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BY

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CHAPTER V (CONTINUED).

§18. GLOBE AND CHALLENGE EXPLORATIONS, LIMESTONE MOUNTAIN. PL. XI AND FIGS. 48 AND 59.)

The strike on the Baltic is very much west of south (S. 62° 30′ W.). It continues this course across Section 21 T. 44 R. 34 nearly to the Trimountain line near the center of Section 20. Then it is much shattered and very poor and turns quite abruptly and gradually becomes richer in copper on the Champion property where the strike is S. 26° 27′ W. Next beyond it was tested in Section 1, T. 55 R. 35 on the Globe property (Pl. XI) which was abandoned after a good deal of money had been spent on it. Only a limited section was exposed. The overburden of glacial deposits is heavy along this side of the Range now, from about the Baltic south, as a great moraine[1] extending from Wheal Kate has a course more southerly than the range. The location of the shaft and the three holes to determine the lode on Section 1, T. 55 N. 35 W. is given on Plate XI. Hole No. 2 is farthest north, then comes No. 1 (about 600 A. L. S.) and No. 3. At 280 feet the bed rock a "red trap" was found; at 306 to 585 feet was amygdaloid. See also discussion of samples of water from it. The surface sands proved exceedingly difficult to sink through.

It is about four miles farther to the Challenge where has been a very thorough bit of exploration with enough copper to be tantalizing, by the St. Mary's Company (R. R. Seeber, Supt.) guided by Dr. L. L. Hubbard, their General Manager.

It covers all the Bohemia Range group exposed,—from 655 feet above Conglomerate 8 down. The details of the drill records with large assistance from Hubbard's notes are as follows. See also the discussion of the distribution of salt water and especially Fig. 59 accompanying the same.

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[1]For further details, see F. Leverett in Publication 7, and § 19.

St. Mary's Mineral Land Co. Challenge drill hole 7. T. 52 N., R. 35 W. Elevation above datum 208.5 (1110 A. T.), above Portage Lake 717 ft., above cross-cut about 842. 1360 feet north, and 1016 feet west of the quarter-post between Sections 21 and 22. Inclined at an angle of 57° to E. 38° S., so that if the dip is 61.5° the depths along the hole correspond to breadth of outcrop. At a strike of N. 45° E. to N. 38° E. there would be (comparing it with d 6) (1360-400) sin 45°+(1016-80) cos 45°=1332 feet to 1305 feet difference in a section across the strike, which at a dip of 59.5° would mean about (1150) feet.

This would make the top of 6 correspond to about 1110 feet in No. 7. Now we have in No. 7 conglomerates—

(5) 1254-1259
(40) 1302-1342
(27) 1379-1406

The question is, do they correspond with

57-83 in No. 6.
or 226-259
or 368-397?

The most probable correlation is of d 7. 1302-1406 with d 6. 57-83. To suppose no correlation is to suppose something unnecessary and a dip steeper than there are any other indications of. To suppose a correlation of 7. 1406 with the next lower conglomerate 6, not only makes an ultra flat dip, but the beds above and below match poorly. This correlation (7. 1322 to 1323+37′ for difference in altitude with 6.0) means a dip of about 61.5°. An allowance of perhaps 1% might be made for the fact that the hole is not at right angles to the strike.

1.	Surface		
2.	Trap d 7. 92-124	32	(29)
3.	d 7. 124-145	21	(19)
4.	d 7. 145-160	15	(14)
	At 152-155 epidote.		
5.	Ophite	232	(210)
	Amygdaloid d 7. 160-162		
	Trap d 7. -394		
	Alteration seam, fine grained ? at 171		
	Coarse, ophitic at 173		
	Altered at 209		
	Cf. hanging of Winona lode		
		272	
6.	Amygdaloidal melaphyre d 7. 394-402½	8½	(8)
7.	Amygdaloid d 7. 402½-406½	8½	(8)
	Trap d 7. 406½-411		
8.		6	(5)
	Amygdaloid d 7. 411-414		
	Trap d 7. 414-417		
9.	Top of flow or thin flows of	26	(23)
	Amygdaloidal melaphyre d 7. 411-437		
10.	Ophite d 7. 437-563=126		
	Amygdaloid above?		
	Trap to d 7. 563		
	Inclusions at d 7. 513		
11.		21	(19)
	Amygdaloid d 7. 563-566 with large calcite		
	Blotches d 7. -573½		
	Trap d 7. 573½-584		

12.		11	(10)
	Amygdaloid d 7. 584-590		
	Calcareous and highly epidotic, compare Winona lode.		
	Trap d 7. 590-595		
13.	Amygdaloidal melaphyre	15	(14)
	Amygdaloid d 7. 595-599		
	Trap d 7. 599-610		
14.		6	(5½)
	Amygdaloid d 7. 610-612½		
	Trap d 7. 612½-616		
15.		14	(13)
	Amygdaloid d 7. 616-620		
	Amygdaloidal trap d 7. 620-622		
	Trap d 7. 622-630		
16.		41	(37)
	Amygdaloid d 7. 630-633		
	Amygdaloidal melaphyre d 7. 633-640		
	Trap d 7. 640-671		
17.	Amygdaloidal melaphyre	23	(21)
	Amygdaloid d 7. 671-679		
	Trap d 7. 679-694		
	Amygdaloid streak at d 7. 680-682		
18.		122	(111)
	Amygdaloid d 7. 694-697		
	Red, altered.		
	Trap d 7. 697 to 700-816		
	At 712 and 720 feet veins of calcite parallel to core and at 794 to 795 feet a vein of calcite with copper.		
	Base below "hanging" of Winona Lode		(383)
19.	*Conglomerate* d 8. 816-869	53	(48) 431

Pebbly, with basic matrix and copper 816-836, then to 851 amygdaloid?. perhaps a flow; then to 853 sandstone; then to 856 laminated, shaly sandstone; then to 869 amygdaloid conglomerate. This is the first conglomerate in nearly 800′ anyway. In the next 850 (1379-869+397-57) feet there are a goodly number. It is presumably Marvine's Conglomerate No. 8.

Cf. Wyandotte Hole 8. 186-200

20.		60	(55)
	Chloritic amygdaloid d 7. 869-871½		
	Occasional amygdules to 881		
	Trap? d 7. 871½-929		
21.		129	
	Amygdaloid d 7. 929-948		
	Trap d 7. 948-1058		
	Down to here from notes of L. L. H.		
22.	Ophite	196	
	Amygdaloid d 7. 1058-1083		
	Trap d 7. 1083-1254		
	Grain at		
	1231, 1244, 1249 feet		
	2, 1, ½ mm. augite mottles respectively.		

23. Conglomerate d 7. 1254-1263 9 (8)
Sandstone at 1259
Marvine's No. 7 or 7½
24. Amygdaloidal melaphyre d 7. 1263-1278
Coarsest, but a fine grained trap at 1270
25. Melaphyre
Amygdaloid d 7. 1278-1287
Very amygdaloidal at 1278
Trap d 7. 1287-1302
Fine grained.
26. Conglomerate d 7. 1302-1406 (104)
A little basic matter but mainly felsitic to 1388, sandstone to 1393, with a little conglomerate to 1395, amygdaloidal to 1398, then largely sandstone. This may well be Marvine's No. 7. The sandstone base seems to be struck at the top of hole 6.
Base of No. 19 to base of No. 26, 1406-869=537 (488)
27. Doleritic, feldspathic melaphyre
Amygdaloid d 7. 1406-1441+
Coarse, feldspathic, with scattered white amygdules, corresponding closely to Hole 6, Belt 3, 83 to 129.

Challenge drill hole 6. T. 52 N., R. 35 W. Elevation above datum 239 (road bridge over 13-mile creek = 100) above long cross-cut about 862 (Fig. 59). 2800′ west, 2160′ south of the ¼ post between sections 15 and 22, and 80′ west and 400′ north of the ¼ post between Sections 21 and 22. Nos. 6 and 7 are ½ mile away from 2 and 3 and upon the plateau. The inclination of the hole is 57° and the dip of the strata in the hole seems to be about 59½° (63½°) from the drill hole, so that the thickness along the hole should be multiplied by .89 for true thickness. In the first 400′ there are at least 3 conglomerates, which may correspond to some of the 3 conglomerates in No. 7 at the bottom 836 to 1342. Then comes a bunch of heavy ophites with mottles up to 4 mm.

1. Surface d 6. 0-57
2. Conglomerate 26 d 6. 57-83. Marvine's No. 7 perhaps. (24)
55-67 pebbles, felsitic, red, with small phenocrysts, also porphyrite.
67-72 more matrix, pebbles of amygdaloid, etc.
72-79 mainly sandstone, slope of dip against core 8 to 3 to 4.5 or 4.
79-83 finer, more red shale, slope of dip very uniform 78:38
3. Feldspathic melaphyre 46
Amygdaloid d 6. 83-90 (41)
Well-marked d 6. 83-86, white amygdules, then chloritic and feldspathic.
Trap d 6. 90-129
Feldspathic, with occasionally chloritic amygdules, feldspathic, with copper at 99, getting compact from 110 down, with occasional speckled doleritic bunches.
4. Amygdaloidal melaphyre 10
Amygdaloid d 6. 129-139 (9)
Trap with sediment, a fine black, also brecciated with green am.; hard with white amygdules to 135; yellow-green epidote to 139; a gush of the underlying?

5. Feldspathic melaphyre 38 (33)
Amygdaloid d 6. 139-150
To 150 a typical hard amygdaloid with white amygdules on dark purple ground; near 150 a very feldspathic green seam.
Trap d 6. 150-177
To 167 coarser, feldspathic; at 163 coarse; at 167 the feldspar is 1 to 2 mm.; coarsest about 170; to 172 feet epidote, yellow-green.
6. Melaphyre (separate flows?) d 6. 177-226 (43)
Yellow, fine grained epidote at 177; apparently coarser at 193; at 194 calcite seams nearly parallel to core, making 12° to 11° with it; at 199 clasolitic with apparent contact at angle of 60° to core as usual; at 201′ 9″ fine grained, and thence to 204; calcite seams at 18° to the core length; at 204 to 213 slightly feldspathic and coarse. Amygdaloid with a clasolitic seam at 213 feet; at 214-224 the same calcite seams probably nearly perpendicular to the bedding at an angle of 14° to 15° with core barrel. There are other transverse seams at 224 quite amygdaloidal.
7. Conglomerate, Marvine's No. 6? d 6. 226-259 (29)
Well-marked, round pebbles, both of felsite and amygdaloid. Cross-bedding lines at 40° with core.
There are a large number of basic pebbles.
d 6. 241-252 half-inch black and red pebbles
d 6. 254-256 sandstone slope 63° against core
d 6. 257-259 " finer, calcite lines (160)
Slopes 58°, 63°, 65° very well marked, cross-bedding is near 54° (37)
Base from base of Marvine; 7. (6.83) (147 to 160)
" " " 8. (7.869) (648)
8. Ophite 42
Amygdaloid d 6. 259-301
d 6. 259-263 small amygdaloidal slope; at 250 small amygdule line distinctly 58° against core.
Trap d 6. 269-301
Calcite seams and few amygdules at d 6. 275-282 fine grained, at 282-3 calcite seams at 45°, fine grained ophitic mottling 287-290, a little coarser at 294. Apparent contact at 296 feet, but not very amygdaloid; 294-301 is chloritic ophite.
9. Amygdaloidal melaphyre 22 (20)
Amygdaloid d 6. 301-305
Marked white on red ground to 303, then yellow-green epidote to 305.
Trap d 6. 305-323
Then more compact to 315 and finer to 323, where there is a well-marked contact at 63.5° to core.
10. Amygdaloidal melaphyre 21 (19)
Amygdaloid d 6. 323-339
With epidote streaks 330-334; and a spotted banding parallel to dip at 63.5° to core 334 to 337, largely epidote to 339.
Amygdaloidal trap d 6. 339-344
Fine grained feldspathic, largely amygdaloid
11. Scoriaceous conglomerate at 344 0 (0)
Narrow streak on top of 12?, but cf. 13
12. Amygdaloidal melaphyre d 6. 344-365=21 (19)
Amygdaloid d 6. 344-351

345-347 often epidotic
amygdaloid 351-359
The rest above and below the contact at 365 feet is nearly all changed to epidote

13. Sandstone and basic conglomerate d 6. 368-397=29 (26)
Upper contact has usual slope about 63.5° against core.
365-368 epidotic, to 372 indurated, 372-380 same passing down into basic sandstone
d 6. 388-389 basic sandstone and scoriaceous conglomerate.
If 15 correspond to the doleritic ophite of the cross-cut, then 13 to 11 would pretty well match lodes C and D in the cross-cut and Hole 2, Belt 7. But in the cross-cut there are 340 feet above C and D without conglomerate, see Figure 59.

14. Ophite (72)
Amygdaloid d 6. 397-413. Cf. lode C.
d 6. 400-408 epidotic; 408-413 fine grained with calcite seams slope against core 51.5°.
Trap d 6. 413-480
Grain at: 414, 417–424, 428–431, 435, 438, 445–450, 458,
2, 2–3, 3, 4, 3–4, 4–5, 3–4,
465, 476, 476?, 480 feet respectively augite mottles
3, 2, 1, contact

15. Ophite 102 (91)
Amygdaloid with copper d 6. 480-499. Cf. lode B.
Brecciated to 485; epidotic to 494, trap and epidote at 495, and ophitic at 497, seamed at 498, epidote and copper at 499.
Trap d 6. 499-582
Grain at: 505.6, 511–512, 515, 517 & 526, 534–548,
1, 2, 2–3, 3, 3–4,
553 to 559 finer, 562, 569, 575, 576, 582.
3, 2–3, 1–2, 1, 0.5, ?

16. Ophite, doleritic 154 (136)
Amygdaloid d 6. 582-595. Cf. lode 1 or A. St. Mary's No. 2, 228-294. Such a correlation implies that the throw along the fissure is of the northwest side down, or that there is some cross-fissure.
To 592 very amygdaloid, fine, epidotic; to 595 small chlorite amygdules.
Trap d 6. 595-736
At d 6. 599-601 amygdaloid streak near flow ? with fine chloritic amygdules
d 6. 601-608 long cores, fine grained with small amygdules; at 612 a white seam parallel to bedding 67° against core, with copper; at 619 altered, with copper, fairly coarse, 2 mm. mottles.
Grain at: 619–623, 640, 725, 730 feet respectively augite
mottles 2–3, 3–4, 1, 0.5 mm. diameter.
At d 6. 634 very epidotic with copper.
At d 6. 625, 627, 630 doleritic, altered, epidotic.
Cf. the doleritic ophite between 1 and 2 in the cross-cut.

17. Amygdaloidal or scoriaceous conglomerate
Cf. lode 2; St. Mary's d 3. 905 to 925 d 2. 549-590
d 6. 736 - 769=33 (30)
d 6. 736-740 appears like a red and white amygdaloid, then passes into an agglomerate with fragments not rounded and of the same general

nature; at 754 the fragments are large and full of bubbles; then it becomes more epidotic, but though the general structure is more uniform, outlines of fragments appear. These gradually fade, but the epidotic alteration obscures the contact with the underlying trap.

18. Ophite (eroded) 104+
Amygdaloid (eroded?)
Trap d 6. 769-885
Grain fine to 779, at 785–700, 794–800, 810, 825, 840,
1–2, 2–3, 3, 3–4, coarsest.
847, 863, 883–885
3–4 finer, 3, 1–2 mm. across
Cf. trap between lode 2 and lode 3

19. Basic sandstone and amygdaloid conglomerate d 6. 892-950 (52)
To 896 sandstone (slope against core 8:3), dip 54° with calcite seams parallel to it; to 914 a uniform basic sandstone dip 59.5° with white, perhaps vertical calcite seams to 945 amygdaloid fragments with a red mud or sand matrix, the bottom uncertain, the transition to an ophite with no distinct amygdaloid on top gradual exactly like No. 17.
Cf. lode 2 bis. Nos. 17 and 19 are evidently closely allied.
Cf. St. M. 3. 910-925

20. Ophite 24 (21)
Trap d 6. 950-974
Grain at: 956, 959, 970, 974 respectively augite mottles very minute, 1–2, very fine grained contact.

