2, 5, 1, 7, 9, and 3 around the Mandan overlap
a good deal.
As near as I can make it the following is the correspondence

Houghton (8) Cong.	(10)	(12)	Montreal (12)		
12.530-548	12.590-599	12.670-682	12.743-752	1.480	1.901-920
1.121-124	1.185-196	1.263-277	1.350-359		
3.120-128	2.112-128	2.191-200	2.277-304		
9.141-150	3.178-195	5.171-201	3.339-349	3.461	3.881-901
	9.210-223	9.282-305	5.280-290		10.177-194

Holes 7 and 9 have been thrown north 90 ft., i. e. the west side is thrown N.

There appear to be at this horizon (that of the Houghton
conglomerate) three or four flows which are very similar,
all having a well-marked ophite texture with amygdaloids
which on top verge into an amygdaloidal conglomerate.
See Plate VII, Sp. 20485. If the Houghton conglomerate
is the top of the series, the lode opened on the Manitou
property known as the Montreal lode appears to be this
third. It was, however, enriched apparently only in the
spot near a fissure.

Mandan hole 11 was merely to bed rock.

Mandan hole 12 vertical. Dip 22°.

- (24) (5) Medora foote
Trap d 12. 2-20
Fine grained.
- (27 to 28) (6) Mandan ophite (475)
Amygdaloid d 12. 20-33
Ill marked; contact also at 28 ?
Trap d 12. 33-511 = 478 (462)
Feldspathic ophite, at 70, 89-127 ft. the mottles are
3-5 7 mm.
Doleritic with 4 mm. feldspar at d 12. 136-137
Up to 10 mm. " at d 12. 192-193 with copper
and coarse amygdules on a fine grained, red ground, another
doleritic streak at 245-262 with 10 mm. feldspar. These
streaks develop from normal ophite with no sharp contact.
The augite patches continue coarse into them but the feld-
spar becomes much coarser, and more chloritic interstices
form.
Chloritic seams at 89 are at 45° to the core.
at 239 are at 20.5° to the core.
at 386 and 439 at 69° to the core.

Toward the base they fall into a system parallel and perpendicular to the contact.

At 70, 89-127, 134, 164, 188-198, 213, 239-256, 284, 305, 328, 360, 386, 394, 439, 465, 478, 485, 495, 502, 506 ft. the mottles are 3-4, 7, 8 mm., 5-6, faint 7 mm., 1-2, 10-15, 15, 17-20, 20+, 13, 10-12, 12, 8, 5, 4, 4, 3, 2, 1 mm. a rate of increase = A about 1 mm. in 10 ft. (9.3) starting from 518 to 328. About 213 there is an irregularity that suggests close welding of two flows, or faulting, or possibly super-heating and hence finer grain.

In the coarseness of the mottling this is next to the Greenstone, and one might even think of repetition by faulting. In no other section is there nearly as heavy a flow here. See Mandan Hole 1 down to 121, Hole 9. 10 to 282

Base of Mandan ophite below base of Allouez (637 ft.)

(7) Melaphyre

Amygdaloid d 12. 511-515 (4)

Trap d 12. 515-530 (14)

Fine grained. This does not appear in Holes 9 and 1

(32)

8. Houghton conglomerate ?

Conglomerate d 12. 530-542 (12?) elsewhere (3)

9. 141-150

1. 121-124?

Cf. also 1. 181-195

Base of Houghton conglomerate to base of Allouez (666)

This checks very well with the thickness at the Manitou but the section between does not compare well.

(33)

9. Feldspathic ophite. (48)

Trap d 12. 542-590 (48)

9. 150-185 to 210

1. 124-185

Brecciated and amygdaloidal to 554, lightly glomeroporphyritic to 559; an amygdaloid spot at 585.

10. Amygdaloid conglomerate top.

Amygdaloid d 12. 590-599

9. 210-211

1. 185-196

Brecciated to 592 and from 594-599 appears to be a conglomerate.

11. Ophite (3 mm.)

Trap d 12. 599-670 (66)

At 605, 610, 618, 634, 647, 651, 655, 656, 661 ft. the mottles are $\frac{1}{2}$, 1, 2, 3, 2, 1-2, $1\frac{1}{2}$, 1, $\frac{1}{2}$ mm.

From 661 ft. to 670 ft the trap is brecciated, the core in nubbins.

Same 3 mm. coarseness also in Holes 9 and 1.

12. Amygdaloid conglomerate?

Amygdaloid d 12. 670-682 (17)

9. 282-300

1. 263-277

2. 191-200

3. 265-275

brecciated with green and red fragments, to 682 poor.

13. Ophite

Trap d 12. 688-743 (51)

At 688, 693, 700, 712, 715, 723, 733 ft. the mottles

are 1, 1-2, 1 and 2, 2, 3, 2-3, 1-2 mm.

Chlorite seams at 723 at angle of 51°.

(38)

14. Ophite "Montreal lode" (3 mm.+) (48+)

Amygdaloid d 12. 743-757

9. 365-380

1. 350-359

2. 277-304

3. 339-349

5. 280-290

Green and red fragments of amygdaloid and trap mixed.

Trap d 12. 757-791 + end of hole

At d 12. 781 and 791 + feet the mottles are

1-2 and 3 mm. respectively

Mandan drill hole 1. About 100 ft. east of the west line and 610 ft. north of the W. Q. P. of Section 17, T. 58 N., R. 30 W., about 700 feet from the quarterpost in direct line and about 1460 feet south of the Greenstone (the Allouez conglomerate No. 15) elevation 380 A. L. There is a coarse outcrop of Mandan ophite about 100 feet north of it. The greenstone base is said to be 1460 feet north and by my measurement a point where the mottles are 3-5 mm. across is about 1290 feet north on a level. It must begin then between 530 and 630 feet below the Allouez, probably 680 feet. The reduction factor for the thickness is about 89°.

1. Overburden (hardpan till)

7

6. Mandan ophite

(200?)

Trap d 1. 7-120.6 = 113 (92)

Lower half or third of a heavy ophite begins with 10-12 mm. mottles at 7 feet, and apparently equally coarse to 34 feet; at

57, 83, 99, 109 feet, that is —

52, 30, $17\frac{1}{2}$, 9, feet from the bottom.

the mottles are reduced to

8-10, 4 + mm., 4 mm., 2 mm., across. We have some feldspars, minute brown specks of altered olivine (rubellan) and chloritic seams or joints making angles of

21°, 29°, 32°, 22°, with the drill core at

43'9", 50', 58 to 85, feet respectively

probably about at right angles to the dip; averaging these observations would be 26°, while the dip appears to be 28°.

7. Sediment ? d 1. 120-124 = 4 (4)

Houghton conglomerate?

d 1. 120-122 is greenish white, epidotic and sericitic. At 124 feet there is a pink and green mottling like Castile soap and an apparent dip of (8:15) 28°. This may be the beginning of the Houghton conglomerate horizon but no where else do we seem to have an extra heavy bed just above.

This Mandan Ophite is a very heavy bed and from the grain I could hardly have put it down as less than 250 feet thick. It ought accordingly to be fairly persistent. We find one in the Franklin Jr. under the Albany and Boston conglomerate 15, from 100-233 below, the Houghton being 389, two flows intervening.

No. 37 in Tamarack No. 5, belts 59-60 from 3320-3594 is a massive ophite 217 feet thick, which we find in the other shafts:

In Tamarack No. 4 from 3050-3334, 234 feet thick.

In Tamarack No. 3 from 2819-3114, 225 feet thick.

In the Redjacket shaft at 1954 and 2200, about 202 feet thick, its base about 455 below the Allouez.

At the Cliff an extra heavy bed of trap seems to be between 400 and 500 feet below the "slide".

At the Central, the nearest equivalent would seem to be (8) from 401-476 feet below the slide, noted as very thick and uniform, though the Central mine section is evidently taken so carefully as to give many pseudoamygdaloid and doleritic bands, probably not individual flow tops, elsewhere overlooked. It is taken near a vein where the belts are hard to make out. At the Delaware mine we find a heavy bed of trap from 100-360 feet below the Allouez which in the deeper levels of the mine is counted as two with an amygdaloid. But my studies at the surface show that it is probably all one bed, with a good many doleritic streaks and full of amygdaloid inclusions. It is probably these latter that lead it to be called two beds deeper down. Cf. Manitou d 3. 27 to 28.

There appear to be only two amygdaloids between this and the horizon which has been called No. 2 and has been identified by Marvine as the Houghton. This latter appears as a well-marked amygdaloid contact in an old railroad cut about 1230 feet from and 100 feet below the Allouez conglomerate, or over 600 feet below it.

9. Amygdaloidal melaphyre (53)

Brecciated amygdaloid d 1. 124-129 = 5 (4)

Amygdaloidal trap d 1. 129-163'6" = 34 (30)

Trap d 1. 163-185 = 22 (19)

Amygdaloid much veined but with pieces of red amygdaloid with amygdules in a flaky ground full of irregular seams of calcite which in a general way dip (8:15) at an angle of 28° and probably indicate the sliding. At 129' 6" it becomes hard brown, compact with very small white amygdules. There are then red fragments with calcite seams and blotches to 132, then a foot like 129' 6" fine grained with white specks crosswise, then a foot redder and more calcitic, then like 129 to 142, with brown specks of altered olivine; at 142-143 there is a rusty streak with amygdules still numerous; at 145 there are white amygdules 5 mm. across with chlorite rims, and calcite centers; it remains fine grained with scanty small amygdules to 163' 6" where it becomes

prehnitic. There is a laumontite seam at 161. At 164 it becomes more massive trap with 1-2 mm. mottles at 172, then fine grained and black.