21. Ophite 68 (61+20)
Amygdaloid d 6. 974-992
Clasolitic and black, then fine grained, brown, then coarse, and finally epidotic amygdaloid.
Cf. St. M. 6. 1012 to 1030, lode 3 of figure 59.
Trap d 6. 992-1042 (+20?)
Grain at: 1000, 1013, 1021, 1042 feet respectively
augite mottles 2, 2, 2–3, 2 mm. across
20 and 21 appear to parallel the traps of lodes 3 to 5.
But if such is the case either the strike is northeast, like the big fissure, or there is a cross-fault.

Challenge drill hole 3. Elevation above Lake Superior 575. 488 feet west, 400 feet south of the quarter post between Sections 15 and 22. Drilled at an incline of 59° at right angles to the supposed strike of the formation which was at first taken as N. 38° W., as an average between that of the Champion and that near Elm River. The developments show that N. E. might be nearer but the cos (47°-38°) is so near to 1 that it may be neglected in considering the running record of the hole. The distance between 2 and 3 at right angles to the strike is=678 to 585 feet.

Thus No. 3 should be something less than that above No. 2, and at the bottom No. 3 seems to strike the same horizon about 500 feet deeper than No. 2 and the well-marked conglomerate at 500 feet in No. 3 does not appear in No. 2.

Surface? d 3. 0-172 (172)
5′ Loose rock
4 " "
2

3′ 6″ sand and trap, ran in d 3. 172-181 (9)?
2′ sand and trap d 3. 181-189 (8)
1. 2 Conglomerate? -191
Cf. No. 6 at 259 feet.
2. Trap 3′ 2″ d 3. 191-194
about ⅔ to ¾ sand
3. d 3.
Amygdaloid trap -228
4. Trap -237
Amygdaloid -300
5. Am. and trap -306
Amygdaloid -326
Amygdaloid and trap -334
Fine trap -344
Trap -364
6. Ophite -368
Amygdaloid and trap Lode E. -374
Trap -386
Trap -461

Cf. No. 6 at 368 feet. Grain of trap at 364 2 mm., at 368 feet seam and at 390 calcite seam, at 379 3 mm., at 396 finer than at 408, at 402 to 408 4 mm., at 417 3-4 mm. and 435 2 mm; 411 1 mm; 455½ ½mm.

7. Conglomerate 461-500 (25)

Fine grained basic sandstone (called trap by drillers) 462 to 476, slope against core 12.5° which would imply a dip of 43.5°+ the amount the hole has flattened; felsitic rounded pebble conglomerate at 479; amygdaloid conglomerate at 500. Struck in No. 3 east cross-cut at 570′, (or is that the conglomerate at 191 feet and this "lode 2"?)

8. Brecciated ophite (39)
Amygdaloid d 3. 500-503
At 504 seam red, and at 513 and 538 ft. mottled 1-2 and 1 mm.
Trap d 3. 503-544
9. Ophite 94 (81)
Amygdaloid 14 d 3. 544-558
Broken with large blotches of calcite d 3. 544-546
Trap 80 d 3. 558-638

At d 3. 558-563 epidotic, at 563 fine, at 568 1 mm., at 573 2 mm. mottles, at 583 finer than 593, at 593 2 to 3 mm. mottles and at the same time amygdaloid inclusions indicating a dip of 45° to 46°; at 606 3 mm., at 614 to 625 1 to 2 mm.

At 558 to 563 very epidotic trap.

Cf. top trap of No. 2 to 228 feet.

10. Ophite 164 (142) (153) in second level.
Amygdaloid d 3. 638-672
Red and white typical brecciated. Lode at 390 to 415 in cross-cut.

With calcite blotches and at 672 copper, ending with 4 or 5 feet of semi-amygdaloid and clasolitic matter.

Trap d 3. 672-812
Mottles are:
at 675; 690; 704-713; 727; 753; 756-766; 772; 785; 793; 796; 808 feet
1; 2; 2 to 3; 3; 4 to 5; 4; 3 to 4; 3; 2; 1 to 2; 1 mm.

From 687-690 is epidotic; at 713 is a seam.

11. Amygdaloid and amygdaloid conglomerate. Lode 2. 31 (27)
Amygdaloid with small blotches of calcite—foot of trap? d 3. 812-822
Amygdaloid conglomerate d 3. 822-843
Light colored cement last 5 feet.

12. Ophite (57)
Amygdaloid d 3. 843-847
Coarse and brecciated, probably eroded.
Trap d 3. 847-905
Grain is:
at 848; 851; 853-859; 859-866; 866-875; 879; 880-890; 893-895; 901-905, at 870-890, very full of seams but ophitic; at 890-893 much seamed, slope of seams (12:9) 36°⅔ against core, i. e., perhaps nearly vertical, at 895-901 laumontitic.
½; 1; 1-2; epidotic; 2-3, light epidotic; 3; 2-3; 1; ½ to 1 mm.

From 843 to 846 somewhat seamed with calcite and altered; from 867½ much altered and rather coarse grained; from 875 to 881 epidote and calcite in streaks, at 905 apparently amygdaloid shows sediment, *a zone of alteration in trap* ? calcite and laumontite; at 978½-980 1″ prehnite seam, epidotic foot of trap or amygdaloid?

11. (Represented by fault).
Amygdaloid conglomerate d 3. 905-925
With some sediment; slope (5:9) 61° against core; about 60° dip.
From 923 to 925 breccia. This is Lode 2 repeated.

12. (Repeated) Ophite
Amygdaloid d 3. 925-930
Trap d 3. 930-1012
Grain at:
928-930, 944, 970, 995, 995-1005, 1012
1 to 2, 2–3, 3, 2–3, 1-2, 5 mm.

13. Ophite 117 (104)
Amygdaloid d 3. 1012-1030, lode 3 of mine cross-cuts.

With large patches of calcite to 1030 at which point is about 1′ brecciated. At 1035 to 1036 a few amygdules, and an epidotic altered, chloritic aggregate; at 1058 a thin vein of calcite.

Trap d 3. 1030-1129

At 1120 very epidotic with copper in small dots; at 1124-1128 a dark rock with patches of calcite.

Grain at:
1059-1070, 1075, 1092, 1108, 1119
2 mm., 2–3, 3, 2, 1 mm.

At 1075 to 1081 slips as at 1151 ft., about coarsest; at 1085 to 1086 relatively fresh, while 1075-1081 is green; at 1088-1090 a big slip at 61° against core about 60° dip.

14. Ophite 46 (41)
Amygdaloid d. 3 1129-1141

At 1129 epidote and copper; at 1131 calcite blotches surrounded by chlorite; to 1141 epidote with large calcite amygdules surrounded by chlorite.

Amygdaloidal melaphyre d 3. 1141-1146
Trap d 3. 1146-1175
Chlorite slip seams, and chlorite and calcite at 1151 ft.
Grain at:
1171. 1161, 1141-1155, 1134-1141
1 mm, 2 mm, obscure 2 mm?, fine grained.
At 1155 fine calcite seams at 66° to the length of the core; at 1160 epidote and calcite seams.

15. Sediment 3 inches at 1175 (0)
16. Ophite (45)
Amygdaloid? d 3. 1175-1207
Looks here and there like an altered, coarse grained ophite, with epidote, chlorite and copper; toward the base black and white passing into gray and white. Cf. Lode 5 of mine.
Cf. d 3. 1208 and d 2. 712
Trap 1207-1223+20+
The grain at:
1202, 1212, 1233 ft. is
3 mm., 2-3 mm., 2 mm.

Challenge drill hole 4. T. 52 N., R. 35 W. Was between Nos. 2 and 3 and never struck rock, though 65 feet and over deep.

Challenge drill hole 2. T. 53 N., R. 35 W. Elevation 53'.5 above datum. 200 feet west; 1056 feet south of the ¼ post between Sections 15 and 22. Drilled vertical. Dip of strata about 59° on the average.

Surface d 2. 0-125
1. Ophite d 2. 125-228 (50+)
Trap. Coarsest at 160 feet.
2. Ophite (faulted) d 2. 228-294 (160)
Amygdaloid, red, brecciated and very calcitic; Lode 1.
There is a 6-foot seam of brecciated quartz and epidote at 279 feet; at 289 feet a light colored streak of altered amygdaloid, with quartz and epidote, and at 294 to 296 there is copper in the altered amygdaloid.
Trap d 2. 294-549
At 334¼ there is 4 inches of chlorite, at 429 one foot of epidote alteration, at 458 a seam of reddish brown altered rock with seams of calcite and copper at 439. It is about as coarse as at 459.
But a fault is indicated between 460 and 549 as in the mine.
Cf. d 2. 228 to -549 with
d 3. 672 to 812
At 549 is a very fine dark trap.
3. Lode 2. Amygdaloid conglomerate d 2. 549-590 (16+)
At 552 feet amygdaloid conglomerate
" 575 " brecciated
" 589 " epidote with quartz amygdules
" 590 " fine grained trap
" 593 " amygdaloidal melaphyre and scattered amygdules to 599 feet, chlorite at 605 feet, possibly amygdaloid conglomerate. Cf. 822 and 843 feet.

4. Ophite (106)
Amygdaloid and amygdaloidal melaphyre d 2. 590-617
3 and 4 are counted as one lode in the cross-cut.
Trap d 2. 617-802
At 712 decomposed to epidote and chlorite so that the rock might be mistaken for amygdaloid.
At 754 a little epidote and seam of calcite.
The 185' of trap at a dip of 60° would give (92) thickness, which is just what we find in the mine.

5.
Amygdaloid (Lode 3.) d 2. 802-821
Brecciated, epidote and calcite in patches.
At 823 feet chloritic; at 825 feet a brecciated chloritic seam.
Amygdaloidal melaphyre d 2. 821-838
Apparently with inclusions of amygdaloid.
Trap d 2. -878
Epidote at 878.
No. 2. 802 may be compared with
No. 3. 1020

Challenge drill hole 5. Elevation above datum 45', (bridge over 13-mile creek on Ontonagon road taken as 100'). 200 feet east, 1928 feet south of the ¼ post between Sections 22 and 15, T. 53 N., R. 35 W. The hole is vertical so that it passes through the beds very-slowly.

From 3 to 5 in a direction E. 38° S. is 1390 feet, and this was nearly across the strike so that this shows the lowest part of the section.

Drift. Surface 143 feet.
1. Ophite d 5. 141-257=116+ 30+ more
The grain of this ophite is never much over 3 mm. for the augite, but the chemical composition is that of a normal ophite. The grain then would indicate a thickness of only (90) feet or so. This thickness is verified if this is the hanging of lode 7 in the 3rd level cross-cut. The thickness is 110 feet or less. Dip of the strata of 60° would mean that a 90-foot bed would intercept 180 feet on a vertical hole. The grain observations on the core boxes were—it begins finest
at 141-4; 144-153; 153-156; 161-172; 202; 215; 228; 234; 245;
3; 2-3; 3; 3; 3; 2-3; 2; 1-2; 1;
253; 257.
0.5; contact mm.
Sp. 20612-20 are of the drill cores used to illustrate the variation in grain in Plate 17 of the Annual Report of 1904, herewith reproduced (Pl. VI). They are typical illustrations of the typical mottled ophite with labradorite laths embedded in augite. The growth of the augite seems to have driven ahead the iron oxide and olivine, though the olivine is all changed to a mineral of low birefraction which seems to be chlorite. Iron oxides are magnetite and hematite. There is a little calcite. In Sp. 20618 the average breadth of the augite patches is 2.8 mm. Feldspar is about $Ab_2 An_3$. There are a few which occur up to 1 mm. across but it mainly runs from .1 to .2 x .05 to .02 and is smaller where it is embedded in the center of the augite patches. The olivine is about .12 mm. The magnetite varies from .5 to .16 mm.

The other sections are similar and the only variation is that of the grain. In 20619 the average breadth of the augite patches is 1.34. The feldspar is .2 to .8 x .02. In 20620 the augite is .75 mm. The olivines are still a few of them .1 mm., but mainly .04 mm. In 20620 individual grains of augite are set rather far apart, and there is a tendency noted by Lawson to compound aggregates of grains making difficulties in fixing the grain, in this transition zone. Comparing the coarseness of grain as measured in different ways we have the following table for the grain of the augite:

No.	Depth.	Distance from margin at 60° dip.	Apparent Grain. In drill core.	In thin section. Naked eye.	In thin section. Microscope.
20617	172	43	3 to 4	4.5	
18	202 An.	28	2 to 3	3	2.8
19	232	13	1 to 2	2	1.34
20	250	4	.5 to 1	1.5	.74
Contact	257	0			

The analysis of 20618 by F. K. Ovitz is as follows:

	%	Molecules.	Molecular %
Silica, SiO_2	45.21	.753	49.3
Titanic acid, TiO_2	2.14	.025	1.6
Alumina, Al_2O_3	15.85	.155	10.1
Ferric oxide, Fe_2O_3	9.55	.0595	11.6
Ferrous oxide, Fe O	4.37	.0608	FeO
Calcium oxide, CaO	10.36	.185	12.1
Magnesium oxide, MgO	7.25	.179	11.7
Manganous oxide, MnO	.89	.013	.9
Sodium oxide, Na_2O	2.47	.039	2.5
Potassium oxide, K_2O	.31	.003	.2
Phosphoric anhydride, P_2O_5	.165	.001	
Carbon dioxide, CO_2	.48	.011	100.0
Sulphur, S	.07	.002	
Chlorine, Cl	.04	.001	
Moisture, H_2O	.47	.026?	
(Loss on ignition 1.36) (1.36-.47 to .48), $H_2O+?$	.41	.023?	
	100.035	1.5363	

By the quantitative classification this will be computed:

2. FeO+MnO =.062

3.b. $FeO\ TiO_2$ =.025 FeO left .037

c. $CaO\ P_2O_5$ =.001 CaO left .184

e. Cl after apatite of c is satisfied may be regarded as negligible. It is probably not in sodalite anyway but in the calcium chloride mine water and amounts to less than .001 mol

g. S with FeO=.002 S+.001 FeO. FeO left .036

h. CO_2 is secondary.

4.a. .155 Al_2O_3 .003 K_2O+.003 Al_2O_3

b. .039 NaO+.039 Al_2O_3 .042 Al_2O_3

.184 remainder .113 Al_2O_3

5.a. .113 Al_2O_3+.113 CaO=Anorthite

.071 CaO left

7.b. .037 FeO+.037 Fe_2O_3=.037 Fe_3O_4

c. remainder .0595-.037 Fe_2O_3=.0225 Fe_2O_3

N. B. From the appearance of the thin section it is probable that part of the ferric oxide is due to secondary alteration. It is also not at all likely that the ferrous iron is all combined with it.

8.a. MgO=.179

FeO=.000 none left!

MgO+FeO=.179

=.071 with CaO+.108 MgO left

9.a. .108 MgO may be assigned to Mg SiO_3 or Mg_2 SiO_4, but probably is present actually as augite or olivine.