10. Scoriaceous amygdaloidal conglomerate d 1. 185-191 = 6 (5)

d 1. 185-188 is a breccia of fine grained red amygdaloid with white amygdules and veins, and to 191 it is a well-marked scoriaceous conglomerate.

11. Ophite (3 mm.)

Amygdaloid d 1. 191-196 = 5 (4½)

Trap d 1. 196-263 = 67 (60)

The amygdaloid is poor and coarse, and probably if not shattered much of the belt above would belong to this amygdaloid. The trap has well-marked mottles:

2,	2-3,	2-3,	3,	1-2,	½ mm. at
205,	212,	217'6"	240,	248,	257 feet
(47)	(43),	(37),	(19),	(12),	(5) (feet from base)

The base of the flow is near 261 feet. From 261-263 is fine-grained amygdaloid.

12. Scoriaceous conglomerate d 1. 263-277 = 14 (12½) (840)

Includes also the broken up (brecciated) part of the beds below. This is the lowest place at which the Houghton conglomerate can come.

13. Ophite (3 mm.) (64) (904)

Amygdaloid d 1. 277-279 = 2 (2)

Trap d 1. 279-350 = 71 (2)

The amygdaloid contains calcite, prehnite and copper (possibly Montreal lode?). The trap has mottles 2 mm. and 3 mm. at

297,	307,
44,	35 feet respectively,

then growing finer.

A fine grained ophite, with chloritic amygdules, from 345-350.

14. Ophite (Montreal lode and foot) 5-6 (114) (1018)

Amygdaloid d 1. 350-369 = 19 (17)

Trap d 1. 369-480 = 111 (96)

The amygdaloid is poor and but slightly brecciated to 359.

There is rather more trap to 365, then to 369 there is much prehnite and copper. Montreal lode? The trap is at first rather broken up, but has well-marked mottles of 2 mm., 3-4 mm., 4-5 mm., 5-6 mm., 4 mm., 2 mm., 1 mm., at 376-380, 399, 409, 426, 442, 460, 469 ft (871-8), (67), (58), (44), (31), (17), (8) above base.

There are numerous chlorite seams, making angles of 33° and 54° with the drill core. (At 456 is a speck of copper in one)

15. Ophite (3 mm.) (52) (1070)

Amygdaloid d 1. 480-482 = ? (2)

Trap d 1. 482-538 = 56 (50) ?

The amygdaloid is pure and the ophitic texture is at once resumed. We may probably infer no great break between.

The mottles are	1,	1-2,	3,	3,	1-2 mm.
at	483,	487,	501,	515,	527' 6" ft.
	45,	42,	31,	19,	8 above base

16. Amygdaloid conglomerate d 1. 538-545 (7)
d 3. 520-545
with copper, red, fine grained, brecciated with different kinds of amygdaloid.
17. Ophite
Trap d 1. 545-622 (73)
At 575, 594, 603, 606, 612, 619 feet the mottles are
1, 1-2, 2, 2, 1, $\frac{1}{2}$ mm.
18. Ophite (1 mm.)
Amygdaloid d 1. 623-625 (2)
Prehnite and perhaps a sphere of Thomsonite.
Trap d 1. 625-648 (23)
Fine grained, with chloritic amygdules and very chloritic at base.
19. Amygdaloid conglomerate d 1. 648-668 (18)
With prehnite; at 668 a slickensided seam, so striated, (it dips 67.5° against core) that if the dip of the plane is really $22\frac{1}{2}^\circ$ to the north, the strike of the striae is about N. 18° E. This is in a way really the top of 20 and should be compared with d 3. 653.
20. Trap d 1. 668-679 (10) Melaphyre (10)?
Fine grained
21. Ophite 3 mm. (143)
Amygdaloid d 1. 679-681 (2)?
3. 653
Trap d 1. 681-835 (14)
Fine grained with amygdaloid spots to 700
Joints at 63° and 58°
At 700, 706, 714, 722, 738, 755-9 ft.
The mottles are 1- $\frac{1}{2}$, 2-3, 3, 4(7x3), 5, 7mm.
790, 796, 801-4, 813, 821, 824, 828
8, 6, 4-5, 3, 1, 1-2, 1 mm.
19 to 21 may well be one flow. Cf. Manitou 42. Cf. Empire 24.
22. Ophite 3 mm.
Amygdaloid d 1. 835-839 = 4
Trap d 1. 839-901 = 62
From 850 distinctly coarser, and at 864 and 881 3 mm. across.
At 891 $\frac{1}{2}$ mm. getting finer.
23. Conglomerate—the Calumet (18)
d 1. 901-920 = 10. 177-194 (19)
One inch felsite, the rest basic
Base below base of Houghton conglomerate
at 24° dip, about d 1. $920-124 = 796 \times \cos 24^\circ$ (726)
or from d 12. 592-743 to Montreal lode hanging 201
from d 3. 339-901 thence to Calumet base 763 (710)
or from d 3. 120-901 781 (725)

Mandan drill hole 3. Laps Hole 1 almost all the way, as follows:

7. Trap d 3. 115-128
8. Houghton conglomerate absent

9. Ophite. (65)
Amygdaloidal trap d 3. 120-128 = 8
Trap d 3. 128-178 = 50
at 136-142, 142-152 feet the mottles are
1 1 to 2 mm.
Amygdaloid d 3. 178-190 = 12
Marked dark and white. This is apparently a basal amygdaloid.
10. Houghton conglomerate?
Amygdaloid conglomerates d 3. 190-195
d 1. 185-188
Marked with red sediment as well as decomposed matter and dark fragments.
11. Ophite (2-3) (64)
Amygdaloid d 3. 195-198 = 3
Poor, the balance in the bed above
Trap d 3. 198-265 = 67
At 208, 228, 240, 246-249 feet the mottles are
1 and 2, 2, 2-3, 1 to 2 mm.
12. Amygdaloid conglomerate d 3. 265-275 (9)
Well-marked with considerable sediment.
13. Ophite (2 $\frac{1}{2}$ mm.)
Amygdaloid d 3. 275-282 = (7)
Brecciated trap d 3. 292-340 = 48
at 295, 303, 315, 320 feet the mottles are
1 to 2, 2 to 3, 2 to 3, 2 decreasing to base. Little thinner than in 1. (110)
14. Ophite (4 mm.)
Amygdaloid d 3. 340-348 = 8
Almost an amygdaloid conglomerate; Montreal lode?
Trap d 3. 348-461 = 113
Fine grained to 378 ft. at 378, 394, 402, 423, 435,
1 to 2, 3 to 4, 4, 4, 3,
443, 455, 459,
2, 1, $\frac{1}{2}$ mm.
There is probably some faulting disturbance near 378.
15. Ophite (2 mm.) (53)
Amygdaloid d 3. 461-465 = 4
Cf. d 12. 670
Brecciated at top
Trap d 3. 465-520 = 55
Fine grained to 407, then brecciated; in spots amygdaloidal; at 491, 2 mm. at 508 about $\frac{1}{2}$ mm., like 459 exactly; 486 was a band of finer grained, 1-2 mm. mottles.
16. Melaphyre (23)
Amygdaloid d 3. 520-535 = 15
d 1. 480
Trap d 3. 535-545 = 10
Brecciated, the Montreal lode being perhaps a shearing band.

17. Ophite 2 mm? (Montreal lode and hanging) (53)
 Amygdaloid d 3. 545-575? = 30 with spots of breccia
 Trap d 3. 575-603 = 28
 Ophitic, coarsest is 1-2 mm., at 598 it is 1 mm. and 599 $\frac{1}{2}$ mm.
 Manitou d 6. 40 or 38?
 Ophite 1 mm.
18. Amygdaloid d 3. 603-605 (45)
 Poor d 1. 648?
 Trap d 3. 605-607
 Poor amygdaloid d 3. 607-612 5
 Trap d 3. 612-653 (? or 643)
19. } Ophitic; at 620, 626, 631, 642 feet the mottling is
 20. } $\frac{1}{2}$, 1, 1, $\frac{1}{2}$ mm. respectively
 Manitou (41)?
21. Ophite (5 $\frac{1}{2}$ mm.)
 Amygdaloid d 3. 653-671 = 18
 d 1. 668 or 679
 Brecciated.
 Trap d 3. 671-812 ? = 141
 Ophitic, at 692, 695, 703, 715, 730, the mottles are
 2, 2, 2 to 3, 3 to 4, 5, mm.
 at 750-760, 787, 798, 803, feet they are
 5 to 6, 3, 2, 1, mm.
 This extra heavy ophite, the second above the Calumet conglomerate,
 is also in the Manitou (b. 42, 167 feet thick). Central (cf. 24). Just
 above, too, in all cases there is a belt with only small mottles often con-
 siderably disturbed.
- (22) Ophite 2 mm.
 Amygdaloid d 3. 812-821-834-836 = 24
 Poor with small amygdules, then trap, then poor again, to 834, then
 poor and coarse with calcite and prehnite to 836.
 Trap d 3. 836?-881 = 45
 At 863 2-3 mm. mottles. In No. 1 it is (61) feet thick with 3 mm.
 mottles. At the Manitou it was from 52-63 feet thick (644) and at the
 Empire it is similar.
- (23) Calumet conglomerate, d 3. 881-901 (18)
 At 881 a narrow band with small pebbles of felsite but mainly an
 amygdaloid conglomeratic with porphyritic, not very amygdaloid frag-
 ments, toward the base considerable red mud, with dips of 23 to 26.5°.
 Cf. d 10. 177-194
 d 1. 901-920
- (24) Ophite
 Trap d 3. 901-961
 d 10. 194
 at 913 to 920 the mottles are
 1 to 2 mm.
- (25) Ophite (1-2 mm. + ?)
 Amygdaloid d 3. 961-971 ?
 d 10. 245
 Trap d 3. 971-1047 plus
 At 1012 the grain is 1-2 mm. Between 1047 and 1073 there is a fine
 and a coarse streak, and much chlorite, cf. d 10. 294.
 The line between (25) and (26) can not be made out.