11. in CaO Al_2O_3 $2SiO_2$ is .753 Si O_2

.223

12. in CaO MgO $2SiO_2$ is .142

17. in 2 (MgO) SiO_2 is .054

.419

balance is SiO_2 .334

.018+.234

18. .042 Al_2O_3 x 6=in albite+Or=.252 SiO_2

Balance .082

a. x+y =.108

x+y/z=.082

y/z =.026=olivine

x =.056 hypersthene

We have then:

	Mol.	%		
Orthoclase	.003	1.67		
Albite	.039	20.44	about Ab_2 An_3	
Anorthite	.113	31.41	Salic	53.52
Diopside	.071	8.24		
		7.10		
Hypersthene	.056	5.60		
Olivine	.026	3.64	P+O 24.58	
				Femic 42.02
Pyrite	.001	.12		
Ilmenite	.025	3.80	M 16.98	
Apatite	.001	.34		
Magnetite	.037	8.58	A .46	

Hematite	.023	3.60
	.394	94.54

Class III Sal:fem=53.42:42.02 <5:3
Order 5 F:Q is infinite >7:1
Rang 4 $K_2O' + Na'_2O : Ca'O = .042 : .113$ <3:5>1:7
Sub rang 3 $K_2O : Na_2O = 3:39$ <3:5
Salfemone-gallore-auvergnase-auvergnose is its class
According to Osann's classification.[1]

S=50.5+1.7 =52.2
A=5.6=(2.6 Na_2O + .2 K_2O + 2.8 Al_2O_3
C=(10.4-2.8) Al_2O_3 x 2
=15.2
F=4.0 FeO + 8.10 Fe_2O_3 + (12.4-7.6) CaO
+12 MgO + .9MnO
=25.75
A+C+F=46.6
$a = 5.6 \times \frac{20}{46.6} = 2.3$
$c = 15.2 \times \frac{20}{46.6} = 6.5$
$f = 25.8 \times \frac{20}{46.6} = 11.3$

The rock is $S_{52.2}\ a_{2.3}\ c_{6.5}\ f_{11.3}$
This would be of the gabbro norite family
"Sulitelma" type $S_{52.5}\ a_{2.5}\ c_{4.5}\ f_{13}$
which stands next to the "Keweenaw" type $S_{51}\ a_1\ c_5\ f_{14}$

Neither the American nor Osann's classification brings out clearly what seem important points, the approach of the analysis to an augite formula $CaR_2Si_4O_{12}$ and that $\frac{1}{4}$ of the base is lime and another $\frac{1}{4}$ magnesia. The formula may be written in round numbers. CaO, MgO (Na_2O FeO Fe_2O_3) (Al_2O_3 TiO_2) 4 SiO_2
The proportion of lime is that common in hornblende.

The differences between this analysis and that of 15523 are within the range of imperfections in analysis and variations due to secondary decomposition. The top of this bed is presumably Lode 6 in the 3rd level cross-section (Fig. 59)

2. Ophite d 5. 241
Amygdaloid d 5. 257-317=40 (about 100)

Green cement and white amygdules to 261; streaked to 264; spotted to 271; greenish epidote to 274 to 275 black; to 284 irregular; to 297 much brecciated; to 300 compact; to 303 epidotic; to 312 brecciated, to 314 black paste with white amygdules; to 317 epidotic.
Trap d 5. 317-498

To 320 fine grained, compact; to 327 occasional large amygdules, then distinctly ophitic with augite mottles as follows:
334, 352, 367, 380, 405, 427, 446, 456, 467, 479, 488,
1, 2, 2, 2-3, 3, 3, 3, 2, 2-, 2-, 1,
495, 498.
barely visible, contact.

This is presumably the foot of lode 7 (of blue print and Fig. 59, i. e, No. 8 of St. Mary's 1907 report), and hanging of Lode 8. It intercepts

[1] A. Osann, Versuch einer chemischen classification der eruptivgesteine. Tschermak's Mineralogische und petrographische Mittheilungen, XXI. Band, 5 Heft, 1902, p. 375.

212 feet there, 257 feet in the hole, which would imply a dip of 50°.
Lode 7 gave Oct. 26, '08 a water with refraction=sp gr 1.015

3. Ophite 62 about (31)
Amygdaloid d 5. 498-503
Amygdaloidal melaphyre d 5. 503-510
Trap d 5. 510-560
Slight mottles from 556 on.

The group of small beds 3, 4 and 5 evidently correspond to the amygdaloids near together, 8, 9 and 10.

4. Melaphyre (ophitic) 49 about (25)
Amygdaloid d 5. 560-565
Trap d 5. 565-609
At 585-587 slightly amygdaloid; at 602 ophitic to 609, and at 605 very much brecciated.

5. Ophite
Amygdaloid d 5. 609-623
609-620 very amygdaloidal, white amygdules on black ground, -623 altered streak and pseudoamygdaloidal, also 1 to 2 mm. ophite.
Trap d 5. 623-632
Mottles 1-2 mm. at 623 feet, altered at 626 feet, epidotic at 629 feet, then fine grained.

6.
Amygdaloid d 5. 632-694
to 638 very amygdaloid, -654 seam light colored, full of calcite, to 661 same, much brecciated to 678, still light colored though not so much brecciated, to 684 darker gray and white.
685-690 fine grained.
Trap d 5. 694-738
At:
694, 700, 706, 713, 724, 731, 738
1, 1-2, 2, 2+, 2, 1-2, contact.
731 to 735 has amygdaloid inclusions.

This very thick belt mainly of amygdaloid from 498 to 694 (196) feet, I made in the drill core 4 distinct flows, but in the mine 3rd level section evidently is lodes 8, 9 and 10 from 670 to 785 feet southeastward from the shaft which correspond at a dip of 59.5°. The division into flows is really uncertain, the small flows are amygdaloidal throughout.

7. Ophite
Amygdaloid d 5. 738-740
Trap d 5. 740-776
Compact with small chloritic amygdules at top from 740-745.
At 758 and 760 feet
mottles 2 mm. across

8. Basic sandstone and conglomerate 776-958
slopes against drill core:
At
780, 785, 792, 809, 821, 824-831, 851,
11½:8, 6:8 cross bedding, 6:8, 11:8, 11:8, 13:8, 12:8,
855
13:8
an average say 52½° or leaving out two cross-bedding dips 56°.
This also agrees with the sandstone at the end of the 3rd level cross-cut.

The cross-cut also indicates flatter dips. At 841 are some basic fragments, and at 855 to 860 some large amygdaloid fragments, at 864 to 876 the sandstone has pebbles and boulders of ophite and down to 883 there are both ophite and (black and white) amygdaloid pebbles. It is very difficult to locate the exact base of this bed as the pebbles increase. This is one of the cases where it appears very strongly that the sediments are formed on an eroded surface of the underlying flows.

At 888 is a 2 mm. ophite, probably a boulder, for at 895 is amygdaloid and gray and white sandstone mixed. Thence to d 5. 903 is mainly amygdaloid. Thence to 907 mainly ophite with 1 to 2 mm. mottles, thence to 912 is amygdaloid, thence to 920 the core is in broken fragments of decomposed ophite, thence to 929 amygdaloid sediment, thence to 933 very epidotic trap with clasolites. The sedimentary base may be at 920 feet. To 936 is gray indurated (probably epidotic) sandstone with amygdaloid, to 938 are fragments mainly ophite, to 940 are very dark fragments and sediment; at 945 is a fine grained ophite; at 947 1 mm. at 949 a fine grained trap; at 952 brecciated fragments; at 954 fine grained ophite, at 958 a basic sandstone slope 7½ to 8, with some trap. I should not be at all surprised if on these boulders the hole had gone very crooked.

9. Ophite
   Trap d 5. 962-996
   at 962 to 971 mottles 1 mm., at 975-978 fine grained; at 984 to 996 fine grained with chloritic amygdules, basal amygdaloid?

?10. Ophite? d 5. 996-1045
   (Drill hole seems to be following a clasolitic seam as from here on sediment occurs frequently).
   At d 5. 996-1000 amygdaloid with clasolite
   At d 5. 1004 fine grained, at 1006 fine grained with clasolite; at 1006 to 1008 indurated sandstone and between 1008 and 1012 much brown indurated sandstone, to 1015 fine grained trap, to 1022 veined amygdaloid, to 1024 fine grained clasolites, to 1026 coarser 1 to 2 mm. ophites mottled with laumontite, to 1028 the same, to 1045 a fine grained trap mainly, at the end brown sandstone.

11. Sediment, amygdaloidal conglomerate d 5. 1045-1090?
   Epidotized brecciated, with amygdaloid enclosures at base 1045-1049, to 1062 breccia with sediment, amygdaloid and faulted pebbles.
   Epidotic yellow-gray indurated sediment and amygdaloid to 1072, mainly fragments of amygdaloid to 1080, at 1084 and 1090 are trap and faint ophite.

12. Ophite ? d 5. 1090-1221
   being eroded and decomposed and the drill following a clasolitic ? seam ?
   Amygdaloid d 5. 1090-1139
   Amygdaloid and sediment d 5. 1090-1095
   Ophite and a 1-inch clasolite seam d 5. 1095-1101
   Mainly amygdaloid d 5. 1101-1103
   Brecciated d 5. 1103-1107
   Fine grained d 5. -1113
   Amygdaloid d 5. -1116
   Very amygdaloid with clasolitic matter near 1119 & 1139
   Brecciated d 5. 1139-1147
   Trap d 5. 1139-1228

Down to 1170 cores badly broken up and decomposed at 1165.
At 1160 is a yellow green amygdaloid inclusion?
At 1187 feet and 1198 feet the ophite mottles are 2 mm., then it grows finer. At 1221-1235 it is amygdaloid. (A good deal of 12 may belong with the amygdaloidal conglomerate or there *may* be two flows).

13. Basic sandstone, slope 6:8 at the end 1235-1235.4?
   This corresponds well with the mixture of sandstone and trap found near the end of the drill holes from the end of the cross-cut.

The Challenge third level cross-cut, referred to above and shown in Figure 59 (course S. 29° 4′ E.) is as follows:[1]

North end was in 1045 feet from shaft and hanging of lode 3 on March, 1909		
Trap	0-123	(105)
Lode F "a little copper unpromising"	123-143	(18)
Trap	143-267	(105)
Lode E "Amygdaloid 7 of heavy copper in epidote"	267-295	(25)

This lode was also reached on the 4th level and drill hole 4 from the end of it gave considerable encouragement and a drill hole 5 cut it very obliquely. Dip of hole 75°, of lode about 61°. It was drifted on. In the foot trap were copper seams at a flatter angle of about 40°, at 363 and 375 etc., also in 4th level and drill hole 4.

Trap. Just west of a 10-inch seam of heavy copper	295-418	(104)
Amygdaloidal conglomerate	418-469	(45)

Lodes D and C (D amygdaloid 8 feet, amygdaloid conglomerate 24, felsitic 19 cut in No. 4 drill hole and level 4 with a little fine copper and a small mass)

Trap	469-506	(31)
Lode B. Amygdaloid cut in 4th level and drill hole B with speck of copper	506-526	(17)
Trap a 4 mm. ophite	526-623	(85)
Total from lodes C and D		(133)
Lode A or 1	623-648	(22)

Cut in 4th level and drill hole B (which dipped about 65° from horizontal). There was also a cross-cut in it (150 feet) from the drift following the fissure to the south and 450 feet southwest of the main cross-cut. Also a drill hole 3 followed it down from the 4th level 485 feet finding some copper in the foot. This may be lode No. 1 of the 1st and 2nd levels on the other side of a great slip which dips 87° 30′ to south and throws lode No. 2 down vertically 200 feet. This slip was followed along its strike S. 52° W. for over 700 feet with traps of varying grain (a sudden jump from 3 mm. to 7 mm. in one place on either side) finally finding lode No. 1 at a proper distance (150 feet horizontal from lode No. 1). There is, of course, no absolute assurance that lode No. 1 is lode A. Lode No. 1 has been supposed to be probably the Baltic lode, in which case the Amygdaloid conglomerate lode 2 would be the Baltic conglomerate. This is rather close under the felsitic conglomerate C and if so I should suspect great displacement in the fissure, and that the Baltic lode continues slowly to rise in horizon south from the Champion Copper mine. The slip was found at the end of the 2nd level about 175 feet from the shaft at right angles to the strike with a nearly vertical (89°) dip.

The tests of saltness of the water given in the chapter on mine waters show dis-

[1]There is a rise in the cross-cut (which is about 700 feet below collar of shaft) going south, from −125 (below Portage Lake) to −102.93 at the drill hole. The distances here given are reduced to horizontal. Two drill holes at the south end dipped respectively 29° and 35° from the horizontal to the southeast, thus giving the dip of the beds they cut. See annual reports of St. Mary's Co. I have also visited the property

tinctly the lower salinity near the fissure. It is, however, a fair question whether this may not be a dilution due to water following the fissure since mine pumping began. I do not think this is wholly true. We have 0.09 to 0.25 grams per liter chlorine near it on the 3rd level.

Trap to Lode 2		
A doleritic 7 mm. ophite	648-807	(138)

Lode 1 was found only on the 1st and 2nd level cross-cuts horizontally above the amygdaloid conglomerate, Lode 2 dipping about 60°. On 1st level Cl was 0.040, Ca 0.033 grams per liter.

Lode 2 Amygdaloid conglomerate	806-843	(32)

Cut and repeated by the fault on the 3rd and 4th levels, also found in 2nd level. Has 1.00 grams Cl and 0.13 Ca on 3rd level per liter, 2.3 grams Cl. and .315 Ca on 4th level per liter.

To repetition of Lode 2 Trap		
Lode 2.	807-920	(98)
Trap under Lode 2 (all these traps are of ophite type)	920-940	(17)
Lode 3. Amygdaloid	940-1045	(98)
	1045-1060	(14)

With a little fine copper on 2nd level, also cut on 4th level, with 5 grams Cl. and 1.8 Ca per liter

Trap		
Lode 5 Amygdaloid. Cf. d 3. 1120-1128	1162-1196	(33)
	1196-1222	(139)

Had some copper on 3rd and also on 2nd level with epidote, and a 350-foot drift was cut on 4th level. On 2nd level had 6.1 Cl and 2.00 Ca in grams per liter, on 3rd level 6.8 Cl. and 2.37 Ca. The strike here appears to be S. 32° E.

Trap	1222-1376	(134)
Lode 6	1376-1391	(13)

Fair stamp rock? with 7.35 Cl and 2.6 Ca in grams per liter

Trap	1391-1507	(101)
Lode 7	1507-1550	(38)

Contains copper, water saline, refraction=Sp. Gr. 1.1

Trap	1550-1730	(157)
Lode 8	1730-1742	(10)
Trap	1742-1770	(25)
Lode 9	1770-1780	(9)

Very salty, Cl 63, Ca 2.06

Trap	1780-1800	(17)
Lode 10	1800-1831	(27)

A drift was run northeast on this and met a slip which cut the hanging trap of this but in the cross-cut was 10 feet above No. 9, thus like other slips showing a strike farther from north and south. On this there was "some fine and some heavy copper" and if we called the heavy trap above 8 the Mabb ophite this might be the Baltic lode. Cl. was 6.4 and Ca. 2.08 grams per liter in the water.

Trap	1831-1870	
Lode 11	1870-1920 or 1926	(25)

It is possible that Lodes 10 and 11 represent the Baltic

Trap	1900-2078	(157)
Lode 12	2078-2108	(26)
Trap	2108-2210	(89)
Basic sandstone	2210-2240	(26)

Can this be Conglomerate 3?

End of drift 30 feet on. Cf. end of Hole 5

Trap (completed in drill hole 5)	2210-2295	(74)
Lode 13	2295-2317	(18)
Trap	2317-2426	(105)

With numerous clay seams

Brown sandstone with conglomerate	2426-2454	(24)

This is the last belt with any thing like normal dips. The two drill holes from this on show very numerous seams and flat dips. The Torch Lake section shows similar phenomena.

Trap rock with clay seams	160-260
Sandstone	260-285
Conglomerate and broken trap	285-305
Sandstone	305-315
Trap	315-375

Sandstone, the Eastern or Jacobsville, ...at 367 feet in one hole and 406 feet in the other.

We see then that in the top of No. 7 we have 655 feet of beds without conglomerate including beds that may be matched with the Winona lodes, and that in the bottom of 7 and top of 6 we have a bunch of conglomerates which are quite thick. The northwest end of the cross-cut and drill hole 3 also includes conglomerate. The lower part of Hole 6, Hole 3 and Hole 2 and the uppermost part of Hole 5 down to 776 feet and the central part of the cross-cut show a broad belt of ophites with practically no felsitic sediment, only amygdaloid conglomerate, which may correspond to the 1201 feet in the Isle Royale section between Bed 38, Conglomerate 4 and Bed 61, Conglomerate 3. Then we have heavy sediments again such as generally occur near the base of the series, from Conglomerate 3 down. The big ophites below Holes 7 and 11 are as identifiable with the Mabb ophite as any, but they are not as coarsely mottled. In that respect Belt 10 of No. 3 to 796 feet would be as near it. But even if the felsitic conglomerate of Belt C is not persistent and important and be taken to be Conglomerate 4, No. 38 of the Isle Royale section, this belt over Lode 2 is much too near. If we call the Amygdaloid conglomerate of Lode 2 equivalent to Conglomerate 4, C and D might be 5, and the sandstone at the E. end of the cross-cut Conglomerate 3. Lode 10 would then be most nearly at the Baltic horizon.