- (26) Ophite (4 mm. +)
 Trap d 3. 1073 minus to 1095 plus
 at 1073 and 1092 feet the mottles appear to be
 2 to 4 mm. respectively.
 There are numerous laumontite seams at 75° to core.
 The grain at 1095, (171) feet below the Calumet, is about that in d
 10 at 401, which is (186) feet below.

Mandan drill hole 7. Falls on the cross section at 5450, but the correlations are
 plainly such as to show it has been relatively displaced 90 feet to the N., being on
 the west side of the section. Vertical, elevation 494.51 above datum.

1. Overburden of drift (sand) 115 feet
 13. Ophite 2-3 mm. (61+)
 115 minus to 166
 Trap at 115, 138, 160
 1, 2-3, 1 mm.
 Amygdaloid conglomerate ? 166-168
14. Ophite (5+) Montreal lode and foot (120)
 Amygdaloid and amygdaloid trap d 3. 168-185 (16)
 d 1. 350-359
 Trap d 3. 185-297 (104)
 At 188 are coarse and fine mottles 1 mm. to 3 mm. in alternate bands,
 with a few chloritic amygdules and a spot of amygdaloid at 190 and
 195.
 At 194, 204, 223, 235, 254 the mottles are
 2-3, 3, 4, 5, 5+ mm. then a chlorite seam, at 26°
 then at 271, 277, 282, 287, 290 ft
 3 $\frac{1}{2}$, 2, 1 to 2 1, $\frac{1}{2}$ mm.
 The hole may cross a fault at 255, and the last ophite does not match
 15 well.
15. Ophite (50)
 or 17.
 Amygdaloid d 3. 297-307 (9)
 Red and white typical
 Trap d 3. 307-351 (41)
 Brecciated to 312 and amygdaloidal to 319
 At 340 to 351 showing 1 to 2 mm. mottles.

Mandan drill hole 2 laps Hole 1 a short distance at the top giving a good chance
 to get the dip, 25°. Vertical elevation 510 above datum, — 410 A. L. S.

1. Drift 58
 (9) 2. Amygdaloid d 2. 58-61 (12)
 Decayed laumontite, with signs of sediment.
 Trap d 2. 61-113 (47)
 Chloritic, fine grained joints at 25° to core.
- (10) 3. Amygdaloidal conglomerate (14)
 d 2. 113-128
 d 1. 185-196
 Marked and sedimentary contact dip 18.5° to 24° fading from con-
 glomerate to amygdaloid with small pink and white amygdules.

- (11) 4. Ophite (2 mm.) (57)
 Trap d 2. 128-191
 Red brecciated and amygdaloidal at base
 At 136, 142, 159, 165, 172 feet the mottles are
 1 to 2, 2, 2, 2, 1½ mm.

- (12 and) 5. Ophite (3 mm.) (90)
 (13)
 Amygdaloid d 2. 191-200 (8)
 d 1. 263-277
 Trap d 2. 200-277 (70)
 At d 2. 215-217 nearly vertical seams
 At d 2. 223, 227-245, 250, 264, 268 feet the mottles are
 1 to 2, 2, 2, 1 to 2, 1 mm.

- Basal amygdaloid 277-290 (12) joints at 59° and perpendicular.
 (14) 6. Ophite (3½+ mm.) Montreal lode (62+35+)
 Amygdaloid d 2. 290-304
 With laumontite, calcite, chlorite
 Traps d 2. 304, 347
 At 308, 321, 332, 342 ft.
 1 to 2, 3, 3, 3½ mm. mottles

Mandan drill hole 10. At 4353 of section, vertical. Correlating with the Calumet and Hecla conglomerate in No. 1 gives a dip of 26.5° and a reduction factor of .90

1. 27 feet of drift
 (21) 2. Ophite (6+) (80+40?)
 Trap d 10. 27-117
 At d 10. 32, 63½, 70, 100, 105, 114 the mottles are
 4, 6½, 5½, 2½, 1, ½ mm.

Then there are chlorite seams at 24.5° and 42° at 114 ft.
 This is evidently the lower part of flow 21, i. e. d 1. 679-683
 d 3. 653-750

- (22) 3. Ophite (54)
 Amygdaloid d 10. 117-139 (20)
 d 1. 835

Poor, fine grained, red, porphyritic
 Trap d 10. 139-177 (34)
 d 1. 839-901

At 145, 157, 170, 175 feet the mottles are
 1 to 2, coarser 2 1½

At 146 it is brecciated and the samples sludge, as also at base. The bed is evidently disturbed.

- (23) 4. Calumet conglomerate Marvine's 13 d 10. 177-194 (13)
 1. 901-920
 3. 881-901

The top is brecciated and ill-defined from the amygdaloid above but passes into a distinct basic conglomerate with red sediment and crystals in the cavities.

- (24) Ophite 2 mm. (46)
 d 10. 194-245 to (40)

At d 10. 217 feet the mottles are 2 mm.

I doubt if this is present in the Manitou section.

25. Ophite 2-3 mm. to (90)
 Amygdaloid d 10. 245-259 (13) (78)
 3.961

Amygdaloidal trap d 10. 259-265 (8)
 with large amygdules

Trap d 10. 265-331 (59)

At 266 to 273, 278, 285 to 296, 306, 327 ft.
 1, 1 to 2, 2 to 3, 2 to 3 finer, 1 to 2 mm.

At 294 ft. a seam at 45°

This would agree well with Manitou 45 M. 3. 2. S 100-172, M. 7. 1. S. 260-320

Amygdaloid d 10. 321-345 (14)

Fine red and white brecciated, its relations with the ophite above and the conglomerate below uncertain.

26. Amygdaloid conglomerate d 10. 345-351 (5)
 Beds 26 and 27 may be d 6. 46 of the Manitou section.

27. Ophite (4 mm.) (73 to 64)
 Trap d 10. 351-433

At 357, 362, 381, 396, 401, 408, 418, 422, 429
 1, 2, 2 to 3, 3, 4, 2 to 3, 2, 1, ½

28. Ophite (5 mm.) (120)

Amygdaloid d 10. 433-450 (15)

Trap d 10. 450-567 (105) (to 105)

At 450, 457, 468, 488, 497, 505, 530,
 ½ to 1, 1, 2, 3, 2 to 3, 4 to 5, 4,
 543, 547, 551, 565 ft

3 to 4, 2 to 3, 1 to 2, 1 mm.

This agrees best with the 5 mm. ophite 6.47 of Manitou section.

29. Ophite (6 mm.) (115)

Amygdaloid d 10. 567-582 (13) to

Typical red brecciated with amygdules (100)

Trap d 10. 582-694 (101)

At 616, 619, 624, 629, 639, 660,
 1, 1 to 2, 2 to 3, 3, 5 (6 maximum) 5,

At 665, 667, 682, 683, 688, 692 feet mottles are
 3 to 4, 2 to 3, 2, 1 to 2, 1, ½ mm.

At 677 is a heavy chlorite slip dipping 80.5°.

This agrees in grain and thickness fairly, with b. 48 of the Manitou section, supposed to be above the Calumet amygdaloids there.

30. Ophite (3 mm.) Calumet amygdaloid and foot (81)

Amygdaloid d 10. 694-700 (5)

At 698 is a phenocryst?

Trap d 10. 700-784 (76)

At 715, 732, 737, 743, 780 feet the mottles are
 1 to 2, 2, 3, 1 to 2, ½ mm.

At 758 and 763 there are amygdaloid streaks. Cf. Manitou 49 M. 3. 2. S., 459-545 also cf. 50. Doleritic. In calling this the Calumet amygdaloid there is a possible error of one flow each way.

31. Ophite (5 mm.) Osceola amygdaloid (128)

Amygdaloid d 10. 784-788 (4)

Red, fine grained, poor

Amygdaloidal trap d 10. 788-793 (4)