Limestone Mountain (*Figure 48*).

Less than ten miles from the region of the Winona mine are outcrops of paleozoic limestone mentioned already by Foster and Whitney and Jackson and Rominger but more carefully studied by W. L. Honnold,[1] which deserve a word of mention for the light they throw upon the date of the Keweenaw fault and the physiographic conditions. There is quite a hill on Sections 13, 14, 23 and 24 T. 51 N., R. 35 W., known as Limestone Mountain, and a smaller exposure on Section 7 to the northeast.

Limestone here occurs plainly of Trenton age as shown by the following list of fossils identified by W. F. Cooper. The Niagara occurs only at the point marked N in Fig. 48.

Ss. 13481 to 13643 were collected by W. L. Honnold.

Ss. 16567 to 16616 were collected in a trip by L. L. Hubbard, A. E. Seaman and A. C. Lane.

13560 Orthoceras vertebrale

13555 Orthoceras undulostriatum

[1]Wadsworth, M. E. Origin and Mode of Occurrence of the Lake Superior Copper Deposits Trans. Am. I. M. E. xxvii 669, also A. J. of S. XLII (1891, p. 171, and my annual report for 1903, p. 178.

13549, 13552 Trochonema beloitenses
13565 Pleurotomaria subconica
13574 Orthoceras
13564 Orthoceras (vertebrale) darus
13596 Cypricardites ventricosus?
13547 Cypricardites ventricosus
13556 Cypricardites obtusus
13567 Buthiatrephis
Cypricardites obtusus
13586 Cypricardites megambonus / niota
13545 Modiolopsis lata
13597, 13579 Cypricardites latus?
Cypricardites megambonus
13584 Cypricardites megambonus
13587 Cypricardites glabella
13582 Cyrtodonta billingsi
13557 Cypricardites amygdalinus
13558 " "
13572 Cuneamya subtruncata
13601, 13605 Pentamerus
13576 Rafinesquina alternata
13577 Orthis testudinaria

The hill to the northeast on Section 7 has a different but characteristic early Palaeozoic fauna (Ss. 16596 to 16616). I feel sure that not only Trenton but Niagara limestone occurs in the main hill (and is represented by Ss. 13601 to 13605, 15671, etc.) about 925 to 1000 paces north and 25 to 200 west of the southeast corner of Section 23, T. 51 N., R. 35 W. at the point marked N. in Fig. 48. Not merely the Pentamerus but the peculiarly white and sugary lithologic character are suggestive. The main hill rises to a height of about 1000 A. T. from flat clay plains which are about 695 A. T. Of course, these limestones are harder than the surrounding sandstones and may be to some extent forms like Mt. Monadnock.

In Fig. 48 is given not only a sketch map of the immediate neighborhood, but the section prepared by W. L. Honnold, east and west along the section line BB, and also his section showing the pits which he had dug, exposing the contact between the limestones and the underlying sandstone, 10 paces north and 575 feet west of the southeast corner of section 14. There is a possibility of a minor unconformity and Honnold queries whether the sandstone exposed is the Madison sandstone with the Mendota limestone beneath unexposed or not.

§19. GLACIAL PHENOMENA. (FIG. 49.)

Near Stonington and Heron Lakes we get to the west side of the heavy belt of drift. It is worth noting that whereas the striation and motion around Houghton and north seems to be from Keweenaw Bay, from a little south of east, on the other side of this belt of drift, it is from the northwest. It thus appears that this heavy line of drift was formed or pushed up between two different lobes

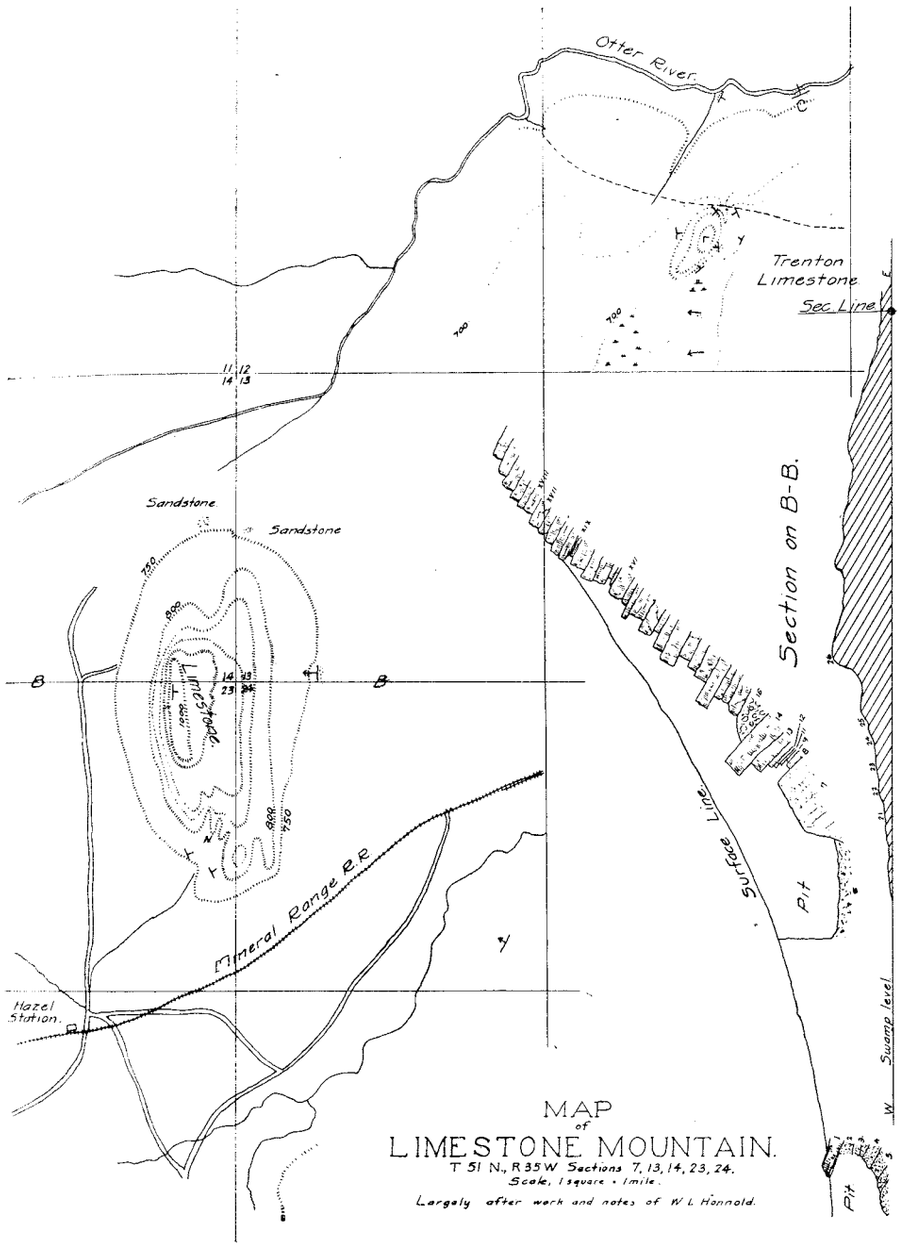

Fig. 48.—Section of Limestone Mountain. The 50-foot sketch contours refer to sea level. The line B B marks position of cross-section, the letter N the position of the Niagara.

of the ice from the Keweenaw lobe and the Chippewa lobe. See Figure 49, reproduced from Figure 16 of the Annual report for 1907.[1] I should add, what a figure cannot show so well, that the position of the ice on the east side and on the west was not coeval. Heavy deposits of clay around Mass City and elsewhere in the Ontonagon valley suggest that the ice came first from the

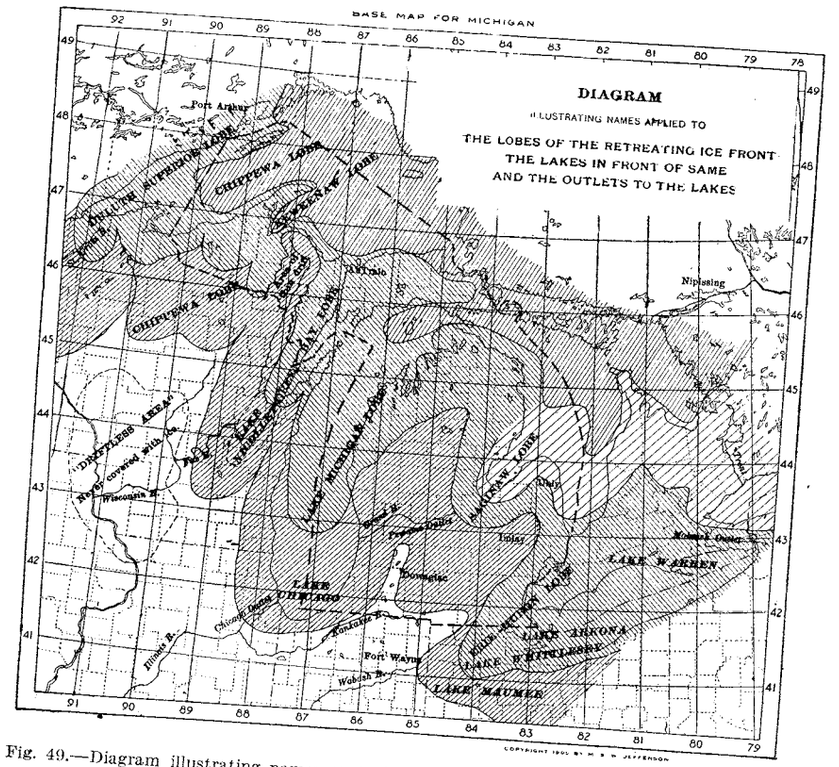

Fig. 49.—Diagram illustrating names applied to lobes of the retreating ice front and the lakes in front of the same.

northwest side, the Keewatin center damming up a lake (in which copious red sediment of slip clays settled) on the southeast side of the range, while at its very latest stage, the ice retired toward a western Labrador center, damming up a lake on its western front which has left its scorings all along the front of the range on the west side, even as much as 650 feet above its present level.

Along the south part of the Range, therefore, a deep valley which once followed nearly along the line of the Keweenaw fault is nearly

[1]See also Leverett in Publication No. 7, 1910.

filled to the brim with glacial deposits—several hundred feet of glacial deposits before reaching bed rock are not infrequent. This seems to have been made by side streams to the streams that crossed the range transversely in a style of drainage much like that now found near the New Jersey traps. There is a great outwash plain of sand and gravel dotted with lakes that have no visible outlets, that seep away through the sands and mark places where huge masses of ice were left swathed in sand and gravel as the ice retired, to slowly disappear. This plain extends west from the front of the Labrador ice and is well marked around Toivola and the northwest part of Plate XI. This big moraine seems to cross the Copper Range near Portage Lake and make the heavy till deposits east of Hancock, and around Lake Annie. A later stage is the other side of the Otter in T. 52 and T. 53, R. 34 W.

§20. ELM RIVER, ERIE AND ONTARIO. (PLS. XI AND XII.)

The outcrops begin to appear once more southwest of this moraine and near the north line of Section 32 (Pl. XI) is a conglomerate which may well be the uppermost of those in the Challenge Hole 7. In that case a conglomerate near B. M. in Section 20 near Stonington would be about 3,200 feet above it horizontally at right angles to the strike, and about 2,800 feet in thickness if the dip is 61.5°. This is a thickness not unlike that of No. 9 above No. 8 of the Arcadian, but in the Winona section would more nearly correspond to the thickness from Conglomerate 8 up to the Johnson Creek conglomerate,—that at the Shawmut on the Elm River property. In the south part of Section 31 is a lower conglomerate. In Section 6 begins a conglomerate with very fairly continuous outcrops (Pls. XI and XII) that can be traced thence as shown across the Elm River (Contact Copper Co.) property.

Here we have once more extensive drilling and with the help of a cross-cut on the mine from above the Winona lode and this conglomerate (8) down into a belt, drill holes 5 and 6 in which there are few conglomerates but heavy ophites, which seems recognizable as that near and above the horizon of the Mabb ophite and shortly above Conglomerate 3. The record for which we owe acknowledgments to H. B. Fay, J. Chynoweth and S. Chynoweth, and G. S. Goodale, is as follows:

Beside the drilling there were cross-cuts from No. 1 shaft as shown and from No. 8 shaft from No. 6 conglomerate to and including the beds of drill hole 5. The old Shawmut shaft is close above a conglomerate. There is another whose

base is below it	1750	(1600)
Thence to No. 2 drill hole is	1320	(1200)

To the Winona lode is		
To the base of Conglomerate 8	1800	
Base of Conglomerate 8 to top of No. 3 hole	2460 (at 67.5° dip)	(2270)
Base of Conglomerate 8 to base of No. 7	130	
Base of Conglomerate 7 to top of No. 4 hole	460	
Base of Conglomerate 7 to base of No. 6 conglomerate	250	
Base of No. 6 conglomerate to top of No. 5 hole	560	
Base of No. 6 conglomerate to top of No. 6 hole	270	
Base of No. 6 conglomerate to base of "Elm River" conglomerate	780	
Base of No. 6 conglomerate to base of "Wyandotte"	1250	
	2130	

Abstract of Elm River section

Drill hole & No. of belt.		Thickness.[1]	
Ed 2 b	1	(130) 130	Ophite, feldspathic (Minong trap type)
	2	(105) 235	Feldspathic M. Sc. Am.
	3	(148) 283	Doleritic ophite
	4	(74) 457	Melaphyre, feldspathic
	5	(41) 498	Melaphyre, feldspathic
	6	(27) 525	Am. brecciated
	7	(44) 569	Am. feldspathic
	8	(120)? 689	Am. feldspathic M.
	9	(106) 795	Ophite dense
	10	(121) 916	Ophite with Sc. Am.
	11	(45)+961	Ophite.

Lapping drill holes		Thickness.	Cross-cut Running measurement.	
		(62)	23	Winona lode
	From the foot of the Winona lode to the top of		total 979	
			43 Trap	
			11 Am.	
		(48)	40 Trap	
			18 Am.	
		(99)	87 Trap	
			19 Am.	
	Conglomerate 8	(283) 308 (103)	90 Trap	
Ed 1 b 1	55+ Conglomerate No. 8?	(194)	205 Cong. top	
Hanging of Winona lode above base of Conglomerate No. 8		(506)		

[1]Most of the drill holes were at an angle of 30° with the horizontal and supposed to be at right angles to the beds. This is probably so nearly true that little correction for the thickness is needed. In Hole 2, for instance, 974 feet is reduced to (961). The term sc. (scoriaceous) in these records is synonymous with what I have elsewhere called amygdaloidal conglomerates.

Lapping drill holes.			Thickness.	Cross-cut Running measurement.
	2	48	Feldspathic Am. (42.5) and Trap	105 Am. 35 Trap
	3	171	Ophite Sc. Am. (131.5)	24 Am. 115 Trap
	4	74+ 348	Conglomerate (63) (118'? thick) No. 7	23 Am. 45 Trap
Ed 1 b	1	32	(Conglomerate just above?) (91)	17 Am.
		32+60?	Ophite	79 Trap
	2	23 ∧	Am. and trap Sc. (79)	4 Am.
	3	74	Ophite feldspathic	80 Trap
	4	12	Trap (47)	23 Am.
	5	50	Am. and trap Shaft A	11 Shaft
	6	21	Am.	40 Trap
	7	85	Conglomerate basic sc. with ss No. 6? (118)	126 Cong. 6
		265 ∨	Base to base of No. 8? (552)	(? or 7)
	8	31	Am. feldspathic	20 Am.
	9	112	ophite Sc. Am.	
	10	60	(Conglomerate ?) M	84+69+Trap
	11	13	Am.	
Ed 4 b	1	50±(<50)	Ophite,—veins of sandstone in the bottom	
	2	203 494	Sandstone and conglomerate No. 5. Base from base of No. 8 (1085)	
	3	185	Ophite, sc. top 130′ doubtful	
	4	52	Am. and fine grained ophite, epidotic at bottom	
Ed 5 b	1	23+(30+)	Ophite	
	2	169	"	
	3	137	" sc. Am.	
	4	86	"	
	5	180 (40)	" sc. A	
Ed 6 b	1	17	Epidotic	
	2	36	Amygdaloid, thin, red,	
	3	45	brecciated and epidotic	
	4	188	Ophite, brecciated top with	

		much sandstone mixed marked ophite Am. clasolitic and sediment?	
5	149		7

Elm River[1] *Copper Company.* Shafts No. 1 and 2 are supposed to be on Winona lode. Shafts No. 3 and 4 are supposed to be on the Shawmut amygdaloid. Shaft No. 5 (A of these notes) is on an amygdaloid about 1000 ft. E. of the Winona lode.