- At 200 seamed perpendicular, at 212 at 30° dip, at 331 35° and vertical or 69° and 45° seams at 33° parallel to bedding?
Doleritic with coarse feldspar and amygdaloidal at 260, 262, 387, 388, 392 to 4, 403 to 5, 409 to 410 with 5 mm. feldspar and blotches of chlorite, 426.
- This is probably Manitou Belts 57 and 58
41. Feldspathic melaphyre (296)
Amygdaloid d 8. 519-523 (3) (25)
There is a distinct contact here, and below it is red glomeroporphyritic with sparse amygdules of prehnite.
Trap d 8. 523-548 (25)
Faintly mottled at 528-542 (2 mm?) Perhaps this faint coarse mottling is due to feldspar aggregates, glomeroporphyritic.
42. Feldspathic melaphyre
Amygdaloid d 8. 548-559 (10)
Glomeroporphyritic coarse amygdules (24)
Trap d 8. 559-573 (12)
Glomeroporphyritic finer
Basal amygdaloid d 8. 573-574.5 (2)
43. Sediment at d 8. 574.5
(Cf. the sediment in Manitou Beds 59 to 64)
44. Melaphyre d 8. 574.5-585 (8)
Fine grained
45. Sediment at 585 ft. below Kearsarge conglomerate 353
46. Feldspathic ophite (71)
Amygdaloid d 8. 585-589 (3)
Trap d 8. 589-667 (68)
At d 8. 635 2 mm. mottle, seam at 39½
Cf. Mandan 63, the top of which is 258 feet below the Kearsarge.
A steeper dip here would make a better agreement.
47. Feldspathic ophite (40)
Fine grained top Mandan d 8. 667-672 (4)
Red glomeroporphyritic, only slightly amygdaloid
Trap d 8. 672-713 (35)
Perpendicular seams at 687
At 692 and 712 is a 2 to 3 respectively 1 to 2 mm. faint mottling.
48. Feldspathic ophite (60)
Amygdaloid d 8. 713-716 (3)
Fine grained with prehnite and copper
Trap d 8. 716-782 (56)
Seam at 26.5°. Toward base is darker and mottled, at 753 3 mm.
49. Feldspathic ophite (62)
Amygdaloid d 8. 782-790 (7)
Fine grained, red with coarse chloritic amygdules.
Trap d 8. 790-853 (55)
At 818 and 825 ft. the mottles are 2 to 5 and 2 mm.
The base is also red and porphyritic.
50. Amygdaloid d 8. 853-871 (15) (25)
Red and pink or white laumontite, at top; toward base prehnite or thomsonite and slightly amygdaloid.
Trap d 8. 871-882 (10)

51. Sediment at 882 (marked contact)
Base below base of Kearsarge (611)
Cf. Manitou b 67 which is 178 ft. above the Kearsarge lode and Central 650.
52. Melaphyre. (25)
Amygdaloid d 8. 882-888
Coarse, poor
Trap d 8. 888-end
Cf. Manitou b. 68
Owing to the unexpected steepening of the dip this hole does not quite lap No. 6. Assuming that Belt 51 is 178 feet above the top of the Kearsarge lode, as at the Manitou, the dip from 6 would be 31¼° and all indications are that the dip is at least as steep as that.⁶
The total distances from the Kearsarge lode up to the Kearsarge conglomerate would be about 775 to 789 feet, of which perhaps 88 feet are unrepresented and must be filled in with the aid of the Manitou sections.
If the total distance from base of the Kearsarge conglomerate to top of the Kearsarge amygdaloid is only 724 feet as in the Manitou 3 section there will be but 29 feet unrepresented. If the dip is steeper⁶, then Manitou Belts 70 and 71 may be unrepresented as 71 certainly is.
53. Sediment Manitou, Cf. 71 unrepresented at (636?)
- Mandan drill hole 6.* 50 feet south of Montreal River, see Fig. 25. Elevation 439.31 above Lake Superior. Vertical. Overburden drift. (636) (52)
54. Feldspathic ophite (26+20)
Trap d 6. 52-82 begins faintly mottled grows finer, at 692, 3 mm.
Cf. Manitou 6. 69 and 70
55. Melaphyre (18)
Trap d 6. 82-106
Fine grained with a little poor amygdaloid top.
Cf. Manitou d 6. 72 which may include 53 also
56. Ophite hanging of Kearsarge lode (38)
Amygdaloid d 6. 106-112 (5) with red amygdules and white pink bordered ones.
The amygdaloid looks something like the Kearsarge.
Trap d 6. 112-150 (33)
Faintly mottled cf. Manitou 73 Frontenac 3. 5. S. 235-238
This will be No. 53 of the Central mine section
No. 73 of the Manitou 3 section
Base top of Keweenaw lode below base of conglomerate as estimated implying a dip of 30° 732
Cf. 724 feet at Manitou 3 724
57. Kearsarge lode and porphyritic ophite foot
Amygdaloid d 6. 150-156 (5)
With pink bordered amygdules so common in the Kearsarge lode and porphyritic crystals.
Trap d 6. 156-220 (55)

⁶Later drilling (No. 16) shows that this is so, and indicates dips as steep as 46°.

The porphyritic crystals are up to 10 or 15 mm. x 2 or 3 mm. at the beginning; at 168 appear a little coarser 25x5.

At 180, 200, 208, feet the mottles are
2-3, 2, 1-½ mm.

At base chloritic and numerous other seams.

In Mandan Hole 17. 28 or 62-105, the figure 62 being the lower amygdaloid in 18.51? or 84-135-½

in 19.35-89 (54) at a 60° dip, the hole beginning in amygdaloid.