Elm River drill hole 2. In section 11, near the pond and showing the section above the Winona lode. From its position it should be about 600 feet above it, at an angle of 30° to the S. E. like the rest of the holes. The first box of samples were somewhat misplaced but began with Ed 2 b 1, 0? to 132-amygdaloid, then porphyritic, and fine grained feldspathic ophite, rather feldspathic at 49 feet, and the second box begins with long cores of hard trap and an ophitic texture only appears at 70′ 1″ to 70′ 4″, reminding one of the Minong trap. Cf. Central mine Beds 97-112 and Torch Lake, No. 59. From 76′ 9″ to 78′ 3″ is plainly feldspathic ophite and at 86′ 9″ the mottles are 2 to 3 mm. broad, but it never gets very coarse grained. The bottom is at 132 feet.

Thickness 132 (130?) feet.

Ed 2 b 2, 132-239. Begins with a scoriaceous conglomerate and some amygdaloid, becoming yellow and white epidotic, scoriaceous, with copper in the epidote, at 177 to 218 it is feldspathic and fairly fine grained with a trace of ophitic texture.

Thickness 107 (105) feet.

Ed 2 b 3, 239-390. 5 mm. ophite, coarse porphyritic amygdaloid to 245 feet, with patches amygdaloidal at 259 and 291; near by, however, is a coarse doleritic texture with feldspar tablets 3 to 4 mm. broad. At 322 feet the mottles are about 5 mm. broad, by 345 feet they begin to get finer. At 362 feet there are veins (1:10 & 12:10) one set of which may be nearly parallel to the bedding. Dark at the bottom (382 feet).

Thickness 151 (148) feet.

Ed 2 b 4, 390-466. Melaphyre, feldspathic, and glomeroporphyritic, small amygdules down to 411, coarse amygdules at 422 to 444. This might be classed as a broad amygdaloid belt.

Thickness 76 (74) feet.

Ed 2 b 5, 466-508. Melaphyre, feldspathic and amygdaloidal, blotched at 482 and 492, and veined and seamed which makes it difficult to determine the boundaries of the flows here.

Thickness 42 (41) feet.

Ed 2 b 6, 508-530. Melaphyre, amygdaloid, brecciated, altered and seamed, and porphyritic in texture.

Thickness 28 (27) feet.

Ed 2 b 7, 530-575. Melaphyre, amygdaloidal and feldspathic. Epidote seam at 545 and long cores of compact trap beneath.

Thickness 45 (44) feet.

Ed 2 b 8, 575-697. Melaphyre, feldspathic and with heavy amygdaloid down to about 600, more or less streaked, the dip of the vein against core barrel (1½:10 or 2:10) may indicate vein dipping 68.5° to 71°, or nearly parallel to the bedding while another set of seams (30:10) may be nearly at right angles to the same.

Thickness 122 (120) feet.

Ed 2 b 9, 697-805. Ophite. Hanging of Winona lode (?). The top is a fine

[1]Now contact Copper Company.

grained marked amygdaloid, and below it is a fine ringing dark trap, with seams and amygdules perpendicular to the drill hole (and probably nearly parallel to the top), while there are some white seams, more nearly (60:10) parallel to the drill hole. At 720 the augite mottles are 2-3 mm. broad, at 737 3 mm., below as much as 5 mm. perhaps, at 756 3 mm., and 774 2 mm.; by 786 it is very fine grained black.

Thickness 108 (106) feet.

Ed 2 b 10, 805-928. Ophite. A marked scoriaceous amygdaloid for the first 11 feet, there is a white and green amygdaloid from 5 to 10 feet, and streaks of amygdaloid below.

At 842 to 852	the	mottles are	2 to 3	mm.	broad.
At 877	"	"	" 3 to 4	"	"
At 883	"	"	" 3	"	"

Then they grow distinctly finer, being 1½ and 1 mm. between 902 and 928.

Thickness 123 (121) feet.

Ed 2 b 11, 928-974. Feldspathic ophite with about 12 feet of amygdaloid on top, and below a feldspathic ophitic texture.

Thickness 46 (45+) feet.

Above the three heavy belts of ophite in the bottom of Ed 2 came a series of more amygdaloidal and feldspathic and generally thinner belts.

Elm River drill hole 7. On the S. E. corner of Sec. 6, T. 52 N., R. 35 W., was put down 250 feet through overburden, mainly sand, though there was a 14 feet core of mica schist, a boulder, without striking bed rock, and at the center of Section 6, T. 52 N., R. 35 W., a hole at an angle of 50° found 350 feet of "overburden" drift.

Elm River drill hole 1. (Ed 1). Put down at an angle of 30° about 600 ft. N. W. of the W. ¼ post of Sec. 12, T. 32 N., R. 36 W. Cf. Wyandotte Mining Company's holes 5 and 7. From 0 to 40 ft. was overburden of sand, etc.

Ed 1 b 1 96′ 6″

Conglomerate with well rounded pebbles often red felsite and also dark, with much calcareous cement, especially from 69 ft. down.

Thickness 56+[1] (55)

Ed 1 b 2 96′ 6″-144′ 10″

Amygdaloid and trap, never coarse grained, feldspathic, amygdaloid for the first 6′, and along at 131 coarsely feldspathic and green. Amygdules and amygdaloid white.

Thickness 49 (48)

Ed 1 b 3 144′ 10″-289″

Ophite, with scoriaceous epidotic amygdaloid the first 16 ft., seams at right angles to drill holes, i. e., parallel to the bedding at 203′ 8″ and a vein at 207′ 3″ to 209′ 7″, also at 237, 239, 242, 247, 250, 255, 256 to the bottom. The bottom 60′ just overlying the conglomerate is evidently a good deal shattered. At 223′ 7″ the augite mottlings are 2 to 3 mm. broad, the ophite texture being apparent to the eye from about 203 to 255 and more. It is clearly finer grained at 277.

[1]True thickness, since the dip of the strata is supposed to be about 70° and the hole is at 30°, with a horizontal plane, or 80° with the strata, is about the same as the apparent within the limits of error which may be increased by deviations from the hole. The correction factor is from .978 up. We have subtracted 2% for correction.

Thickness 174

Ed 1 b 4 289-363 (171) ft.

Conglomerate, basic conglomerate at the top, with rounded pebbles and basic cement, and some (378 ft.) big felsite pebbles.

Thickness 74+

This is correlated as Conglomerate 7, outcropping near the quarter post. W. J. Uren says it is 118′ thick. I think, however, that it is one which must be interpolated as 7½. (72+)

Elm River drill hole 3. (Ed 3). Also at 30° or at nearly right angles to the strata and is located 250′ S., 300′ W. of the center of the N. W. ¼ of Sec. 12, T. 52 N., R. 36 W. It is said to begin in a bed of ophite, which lies just under the conglomerate cut in diamond drill hole No. 1. The holes do not therefore overlap enough to give us a section independent of the strike of the beds and surface exposures and I think in reality there is a gap from conglomerate 7½ to conglomerate 7, unrepresented in the cross-cut, for on Ed 3 b 5, 141 to 191 feet a shaft was put down, supposedly following the dip of the lodes, and at a depth of 250′ cross-cuts 255′ S. E. and 979 N. W. were driven. Beginning with the shaft the section scales to N. W.:

	Feet along the cross-cut.	Total from the shaft to N. W.	Thickness.
Trap	80	80	
Amygdaloid	4	84	74
Trap	79	163	78
Amygdaloid	17	180	150
Trap	45	225	167
Amygdaloid	23	245 drift on this	209
Trap	115	360	227
Amygdaloid	24	384	333
Trap	35	419	356
Amygdaloid	10	429	388
Conglomerate	205	634	397
Identified by W. J. Uren as No. 8.			587
Trap	90	724	
Amygdaloid	19	743	674
Trap	87	830	694
Amygdaloid	18	848	770
Trap	40	888	788
Amygdaloid	11	899	822
Trap	43	942	834
Winona lode	23	965 above cong. 8.	877
Width of shaft	11 feet	976	898
979 from the foot of the shaft		965	
...3′ of accumulation of error in scale.			
The section to S. E. is:			
Trap	40		
Conglomerate	126	166	10
Identified by Uren as No. 7.			37
Amygdaloid	20	186	
Trap	69	255	117

Ed 3 b 1. 0 to 32 ft. Ophite; base of a bed which occurs just under a conglomerate it is said, by Capt. S. Chynoweth. The coarsest mottling is 1 to 2 mm. at the beginning, say at 8 feet.

Thickness 32+

Ed 3 b 2, 32 to 55. Small amygdaloidal melaphyre, a scoriaceous amygdaloid with intermixed sediment showing that the dip is practically at right angles to the drill hole at 32 to 35 ft. More massive below 37 feet.

Now Ed 3 begins in a well-marked ophite, which is not less than 32 feet thick, probably more than twice that, 140′ above the level of shaft A and 212′ (208) above a conglomerate. At any probable dip it would be the 79-foot trap, then Ed 3, 32 to 142 corresponds nearly to 84 to 163 feet in the cross-cut, or 139 feet, implying a dip of 72°, as good an agreement as could be expected. Or if we take the largest range of correlation for Ed 3 (32 to 297) we have for the dip 67° 53′ or say 68° which is perhaps as accurate a dip as we can get, since the slope of the adit and the rolls of the strata affect it somewhat.

Ed 3 b 3, 55 to 129. Feldspathic ophite, with patches of amygdaloid scattered through, possibly the same as the flow above. Epidote alteration at 90 to 92 and 106, brecciated, pseudamygdaloid at 118.

Thickness 74 feet.

Ed 3 b 4, 129 to 141. Fine grained melaphyre.

Thickness 12 feet.

Ed 3 b 5, 141 to 191. Amygdaloid. Very well marked at the top, fine grained and seamed throughout. On this lode shaft A was sunk (or No. 5), and from this a cross-cut driven east and west, which enables us to fill the gap from No. 3 hole to No. 1 hole.

Thickness 50 feet.

Ed 3 b 6, 191 to 212. Amygdaloid.

Thickness 21 feet.

Scaling from the cross-cut section prepared by the engineer there is for the amygdaloid followed by the shaft 11 feet and 40 ft. for the trap 51 feet which corresponds in part to Ed 3 b 5 and Ed 3 b 6 perhaps. Of course the exact determination of the limits of the amygdaloid is uncertain.

Ed 3 b 7, 212-297. Conglomerate, scoriaceous, pebbly, basic, with much sandstone at 244 and 295, the bedding at right angles to the drill holes.

Thickness 85 feet.

This in the cross-cut east from shaft A is given as 126 feet which would imply a much flatter dip angle than is possible. S. Chynoweth told me that they struck this within 5 feet of where they expected in putting in the cross-cut.

Ed 3 b 8, 297-328. Amygdaloid, feldspathic, fine grained, porphyritic, red.

Thickness 31 (30) feet.

Under the conglomerate in the cross-cut east from shaft A is amygdaloid 20 feet.

Ed 3 b 9, 328-442. Ophite. Beginning with a well-marked scoriaceous and clasolitic amygdaloid down to 345 (17 feet), then veined to 349, epidotic to 632, and brecciated and veined to 381, fissured at 406 and 432 also. The augite mottling is 1 to 2 mm. across at 397, 2 mm. at 408 to 411, and at 413 is 2 to 3 mm. across.

The cross-cut section east from shaft A from 255 feet shows trap for the last 69 feet.

Thickness 114 (112) feet.

Ed 3 b 10, 442-503. Melaphyre. The top has apparently a little conglomerate and is then amygdaloid for about 30 feet (471), at 483 light yellow-gray, feldspar laths prominent, altered, then finer, and at 501 fine grained black.

Thickness 61 (60) feet.

Ed 3 b 11, 503-516. Melaphyre. Amygdaloid, but at the end augitic, compact, trap.

Thickness 13+

Elm River drill hole 4. (Ed 4.) At an angle of 30°, along the road from the location to the station, the conglomerate Ed 4 b 2 being, it is supposed, the same as that exposed in the cut of the Copper Range R. R. back of the Elm River station. It is about 600 feet S. and 125 east of the center of the N. W. ¼ of Sec. 12, T. 52 N., R. 36 W. I should not be surprised if this hole was quite crooked. The angles of dip in the drill hole indicate that.

Ed 4 b 1, 1-51. Ophite. As the grain is growing coarser at the beginning going down we may be reasonably sure that the whole thickness of the belt is less than 102 feet. At 31 the mottlings are about 1 mm. broad, and still visible at 40. Clasolitic veins of sandstone appear in the bottom part.

Thickness 51+ (50+ and 100-, about 75 feet probably).

Ed 4 b 2, 51 to 258. Sandstone and conglomerate. First 10 feet sandstone; bedding of sandstone against cores about (4:8) 53° 30′; perhaps nearly vertical. With felsite and basic pebbles, large at 201, and calcitic cement, passing into a scoriaceous conglomerate. At 232 there appears to be bedding at an angle with the drill cores of 43° 10′. The line between this and the belt below is quite uncertain.

Thickness 207 (203).

Ed 4 b 3, 258-447. Ophite with scoriaceous conglomerate top, red seams (clasolites) of shaly sediment at intervals to 388, a black amygdaloid with red sediment being predominant type, but there are epidotic seams 319-328 and 350 and pebbles of ophite at 350 and labradorite porphyrite at 388. Red shale at 367 is at an angle (4 to 6:8) of about 50° with the drill cores. The ophitic texture is marked from 395 down, and is very fine grained by 447.

Thickness 189 (185) feet.

Ed 4 b 4, 447-500. Melaphyre, amygdaloid, epidotic from 492 to 500; this may be the top of the same bed as Ed 5 b 1.

Thickness 53+ feet (52+)

Elm River drill hole 5 (Ed 5). At an angle of 30° with the horizon and about 650 feet north and 650 feet west of the center of Sec. 12, and lower than Ed 4. It probably begins in the belt in which Ed 4 leaves off, Ed 4 b 4. There is 25 feet of overburden sand, etc., and apart from altitude the first samples should correspond about to Ed 4, 450 feet.

Ed 5 b 1, 25-48. Ophite, coarsest mottling at beginning 3 mm. broad, growing finer.

Thickness 23+ (probably not less than 50 feet).

Ed 5 b 2, 48-179. Ophite amygdaloid to 61, then as is often found the case at the margin of an amygdaloid, an epidotic band to 64 feet, the ophite for a way (68) is altered and light colored. The mottles of the ophites have the following breadths:

85	97	114	124	140
2	2–3	3	3–4	5

It is clearly mottled down to 169 feet.

Ed 5 b 3, 179-319. Ophite, amygdaloid, clasolitic, and scoriaceous to 192 feet, and fading out between 196 and 201 but by 226 plainly mottled, at 241 mottles

3 mm. broad, and growing coarser to 267, where it is seamed. At 300 it appears finer, at 310 is veined to 319 and epidotic to 325. There is here apparently a shear zone which the drill hole traversed to another belt (or the same one repeated) without any typical amygdaloid such as occurs on top of flows. The grain indicates also either that part of the flow has been cut out, or that one flow followed before the previous one had been cooled.

Thickness 140 (137±)

Ed 5 b 4, 319-407. Ophite. Epidotic to 325, and fine grained to 333, coarsest from 354 to 371. There is an epidote seam at 382.

Thickness 88 (86+)

Ed 5 b 5, 407-488+. Ophite, beginning with a well-marked scoriaceous amygdaloid or conglomerate to 465, epidotic at 412 to 427, brecciated at 421 and 433. It is said that this lies under the railroad track with 30 feet of overburden. The mottles increase to the bottom, being 2 mm. broad at 472 and 2 to 3 mm. at 486 feet.

Thickness 81 (80+) feet.

Ed 5 has no well-marked conglomerate. Heavy ophites appear predominant, but there are scoriaceous tops.

Elm River drill hole 6 (Ed 6). Put down at 50°, the rest at 30°. The reduction factor will therefore be, if the dip is 70°, the sin (180°-70°-50°)=.866. There was a heavy overburden, for this lies across the railroad southeast of Elm River in the valley, 200 feet west and 300 feet north of the center of the Sec. 12, T. 52 N., R. 36 W.

Ed 6 b 1, 132 to 149	Thickness 17	(17) feet.
Ed 6 b 2, 149 to 186	37	(36)
Ed 6 b 3, 186 to 231	46	(45)

This hole begins in an epidote seam like Ed 5 b 5, at 412 ft. It remains epidote for more than 17 feet, is a red amygdaloid at 157 and 159, brecciated 177 to 181, then more compact but amygdaloidal at 186 and brecciated and still epidotic at 190.

Ed 6 b 4, 231-425. Ophite. A red and white marked, brecciated amygdaloid for the first 20 feet down to 254, at 260 and 268 veined and seamed and from 274 to 283 epidotic. Thereafter the rock is more compact and the mottles plainer.

At 283,	290,	302,	330 ft. the mottles are	
1–2,	2,	3,	4 mm. broad	
Distance				
from bottom 123,	117,	107,	82 and coarsest about 337 feet?	
At 357,	374,	391,	402 ft. the mottles are respectively	
6–7,	4,	2,	1–2 mm. broad	
From the bottom 76,	59,	44,	30,	20

The mean rate of increase of mottling is 1 mm. in 10 to 13 feet. There is an alteration at 370, epidote at 378 and 382.

Thickness 194 feet (188).

Ed 6 b 5, 425-577, clasolitic amygdaloid. The rest of the hole is occupied by fine grained trap or amygdaloid with numerous small streaks and seams of red shale or sandstone often showing the dip.

The dip against the drill cores is as follows:

At 443 ft.	1 or 2 :8,	1½:8 (83°, 76°, 78°) ave. 79.
464	3¼:8,	(67° 50′)
475	2½:8,	72° 40′ indurated white sandstone.

511 6 or 7 :8, 59°
Average 69° 22′

This would mean a dip of 61° for the strata. There appear to be some pebbles at 463 feet and at 495 feet, 498, and 501 there is much indurated sandstone. The question whether there is a broad belt of scoriaceous conglomerate (there appear to be pebbles at 467) or a series of small flows, or whether the drill hole may not have accidentally struck into and followed a clasolitic seam is not easy to determine. I incline to the last supposition. It resembles in many ways Ed 4 b 3.

Thickness 152 (149) feet.

§ 21. WYANDOTTE MINING COMPANY. (PL. XII.)

Next southwest to the Elm River were the explorations of the Wyandotte company, about two miles away on Sections 28, 21 and 16, T. 52 N., R. 36 W.

Here, too, a complete section has been made by drilling from the eastern sandstone in Holes 13 and 14 and the cross-cut in the south part of Section 28 to the shaft on Section 16 above the Shawmut conglomerate and perhaps nearly up the horizon of the Pewabic lode. The section of the upper part is given by natural exposures shown in Plate XII. The following are notes on the drill cores. The record is largely from data furnished by F. Van Orden (agent). There has been much cross-cutting since.

Geological Cross-Section of Wyandotte Property.

Wyandotte drill hole 1. 1100 feet N. and 700 feet W. of the S. W. cor. of Sec. 21, i. e., S. E. of Sec. 20. Dip 40° ends in Winona lode?

Only a small part of the cores was saved. The dip of the beds is about 70°. Hence the true thickness is obtained by multiplying by sin 70°=.94 while the horizontal width is about that in the hole.

Box 1 is all ophite. Box 2 is in part amygdaloid, then feldspathic melaphyre. Box 3 shows a scoriaceous amygdaloid, then a fine grained ophite.

The record by F. Van Orden is as follows:

	Thickness.	Horizontal width.
Standpipe ("overburden" of surface deposits)	118.5 (102)	
Amygdaloid, vein and ore		118.5
Vein trap		
Amygdaloid vein trap, Epidote } horizon of Winona lode?		
Coarse trap (probably ophite)		
Vein trap		
Vein		
Vein trap		
Coarse trap		
Melaphyre sandstone (i e., basic red sandstone. Cf. 7.166 and 5.138)		
Conglomerate		
Vein		

	Thickness.	Horizontal width.
563′ 7″ in rock	(530)	563′ 7″

Hole 2 should be geologically above 1. The two are supposed to make a continuous section and show the absence of any conspicuous sandstone or conglomerate for several hundred feet above the Winona conglomerate No. 8. This is also true in the Arcadian section, and at the Elm River and helps in the broad identification.

Wyandotte drill hole 2. 1475 feet N., 900 feet W. of the S. W. cor. of Sec. 21, the S. E. of Sec. 20.

The dip of the hole is 40°. Assuming the dip of the beds to be 70°, the true thickness is obtained by multiplying by sin 70°, while the horizontal width is about that in the hole.

The record is:

Standpipe	88′ 2″	(83)	88′ 2″
Coarse trap			
Soft "			
Coarse "			
Soft "			
Coarse "			
Soft "	The above probably one ophite belt=Win. d. 10.		244-428
Amygdaloid			
Amygdaloid vein trap	Cf. Win. d. 10.		428-472
Amygdaloid	Cf. Win.	10.	484-end
Coarse trap			
Amygdaloid			
Soft trap			
Amygdaloid			
Soft trap			
Coarse trap			
Soft trap			
Coarse trap			
Soft trap			
Amygdaloid	Winona lode ?		
Soft trap			
Total in rock	448′ 4″	(421)	448′ 4″

Wyandotte drill hole 3. 487 feet S. and 1600 feet E. of center in Sec. 21. From this point two holes were put down; one at a dip of 40°, 204 feet to rock, then the second at 70°, 159 feet to rock. Supposing the strata dip 60°, we have the same factors as for Hole No. 4. For true thickness multiply by .766 and for width by .884. The cores were not legibly marked and for distances I depend on F. Van Orden. Both Holes 3 and 4 show well-marked and good sized ophites.

Overburden	159
Scoriaceous conglomerate d 3.	202
Ophite d 3.	202?-279

		Thickness.	Horizontal width.
Scoriaceous amygdaloid (or conglomerate) top brecciated black and white, with red clasolitic veins, and at d 3. 202-208 an epidotic amygdaloid, then coarser; at d 3. 248 the augite mottles are 2-3 mm. across. Cf. No. 4, 9.			
Melaphyre d 3. 279-311	32 (20)		28
At d 3. 268 1-2 mm.			
Largely amygdaloidal at d 3. 304 feet more compact.			
Ophite d 3. 311-520	209 (160)		184
Amygdaloid to d 3. 311			
Mottles at 336 are 2 mm.; at 374 are 3-4 mm.; at 420, 75′ from bottom; 1-2 mm. at 503.			
Is this the first flow of d 4. 349?			
Ophite d 3. 520-574	54 (42)		47
Amygdaloid nearly to d 3. 535. Mottles 2 mm. across at 545 (22 feet above the bottom).			
Amygdaloidal melaphyre d 3. 574-600	24 (18)		21
Perhaps a gush of the underlying, (rest of 60 vein amygdaloid).			
Ophite d 3. 600?-659+(40+)?	99+ (?85+)		88
Amygdaloid to d 3. 574 finishing in a coarse ophite with 3 mm. augite mottles at 659. (Van Orden 47 ft. trap and part of 60 ft. overlying amygdaloid).			

Wyandotte drill hole 4. 825′ S., 1475′ E. of the center of Sec. 21, T. 52, R. 36, at an angle of 70°. It is near Mich. Geol. Surv. B. M. 40 which is 640.58 above Lake Superior, about 1200 ft. A. T. Being composed of heavy ophites with little or no conglomerates, it reminds one of the beds in St. Mary's drill holes Nos. 3 and 5, and the Elm River drill holes 4 and 5, and Belts 132-144 of the Arcadian section, and Win. d. 12. A hole at an angle of 40° west 316 feet without striking bed rock.

The hole gives no clear indication of the dip of the beds. Supposing it to be 60° the true thickness must be found by multiplying by sin 130°=.766, and the width by sin 130° sin 60°=.884

Overburden	193		
Ophite d 4. 193-4.349	(50+) 156+	(170+)	170
This is evidently struck in the middle of a large flow as the augite mottles are 4 mm. at the beginning, at d 4. 268 they are 4-5 mm. (62′ from bottom). It is somewhat seamed and fissured and *coarsely* amygdaloid at 298 and 311.			196+
Amygdaloidal melaphyre d 4. 349-372	23 (18)		20
A well-marked white and gray amygdaloid for the first 5 feet, and chloritic amygdaloid to d 4. 361. Possibly a gush of the underlying flow.			
Ophite d 4. 372-538	166 (119)		147
A marked green and white amygdaloid for 9 feet, at about d 4. 451 coarsest (4 mm? at 65′ from the bottom).			
Amygdaloidal melaphyre d 4. 538-574	36 (28)		
A gray and white amygdaloid, finer at the bottom.			
Ophite d 4. 574-721 (+10 or 20 feet)	147+		130
At top 6 feet of marked red and white amygdaloid, at d 4. 643 feet 3 mm. patches seamed, at 675, 4-5 mm. patches, (at 35+20 from the bottom), at 721 down to 1-2 mm.			

		Thickness.	Horizontal width.
Wyandotte drill hole 5. 1450′ N. and 1600′ E. of the center of Sec. 21, T. 52 N., R. 36 W. at an angle of 60°. The dip from the drill cores appears to be about 60°. Hence the true thickness is found by multiplying by sin 120=.87.			
Overburden	54.7		54.7
Feldspathic ophite d 5. 11-138	127 (118+)		127+
The top for 12 feet is fine grained and amygdaloid so we must have nearly the whole of this flow. At d 5. 34 the augite mottles show 1-2 mm.; at d 5. 87 they are 2 mm. At d 5. 90-98 are laumontitic seams. From d 5. 125 to 138 it gets plainly finer and amygdaloid.			
Dark shale and scoriaceous conglomerate d 5. 138-169	31 (29)		31
From d 5. 138-144 it is like a scoriaceous amygdaloid and may be considered a mixture of the overlying flow with the red mud. Then there is a dark chocolate indurated shale, then red shale with a well-marked dip (56.5° to 62.5°) with a few inches of basic and scoriaceous debris only at the bottom. Cf. d 7. 166-200.			
Amygdaloidal melaphyre d 5. 169-234	65 (60)		65
This is not clearly defined and may include more than one flow for close beneath d 5. 169 it is a feldspathic coarse amygdaloid, then from d 5. 175 on, finer and markedly amygdaloidal to d 5. 182, then more compact and feldspathic, beginning to be sparsely amygdaloid again at d 5. 228 feet.			
Amygdaloidal melaphyre d 5. 234-297	63 (58)		63
For 5 feet it is a well-marked amygdaloid, but then more compact though near d 5. 245 it is coarsely amygdaloid and laumontitic, also at d 5. 264, while at d 5. 274 it appears more compact and at d 5. 275 very much altered,—a contact of a new flow or a slide fault is quite possible. Cf. shaft A at Elm River. It is slightly amygdaloid at d 5. 282.			
Amygdaloidal melaphyre? d 5. 297-307	10 (9)		10
Sandstone altered, epidotic (copper) d 5. 307-314	7 (6)		7
Cf. d 7. 285-295			
Sp. 20358 is from Wyandotte d 5 at 307 feet. A section was made to see if the sedimentary structure was brought out more plainly. It is composed of granules mainly less than 0.21 mm. up to 0.36 mm. They are of quartz, epidote and feldspar. Calcite also occurs and shows pressure twinning. There is a quartz vein faulted normally by other slips and a quartz seam has a yellow calcite on one side, apparently later. The whole bed is full of veins with little faults and is much shattered. Its sedimentary structure is not plain.			
Amygdaloid, melaphyres d 5. 314-340	26 (24)		26
Scoriaceous amygdaloid at top and the epidotic seam I have classed as sandstone and belongs mainly to it.			
Conglomerate d 5. 340-349	9 (8+)		9+
Rather basic though with many felsite pebbles.			
Cf. d 7. 361 with d 5. 340 and Elm River Hole 3.			
Total 349+55=404			404
I strongly suspect a slide fault disturbing the records, making them different at different places and altering the beds at about d 5. 275.			

	Thickness	Horizontal width.

Wyandotte drill hole 6. 1500′ E. and 700′ N. of the center of Sec. 21, T. 52 N., R. 36 W. 170′ S. E. of the No. 2 shaft, is at an angle of 60°. The dip from the drill cores appears to be 67°±4°. Hence the true thickness is found by multiplying by the sin 127°=.8, the horizontal breadth by sin 127° sin 67°=.87.

The hole begins in a conglomerate and ends in one. The upper may be No. 7, the lower No. 6. Both of them outcrop, from the outcrop the strike is N. 53° E, not as at the Winona N. 59° 30′ E. The holes were probably not quite inclined at right angles to the strike but it would make no appreciable difference in the estimated true thickness.

Conglomerate d 6. 0-21 (No. 6?)	21	(17)	19
Melaphyre d 6. 21-47	26	(21)	23

This thin flow is markedly amygdaloid (black and white) almost all the way to d 6. 41

Sandstone and conglomerate d 6. 47-6.62	15	(12)	14

This is brown (not red) for the first 4 or 5 feet. The dip, from the inclination of its banding to the drill cores, is between 62° and 72°. Then there is a white band (deoxidized), then basic pebbles appear and it passes from a scoriaceous conglomerate to a scoriaceous amygdaloid. Cf. Elm River d 4. 258-315 and d 3. 328-353.

Ophite d 6. 62-135	73	(58)	63

This begins with a marked scoriaceous amygdaloid, at 78 feet very epidotic, with clasolitic seams making it hard to decide where the conglomerate ends. At 127′ 7″ a brecciated red and green chloritic fault zone may be crossed.

Conglomerate d 6. 135-173. This is said to be 200 feet wide at Elm River (Ed 4 b 2 ? or Ed 1 b 1 ?)

Wyandotte drill hole 7. 362′ E. and 710′ N. of center of Sec. 21, T. 52 N., R. 36 W., at an angle of 40°. The dip from the drill cores appears to be 60° 40′. Hence to reduce the thickness one should multiply by the sin 100° 40′=.983. To reduce to horizontal breadth one must multiply by sin 100° 40′ sin 60° 40′=.983÷.872=1.124. The uncertainty as to dip affects the second figure, and makes computations more accurate than 3 places or than a slide rule can give useless.

The record from the samples is as follows (with aid of F. Van Orden's notes) beginning just below the foot of a conglomerate No. 8?

Overburden, Quaternary	29	(29)	33

Feldspathic doleritic melaphyre d 7. 1-48 beginning just at the verge of the amygdaloid top with a band or spot epidotic with copper at d 7. 28 feet.

	48	(47)	55
Ophite d 7. 48-166	122	(118)	139

There is a well-marked brecciated amygdaloid with calcareous cement for 48-77 29 feet, then mottled at 104, to 128, 137-157 (fissured) patches 2 mm., 3-4 mm., and 1-2 mm. respectively.

Red shale d 7. 166-200, dip (on drill cores 10° 40′) 60° 40′	34	(33)	39

The last 8 feet are somewhat uncertain. F. V. O. connected them with the bed below.

	Thickness	Horizontal width.

Melaphyre d 7. 200-264?	64	(63)	72

This bed is at the top a fine grained feldspathic trap, with seams of the overlying red shale filtered down as clasolites into its cracks. The amygdaloid has perhaps been eroded away, or cut off by a slide. It is laumontitic and veined with calcite at 230, 237, 253 and epidote at 254.

Melaphyre, amygdaloid, lower or preliminary gush of flow above? d 7. 264-285	21	(21)	24
Scoriaceous conglomerate passing into brecciated amygdaloid d 7. 285-295	10	(10)	13
Ophite d 7. 295-361	66	(65)	74

The augite patches are 2-3 mm. across at d 7. 315.