Comparison of the thicknesses in the vertical hole and those at 60° would indicate a dip of 42°.

58. Wolverine sandstone. Marvine's No. 9 (9)
Sandstone passing into amygdaloid conglomerate d 6. 221-231
Dips noted were 55° (cross-bedding) 29.5°, 35°, 34° and 32°. Such a dip would imply a thickness of about 863 feet, from the base to the base of the Kearsarge, as against 982 at the Manitou and 752 at the Central.

Such a dip, proportionally greater thickness of section, and less thickness of individual beds is quite likely and has since been shown.

- Central mine b.56 (801)
Manitou b. 78
59. Melaphyre (?) (7)
Trap 6. 231-239
Manitou b. 79 ?
60. Ophite 12 mm. (345?)
Amygdaloid d 6. 239-251 (10) (to 280)
With a clasolite in crack showing bedding at 45° dip (295)
The amygdaloid contact dips 28.5°.
Trap d 6. 251-649 (335)
The mottling is well-marked.
At 254, 267, 275, 281, 302, 314, 330, 340 ft.
2, 3, 3, 3 to 4, 5 to 6, 6, 7, 8,
359, 378, 393 ft.
9, 10, 12 mm.
At 400, 414, 430, 441, 457, 494, 524, 543,
12, 10, 9, 11?, 7?, 8, 7, 5mm.
547, 565, 584 to 586, 593, 602, 607, 609, 619,
4½, 3, 2, 2, 1½, 1, 1 to 2, 1½ mm.
632, 645
½ ½ mm.

The extra slow rate of increase in grain in what appears to be a normal ophite suggests that the bed is cut quite obliquely. This is presumably Central mine 58, occurring in Holes 2 and 8, 42-314. The rate of increase there is about 1 mm. in (10) feet thickness from the bottom, but here it is 1 mm. in 14 to 20 (about 18) indicating a dip of 30° to 45°. In the Manitou Section 3 it seems to be cut out by a fault. Cf. Beds 79 and 80. But in Manitou 7 it is plainly Bed 80, the increase of grain being about 1 mm. in 12 feet. Cf. also Franklin Jr. 666, Hole 3, 451-535.

It does not seem to be coarser grained than at the Central and Manitou or at any rate much so. If its thickness is similar (250 to 280 feet) it must be cut by the hole at an angle of near 45°.

61. Amygdaloid 649-652. (3)
Perhaps just a gush of the great ophite or part of the conglomerate below.
62. Amygdaloid conglomerate d 6. 652-657 (5)
Band of indurated sandstone dipping 33° at the top, then a quite distinct conglomerate.
Base below base of Wolverine sandstone
Cf. Central mine d 6. 59 and 60
Manitou b 81
Franklin Junior 67 at d 3. 535' 4".
63. Amygdaloid melaphyre (16)
d 6. 657-676
Greyish, decomposed in appearance
64. Ophite (121?)
Amygdaloid d 6. 676-699 (21)
Amygdaloid trap and breccia
Trap d 6. 699-814 + (100) ?
Disturbed with laumontite, and copper seams at 33.5°, at 737 fluccan?, near 737 big perpendicular laumontite seam, at 750 and lower, prehnite and copper, also seams at 59° to core.
At 704, 712, 730, 737, 782-802, 814 feet the mottles are
1 to 2, 2 to 3, 3, 4? 3 to 2 mm. invisible, respectively.
Manitou b. 82? Central b. 61 to 62 does not show it. Is there a fault repetition, 58, 59, and 60 being repeated in 62, 63, 64? It is possible.

It will be noticed that Mandan Hole 6 has no good correlation in either direction and therefore might have the steeper dip which is found in this last hole. The fact that a flatter dip was found to the north influenced me, perhaps, in assuming a somewhat too flat dip in this hole. Subsequent work on the Kearsarge lode shows that it dips about 46° and the section should be amended accordingly (Fig. 25), lengthening the section in the ratio 7/5 and narrowing the individual beds.

Mandan drill hole 4. The indication of dip in the upper parts of the hole average 33°. Such a dip would mean an overlap with Hole 6, and a reduction factor of 0.84. This is assumed, *but* the dip might be and probably is steeper.

1. Overburden 20
(64). Feldspathic ophite (18)
Trap d 4. 28-49
Mottles 2-3 mm. at beginning, then finer.
Basal amygdaloid
Base below base of Wolverine, if this is 64 about (497)
(65). Sediment d 4. 49
Green epidotic dip (5:8) 32°

Cf. Mandan d 6. 652. This is the only correlation that can possibly be made for the hole in Bed 6 and is not impossible. The dip would then be 28.5°. But though not lithologically impossible it does not seem likely. If it does not appear in 6, however, there is no reason why the trap above should not be that at the base of Hole 6, the bottom of which is nearly reached. A dip of 33° would be implied.