The base below d 7. 345 is fine grained and blue-black.

Conglomerate d 7. 361-364′ 10″. This may be Conglomerate 7	4+	(4+)	4+
Total 364 feet 10 inches+29=394		(384)	445

Wyandotte drill hole 8. (No cores in a vein; in a trap a little of the conglomerate. Cores are mislabelled 9). 825′ N. and 800′ E. of the center of Sec. 21, T. 52, R. 36.

3-30 ophite, mottles 2-3 mm. across, at 39 veined, at 40 coarsest, at 64 growing finer, at 96-99 altered, at 101 still a fine grained ophite, at 116 brecciated, at 119 clasolite, and from 131 on all dark, brecciated, fine grained stuff with calcite matrix -194, with streaks of epidote. It continues down in this belt all the way, alternating fine grained trap breccia and amygdaloid, and clasolitic seams of red sediment as follows:

Clasolitic at 235, 300;
Trap at 240, 253, 279;
Amygdaloid at 245, 281, 349, 361;
Breccia at 260, 262, 282, 292;

Toward the very end at 370-379 the hole seems to be passing into a feldspathic trap such as is common in the upper parts of flows.

(No copper was mentioned).

Wyandotte drill hole 9.[1] 275′ S. and 372′ W. of the N. ¼ post of Sec. 28, T. 52, R. 36, dipping to S. 37° E., at an angle of 55°. The dip on the red shale appears to be 56° or so. Hence for the true thickness multiply by sin 69°=.93; for the horizontal width multiply by sin 69°/sin 56°=1.12

Overburden	269′ 7″	(251)	302
Conglomerate and shale d 9. 1-9.80	80	(75)	90

Brown and gray calcareous sandstone at d 9. 62-78, red shale d 9. 78-80, dip in the drill core respectively 23.5° and 21°.

Amygdaloid conglomerate (and amygdaloid?) d 9. 80-114	34	(32)	38

Apparently just below d 9. 80 it is a well-marked, black and white amygdaloid with clasolitic seams, which may be merely the top of the underlying ophite or may be a bouldery lower part of the bed above.

[1] Another hole had its boxes also labelled 9, wrongly F. V. O.

	Thickness.	Horizontal width.
Cf. Win. d. 13 which appears to have a similar phenomenon, also the C. & H. in the Franklin Jr. cross-cut.		
Ophite d 9. 114-231	117 (109)	131
At d 9. 202 the mottles reach 3 mm; at 9. 191 it is epidotic. Cf. 10. 374.		
Amygdaloidal melaphyre d 9. 231-307	76 (71)	(85)
A black and white amygdaloid rather coarse to 246, seamed and partly amygdaloid to 279, and fissured at 291, compact at 294. Cf. d 10. 368-426.		
Ophite d 9. 307-430	117 (109)	131
Amygdaloid to 319. The top contact is not well marked. Seams at 324, 328, 331, 360 nearly perpendicular to the hole, 374, 378. At d 9. 352 3 mm. mottles and coarse to d 9. 407.		
Amygdaloidal melaphyre d 9. 430-502	72 (67)	81
To d 9. 460 it is brecciated and scoriaceous, and it is much veined.		
Ophite d 9. 502-552	50 (47)	56
A black and white amygdaloid to d 9. 516, and at 530 mottles 2-3 mm. across, then brecciated and amygdaloid at the bottom.		
Ophite d 9. 552-587 or 624+	72? (67)	81+
It begins with a well-marked red and white amygdaloid but passes at 587 into an epidotic band indurated and altered and ends in a fine grained ophite.		

Wyandotte drill hole 10. 250′ N. of line and 500′ E. of S. ¼ post Sec. 21, T. 52, R. 36, dip at an angle of 55° to the S. 37° E. The strata appear to dip 56°. Hence for the true thickness multiply by sin 69°=.93, and for horizontal width by sin 69°/sin 56°=1.12. It is 290 feet along the strike and 290 in the direction from the dip, i. e., S 37° E? from No. 9. This does not agree with above statement.

Overburden, standpipe	253 (242)	283
Ophite d 10. 1-39 (or 17?)	39 (36)	44
Only the base of this flow is seen and at d 10. 3 it is 1-2 mm. There may be any amount more of it.		
Ophite d 10. 39-156	117 (109)	130½
Begins as a marked black and white amygdaloid to d 10. 49, at d 10. 75 is brecciated, at 89 and 110-116, 118, 131, 143-148, it is veined, the mottling is 2 mm. across at 83-89, and at 137 is 1-2 mm., and is brecciated down to the foot.		
Conglomerate and sandstone d 10. 156-252	96 (89)	108
From d 10. 238 down it is sandstone with good chances to observe dips against the core,—of 14°, 21°, 21°.		
Scoriaceous amygdaloid or conglomerate d 10. 252-277	25	23
Cf. d 9. 80. A marked black and white amygdaloid with clasolites? or in part conglomerate.		
Ophite d 10. 277-368	91 (85)	(102)
Cf. d 9. 114-231. Mottles 2-3 mm. across at d 10. 348, 1-2 mm. at 329, veined at d 10. 355.		
Amygdaloid d 10. 368-395	$\frac{27}{118}$ $\frac{(25)}{110}$	$\frac{60}{162}$
At d 10. 374 light yellow altered, at d 10. 395 fine grained red. This is probably the true bottom of the flow, the amygdaloid above being a skeining or preliminary gush.		

	Thickness.	Horizontal width.
Faulted zone or scoriaceous conglomerate d 10. 395-426	31 (29)	69
Part of this all belongs with the belt below, but it is much decomposed d 10. 405, brecciated d 10. 411, and seamed d 10. 419, with calcite d 10. 414, and the correspondence with Hole 9 breaks off.		
Ophite d 10. 426-491	65 (60)	73
The top of this is represented in the belt above, for at d 10. 435 the mottles are 2-3 mm. across, the rock is still much veined, at 477 the mottles are 3 mm. across, then finer.		
Ophite d 10. 491-557	66+ (61+55+)	130+?
Amygdaloid to 496. Mottles 1-2 mm. at 520 and at 557 coarse 4 mm., so there may be any amount more of it.		

The top of this hole resembles very strongly for a ways the beds in No. 9. This would give a strike of N. 59° E., which is close to that at the Winona lode. But correlating d 9. 80 with d 10. 252, if the holes are on a level would give a more easterly strike. I think it is safe to correlate d 9. 80 with d 10. 252, and a correlation may be made out as far as the fault zone d 10. 395-426, which seems most nearly to correspond to d 9. 430 to d 9. 460 which has, however, different surroundings. It may be that the same shear zone passes through the holes at different levels.

Wyandotte drill hole 11. Said to be 285′ in direction of (thickness) the section from No. 10 in Sec. 21 or 28, T. 52, R. 36, at an angle of 55°. Hence assuming that the dip is 56° for the true thickness, we multiply by sin 69°=.93, for the horizontal width by sin 69°/sin 56°=1.12.

Overburden (standpipe)	218	245
Ophite d 11. 1 to 117	117+ (109)	131
There are amygdaloid enclosures. The mottles are 2-3 mm. at d 11. 44, and it is coarse from d 11. 68-91. It can not be much thicker. Should correspond to d 10. 277-395.		
Ophite d 11. 117-363	246 (228)	275
It is amygdaloid from d 11. 117 to 124 and scoriaceous or a fault breccia at 129, 134, 139-141, succeeded by a fine grained black trap and the coarser mottles 2-3 mm. do not appear until d 11. 151. I judge there is slide faulting along the scoriaceous top of the ophite. It is brecciated again at d 11. 160-166 and seamed between d 11. 194 and 208. The mottles are 2-3 mm. across at d 11. 189 and 215. It is more seamed at d 11. 221. At d 11. 232 the mottles are 3 mm. across, at d 11. 289 4-5 mm., at d 11. 331 2-3 mm., at d 11. 338 it is somewhat amygdaloid. The grain and brecciation indicates that the top of the belt is much faulted. The only thing this can correspond to in No. 10 is d 10. 491-557 which is as coarse.		
Conglomerate d 11. 363-367	4+ (4+)	4½
Cf. Win. d 11. 460. Cf. Wy. d 9. 1 and Wyd. d 10. 156. If that is the case d 10. 557=d 11. 289 about,—a difference of 288 feet. The beds above can not be closely correlated since the fault comes in. The beds in No. 11 should be struck if the dip is only 56°, about 255 feet sooner than in No. 10. Cf. the big ophite in Winona drill hole No. 11.		

Wyandotte drill hole 12. 88′ E., 525′ N. of the W. ¼ post of Sec. 28, T. 52, R. 36. Dip of hole 55°, 131 feet standpipe, 626′ 7″ in rock. Total 757′ 8″. If the dip of

		Thickness.	Horizontal width.
the strata is 70°, the true thickness is obtained by multiplying by sin 125°=.819 and the horizontal breadth by sin 55°/sin 70°=.87.			
Overburden	131		width 114
Melaphyre, fine grained amygdaloidal d 12.	1-25	24 (20)	21
Van Orden trap 22.5 ft.			
Sheared amygdaloidal melaphyre or scoriaceous top of ophite perhaps including a sedimentary horizon.			
Cf. Baltic lode d 12. 25-39 light yellow epidotized, also at 59, and amygdaloid brecciated at d 12. 71. At d 12. 73 the augite mottles are 2 mm. across.			
d 12.	25-86	61 (50)	53
This and the following are divided by Van Orden as 28.7 amygdaloid, and 143.2 trap.			
Ophite d 12.	86-202	116 (95)	101
Much sheared with epidote top to 93, at d 12. 124 the augite mottles are 2 mm. across. From 190 down it is light colored, altered.			
Amygdaloidal melaphyres d 12.	202-264	62 (51)	54
Part of this probably belongs with the flow but the strata are much disturbed and it is hard to make out the belts. Van Orden divides this and the following as 9′ 2″ quartz and calcite, and 234′ 3″ trap.			
Ophite d 12.	264-437	173 (142)	150
Decayed and decomposed.			
Conglomerate and sandstone d 12.	437-530	93 (76)	81
The bottom 9 feet are sandstone apparently. Unless there is a fault this is lower than any conglomerate in the Winona section, i. e., it must be No. 3, the Baltic conglomerate or lower.			
Amygdaloidal melaphyre d 12.	530-626.7	96.7 (89)	84

The samples as found were largely amygdaloid but Van Orden divides it into 44 feet amygdaloid and 55′ 3″ trap. The hole is probably near some disturbance, either a slide fault or a cross-fault. It is pretty near the Eastern sandstone and the great Keweenawan fault.

Wyandotte drill hole 13. 213′ E. of the ⅛ post on the S. line of Sec. 28, T. 52, R. 36.

Overburden	(196) feet.
Eastern sandstone	(400)

There is very little core, not more than 2 boxes, say 50 feet from the whole 400. The bedding is at nearly 45° to the core (36° 40′ to 41° 20′) which indicates that the bedding is either about horizontal or about vertical. I presume in this core it is nearly horizontal dipping between 1° 40′ and 6° to the N. W. Much of the sandstone is white, loose grained and sugary, but it is also red and white banded and spotted.

Sp. 20356 is of the eastern sandstone, from this hole. About 50% of it is quartz. Orthoclase is about 30%, microcline with distinct twinning net-work about 10%, and there is plagioclase and a micaceous cement, perhaps not more than 10% of the whole mass. Biotite occurs. There is one grain of pleochroic tourmaline. There is, I should judge, not over 1% of iron oxide and there appear to be 1 or 2 grains of felsite ground mass with a trichitic arrangement of the feldspars.

Wyandotte drill hole 14. 50′ E. of the ⅛ line and 565′ N. of the S. line of Sec. 28, T. 52, R. 36.

Overburden	(160)
Eastern sandstone	(406)

There was so much water in it that the sandstone fretted away and had to be cemented before boring, it was so friable. The grains were rather coarse (2 mm. or so). The dip against the drill core was (5:8) 32° and the true dip perhaps 3°, practically horizontal.

Wyandotte drill hole 15. 910′ N. and 392′ W.

Overburden	(185)

Sand, gravel and boulders,—no rock.

Wyandotte drill hole 16. 8′ S. of the ⅛ line and 637′ E. of the W. line of Sec. 28, T. 52, R. 36.

Overburden	(199)
Eastern sandstone	(100)

Soft, red (and spotted white) sandstone, largely came up as sand.

Wyandotte drill hole 17. Abandoned.

Overburden	(60)

Wyandotte drill hole 18. 488′ S. of W. ¼ post, and 87′ E. of W. line of Sec. 28, T. 52, R. 36.

This is near the shaft from which drifts are run which is 450′ S. of the W. ¼ post and 175′ E. in Sec. 28, T. 52, R. 36. Just a short way in. Cf. record of shaft and drifts.

Wyandotte drill hole 19. 475′ S. E. of No. 6, on a line perpendicular to the strike. Dip 55°. Hence if the dip is 67°, the true thickness will be found by multiplying by sin 122°=.848 and the horizontal width by (sin 122°/sin 67°)=.91.

		Thickness.	Horizontal width.
Overburden	128	(109)	116
Ophite d 19. 1 to 253	253	(214)	230
This is struck near the top and is at the beginning amygdaloid. The augite mottles grow coarser down to about d 12. 188 feet (55 feet above the bottom) where they are 5 mm. across, at d 12. 193, (50 feet), 4 mm. across and then finer.			
Ophite d 19. 253-320	67	(57)	61
Amygdaloid for 2 feet, then from 265-270, an epidote streak or inclusion, also at 289-296, and at 311.			
Fault ? at d 19. 320			
The rock is brecciated and no well-marked amygdaloid separates the two ophites.			
Ophite d 19. 320-390	70	(59)	64
The augite mottles are at 343 2-3 mm., growing coarser, at 359 (26) 3 mm., at 371 (18) 2-3 mm., at 378 (11) 1-2 mm. The last 4 feet 386-390 are amygdaloid.			
Conglomeritic sandstone d 19. 390-400	10	(8)	9

§ 22. WINONA MINE (Pl. XII, Fig. 50).[1]

The next section, that at the Winona mine, is extra complete, and may be taken as a sort of standard, as the cores are preserved in the survey office, thanks to Dr. Hubbard, and the drilling was done under the supervision of F. W. Denton, the holes connected with adjacent outcrops, and a careful section prepared by R. T. Mason upon which Figure 50 is based. I have also examined the cores and made supplementary observations.[2] This is the first section below that at Calumet where a section can be made out from the Great (Copper Harbor) conglomerate down to and including much of the Bohemian Range group, in all 9,000 feet or so only, indicating a very considerable shrinkage in the traps, which appears to be largely in the upper part. On the other hand the conglomerates are as heavy and heavier than farther north.

GEOLOGICAL SECTION AT WINONA MINE.

ABSTRACT.

Conglomerate		980
Alternating conglomerate and ashbed trap to Island mine conglomerate? Above drill hole covered! Dip 52° d 1.	230–750	Sum.
Ashbed type Holes 1, 2, to d 3.131-213 (80.5) (Pewabic or Hancock W)	(580)	(1330)
From base of conglomerate d 3. 213 to base of conglomerate d 4. 581+ (60), Dip 56°¼	(825)	(2155)
From base of conglomerate d 4. 581+ (60) to base of d 6. 452+ (74), Dip 57.5°	(1517)	(3672)
From base of conglomerate d 4. 581+ to base of possible Allouez exposed in trenches	(117)	
First big trap and some pretty heavy beds and faults between	(129)	
From base of conglomerate d 4. 581+63 to base of d 5. 213 conglomerate	(737′)	
From base of conglomerate—d 4. 581+(60) to base of d 5. 440 (first ophite noted by Mason) d 5. 208-213 is a *conglomerate and* sandstone.	(963)	
From base of conglomerate d 6. 452 (Johnson Creek or Shawmut) to base of d 7. 148-166	(128)	(3800)
base of d 4. 581 to base of d 7. 148-168 (1645)		
From base of conglomerate d 7. 166 to base of d 8. 232-282. Dip 66°	(397)	(4197)
base of conglomerate d 3. 213 to d 8. 282 is (2867)		

[1]Plate XII and Fig. 50 are in envelope.
[2]Separated from the earlier notes by a double dash.

From base of conglomerate d 8. 282 to base of d 9. 88+ (—d 8. 590, d 8. 450 between) sandstone, dip 70°	(321)	(4518)
From base of d 9. 88 to base of d 9. 217 (The Wolverine No. 9)	(123)	(4641)
Discussion of correlations here.		
From base of d 9. 217 to hanging of Winona dip about 70°	(1090)	(5731)
From hanging of Winona to base of Winona conglomerate (S) about	(493)	(6224)
From hanging of Winona to base of conglomerate 6 (acid)	(575)	(6799)
From base of conglomerate 6 to base of Winona d 13. 62	(632)	(7431)
From base of d 13. 62 to base of Winona d 11. 168 (3 big ophites?)	(613)	(8044)
From base of d 11. 168 to base of Winona d 11. 544 (Fault repetition?)	(362)	(8406)
From base of d 11. 544 to base of Winona 12 and end of section all ophites	(602)	(9008)

Winona Cross-section.

In this section the following conventions are used. Annotations or additions by the geologist to the engineer's record are separated by a dash repeated thus, (– –)

The word thickness refers to the thickness at right angles to the dip and the strike; the word width to the horizontal width, which is formed by multiplying the thickness by the cosecant of the dip. The word depth refers either to distance along the drill hole or down a shaft. The thickness is derived from the distance along a drill hole by multiplying by the sine of the sum of the angles of dip of the drill hole and of the strata, since the drill holes are inclined practically at right angles to the strike. Figures referring to thickness are enclosed in parenthesis. Figures referring not to an immediate belt but to totals for several belts when occurring in the course of the column have a line above them, and are taken usually from tops of amygdaloid to top of amygdaloid, which are much better defined than their foots, and from base of conglomerate to base of conglomerate, since the bases of conglomerates have usually been used to figure from, though their hanging walls are often better defined and are really in many cases slide planes.

Reference to other sections are abbreviated as follows:
Winona drill hole No. 1 at 355 feet from the surface to Win. d 1. 355, etc.
Tamarack No. 5 shaft, engineers belt 6 to T 5 b 6, etc.
Tamarack No. 5 shaft, my division into flows and beds in the Annual for 1903, p. 253 et seq. to T 5 f.
Elm River drill hole to E. d
Wyandotte drill hole to Wy. d
Arcadian drill hole to Arc. d
Calumet & Hecla to Cal.

The elevations are referred to sea level by way of the Bench Marks of the Ontonagon road survey.

There are some indications of a flattening dip from the south to the north end of the sections. Mason notes with pencil a dip of 52° for Hole 3. A correlation of the bottom of Hole 4 gives 56°¼. From outcrops in Sec. 19 a dip of 55° was obtained. The dip on the Winona lode is 70° at the beginning, 68° average.

In putting in the belts on Fig. 50 the draftsman used a uniform dip of 65° but

that does not seem strictly accurate. I have accordingly computed the dips and thicknesses for each part of the section independently, using the slide rule, and such dips as seemed probable, with due regard to correlations, etc.

The direction of the dip of the drill holes was intended to be that of the section, at right angles to the strike of the formation or the Winona lode N. 59° E. In getting the standpipe in place a little shifting would occur, and I have given the actual directions. These differ, however, not over 3° from N. 31° W., the direction of the section, and would not affect the thickness a tenth of a per cent, being entirely inappreciable in individual belts, and much less than the probable errors introduced by faults, unknown veering in the course of the drill holes and other sources.

The section above drill hole 1 may be completed somewhat by outcrops, especially a section on a stream in Sec. 24, T. 52 N., R. 37 W. See map. (Plate XII.)

Nothing but conglomerate has been found above this section—say 1200 feet above drill hole 1 say in thickness *above* (980) feet.
This perhaps outcrops near the E. Q. P. of 24 and a conglomerate is exposed in Sec. 33, T. 52, R. 37 which may be the Great conglomerate.

3. Melaphyre (trap succeeds for 114 paces or is covered). There *may* be more than one flow. (49) 60
4. Amygdaloid and trap. (38) 47
   Forbes compared the amygdaloid with one at the top of the section on Sec. 16, T. 52, R. 36; the contact with the underlying conglomerate strikes N. 60° E., and dips 55°.
5. Conglomerate dip 55° to N. 30° W? (12) width 15 ft.
6. Porphyrite, fine grained trap of Ashbed type. (58) 71
7. Conglomerate (17) 21
8. Melaphyre (30) 37
9. Conglomerate (17) 21
10. Melaphyre porphyrite (10+) 13+
    An agatiferous amygdaloid passing to south down into a fine grained feldspathic trap. The elevation at the S. E. end of the section is about 1170 A. T.

Total perhaps (231) 285
End of section above drill hole 1 say (750)

An outcrop of conglomerate and trap 440 paces S. 1200 W. of the N. E. corner of Sec. 19, T. 52 N., R. 36 W., appears to correspond to the lowest conglomerate and trap of this section. The consequent strike is N. 59° E. like the Winona lode.

No exposures of the section between the end of this section and the top of the Win. d 1 appear nearer than possibly Sec. 10, T. 52, R. 36, but it is not far above Win. d 1.

This section appears to belong to that upper part of the Keweenawan series where the volcanic activity was dying out and traps frequent, just below the Great Conglomerate. This is the Eagle River group, Gordon's Division VI of the Black River Column, the first thousand feet of the Eagle River section, Marvine's Group (c), the top of the Tamarack 5 shaft above T 5 b 7 and westward, and on Isle Royale the part above the Island mine conglomerate. Below T 5 b 7 there are some 2000 feet of beds of sodic and feldspathic type which I have called melaphyre porphyrite. We are not surprised therefore that the beds in Win. d 1 are of the melaphyre porphyrite type, and that the first ophite, noted by Mason as such is (2000) feet lower.

Winona drill hole 1. 1265′ .7 feet A. T.; 520′ N., 2440[1] W. of E. Q. P. Sec. 19, T. 52, R. 36. Dip of hole 40° toward S. 28° 51′ E. Dip of beds 52°. Hence for true thickness multiply distances on hole by sin 92°=.9994, for horizontal widths by sin 92° sin 52°=1 ÷ .788=1.27

Surface deposits (collar to rock) 25 (25)

11. Feldspathic melaphyre – – mainly brown trap
    d 1. 25 to 62 – – 37 (37) (47)
    – – the feldspar is 1-2 mm. long but not really a typical ashbed melaphyre.
12. Melaphyre porphyrite, fine grained, reminding one of a felsite.
    – – Brown amygdaloid with calcite 62-69, brown trap –73, brown amygdaloid with calcite epidote chlorite - 79, brown trap – 103
    – – d 1. 62 – 99 37 (37) (47)
13. Melaphyre porphyrite d 1. 99 – 140 41 (41) (52)
    From d 1. 99 – 103 is a marked red calcareous amygdaloid, and below is a fine grained black trap like the Minong trap.
14. Melaphyre porphyrite d 1. 140 – 189+ + + +
    A red amygdaloid passing at d 1. 152 – 153 into a white brecciated amygdaloid with indurated sandstone seams, clasolites. It continues fine grained all the way to the end. – – From 232 to 282 feet along the line of section from No. 1 is a trench exposing trap – – which extends the last belt down from d 1. 189 equivalent to d 1. 230 making it 70 (70) (89)

This does not quite complete the section to Win. d. 2.

Winona drill hole 2. Collar 1261 A. T.,[1] 100 ft. N., 2400 ft. W. of E. Q. P. of Sec. 19, T. 52, R. 36.

This hole is 322 feet S. 31° E. from Hole 1 horizontally on the section or 254 ft. below. Dip as before 40° to S. 33° 22′ E. For true thickness multiply by .9996. (37.5) (42)
There is a gap of 24+13.5 feet.

Overburden d 2. 0-13.5

15. Trap d 2. 14 – 93 – – Glomeroporphyritic, not mottled, with some white amygdules at top (79) (100)
    Amygdaloid d 2. 93 – – true trap – 116 (23) 28
16. Amygdaloid 5, weathered trap 18 – – the amygdaloid red with white and green concentric banded amygdules, the trap feldspathic.
    Amygdaloid d 2. 116 – 126 and trap – 131 – – reddish feldspathic. Amygdaloid? – 132, compact green trap – 135 and trap – 143 – green and fine grained, or with characteristic specks (27) 34
    Total from top of Win. d. 1 (397)
    – – At the end it is near or at another amygdaloid.

Winona drill hole 3. 1265.8 A. T.

Dip of hole 39° to S. 32° 28′. At 52° dip (multiplying by sin 91°) there will be no appreciable reduction for true thickness. For width multiply by 1.27. This hole is 140 feet horizontally on the section from No. 2 which at a dip of 52° corresponds to a thickness of (109) feet
460 feet from Win. d 1 which corresponds to a total of (362) ft.
Surface deposits 28 feet.
Trap? d 3. 28=36 – – lapping perhaps 7 feet on the bottom of Win.

[1]Pit about 5 feet deep, then cemented standpipe to edge.

d 2. Well-marked contact at 42 with red amygdaloid below, gray trap above.

18. Amygdaloid d 3. 36 – 42 and trap – 65
Amygdaloid, greenish, compact d 3. 65-70 and trap with some amygdaloid – 120 – – at 50 is a hard spot and the epidotic amygdaloid at 65 is not a contact but there is one heavy feldspathic bed to 120.

19. Amygdaloid d 3. 120-126 and trap 131

20. *Conglomerate* d 3. 131-203 and sandstone – 212.84 (81.5)
Win. d 3. 131-212.84 very probably corresponds to T. 5 b 12 or to b 23. The former is assumed to be the *Hancock West* or Marvine's 17 conglomerate. The latter is the Pewabic West or Marvine's 16, not far above the Pewabic lode, at the Quincy mine (623) feet. Counting every conglomerate up from the one we take to be the Wolverine sandstone. Marvine's No. 9, would make this No. 18, and the loss of one number is far from surprising.
The beds are very typical glomeroporphyrites of the ashbed series.
Total from top of Win. d 1 is (362)+(213) at a dip of 52° (575) or allowing something for increase of dip, since the next hole Win. d 4. seems to have a dip of 56° instead of 52° (580)

21. Amygdaloid d 3. 212-218 and trap fine grained chloritic 262 (47)
– – to 239 a very fine grained trap, a porphyrite.

22. Amygdaloid d 3. 262-274 and trap coarse grained 296, (36)

23. Amygdaloid d 3. 296-300 – – with clasolitic seams and ashbed appearance. And trap-317, (21)

24. Amygdaloid d 3. 317-324 and trap 332, (15)
– – a contact at 316′ 8″, trap above very glomerophyritic.

25. Amygdaloid d 3. 332-338 and trap 344, (12)

26. Amygdaloid (some trap) d 3. 344-378 and trap 384, (40)
– – This is at 377, etc., distinctly glomerophyritic and like Sp. 16421.
Amygdaloid d 384-398 and trap 452, (68)

(819)

Belts where so much amygdaloid in proportion to trap is reported have often turned out to be glomeroporphyrites as these are. Cf. T. 5 b 28. This is probably about the horizon of the Pewabic lode.

Winona drill hole 4. 1253 A. T.

Dip of hole 38° to S. 24° 17′. Allowance (38° 08′ to S. 31° E.) factor for incorrect direction of dip of hole .993. This hole begins 464 feet horizontally on the section from No. 3, which should overlap it at Win. d 3. 395, and finishes in a conglomerate the upper contact of which is exposed in trenches, so that a dip of 56°¼ may be inferred. Hence for true thickness multiply by sin 94° and for horizontal width by sin 94° ÷ sin 56°¼=1 83 =1.206.

Surface deposits 34

[27]. Trap – – as at the bottom of Hole 3 ? d 4. 36-62 (28)

28. Amygdaloid d 4. 62-67 and trap -82.5 – – a well-marked porphyrite (20)

29. Amygdaloid d 4. 82.5-90 and trap -215. A seam at 96 feet, above which the trap is hard, brownish, striated. – – This trap is coarse, feldspathic, glomeroporphyritic somewhat, and chloritic. (132)

30. Amygdaloid d 4. 215-225 and trap 309. Amygdaloid highly mineralized. From 232-270 fine grained. From 308 to 309 with olivine. – – The trap at 294 is glomeroporphyritic. (94)

31. Amygdaloid d 4. 309-315 and trap 395 (86)
– – feldspathic. At d 4. 367 coarse, olivine and augite showing. At d 4. 389 to 395 broken, seamy, finer grained.

32. Amygdaloid d 4. 395-406 and trap 424 (30)
Greenish amygdaloid, with quartz and other minerals. This is probably a bomb and not a contact. Trap appears coarse grained.
– – Feldspathic and glomeroporphyritic.

33. Amygdaloid d 4. 424-435 and trap 476 (56)
Copper and calcite in green amygdaloid. – – Not very amygdaloid, more pseudoamygdules and porphyritic feldspar. At d 4. 434 passes into a hard amygdaloid, and at d 4. 435 from this to a coarse grained trap.

34. Amygdaloid d 4. 476-484-a genuine contact and fine grained gray and white Am., and feldspathic trap -534 (56)
At d 4. 460 are indications of slipping. At d 4. 470 it is fine grained.
At d 4. 477 the amygdaloid is very fine and hard. At d 4. 479 it is fine grained and soft and hard again at 482. The trap becomes fine at d 4. 530.

35. Amygdaloid d 4. 532-542 and trap -570 (48)
Calcite and copper in quartz in the amygdaloid, at 539 fine grained.
At 543 to 548 a porphyrite, – – at 551-2 coarse feldspathic.

36. Amygdaloid d 4. 570-574 and trap -581 (10)
The "amygdaloid" may be a vein.

37. *Conglomerate* d 4. 581 to 585+ (4)
Under the trap came a mud, perhaps a fluccan which made no core, and under this was a thin seam of sandstone overlying the conglomerate. Total distance to the *top* of this conglomerate below the base of the Island mine conglomerate d 3. 213 by scaling at right angles to a dip of 56° (762) ft.

In Tamarack No. 5 the top of the Pewabic West conglomerate T. 5 b 23, Marvine's 16 is 930 feet below the Island mine conglomerate, but No. 17, the Hancock West comes only 400 feet below.

This appears to be equivalent to No. 16, and some parallelism can be traced in associated flows.

Hole No. 4 is continued by the trenching of Section A.

710 feet horizontally below No. 4 in the section is a 10 feet deep pit 1310 ft. A. T. which exposes trap and at 740 feet and 790 feet are others exposing the conglomerate while at 800 feet an outcrop of trap has been scraped off so as to expose its contact with the foot of the conglomerate. Its thickness appears to be over 60, say (63) feet (76)

Base of this the Pewabic West Marvine's (16) Winona 4. 585+ below the base of (Marvine's No. 17) d 3. 131-212. (825)

THE BEGINNING OF THE CENTRAL GROUP AND END OF THE ASHBED GROUP MUST BE BETWEEN THIS AND 208 FEET DOWN IN HOLE 5.

Record continued by engineer's Section A. From trenches. Zero is at sta. 167 1340 A. T.

This I visited and sampled May 23rd, 1906. It was not plainly ophitic even in the center. The feldspar up to 1 mm. long-x0.1 to

0.2 mm, wide was rather prominent, especially on the weathered surface. The general type is that of a feldspathic melaphyre.

38. Trap outcrop – – extending N. 59° E. -68 (112) hor. width 127
Fluccan seam with copper stains on its base, then brown sandstone. (5) 5

39. *Conglomerate* -85, float copper found here – – lower (12) 15

40. Amygdaloid (10) with epidote and calcite copper seam and trap -137, covered (10) feet, -147 (54) 65

41. Amygdaloid with epidote and quartz 8 and trap outcropping at center -226 (79) 87

42. Amygdaloid with epidote and quartz (15) feet and trap -405 (158)+ 190
– – trap exposed in pits, not absolutely continuous in section.
Amygdaloid with epidote, calcite, quartz and copper -(7) Pit (G)- and trap, in which Win. d 5 perhaps begins, exposed in pits H, I, J, K, L, to 537. For thickness see Win. d 5. below.

Winona drill hole 5. Elevation 1288.8 A. T.

This hole is 1393 feet from drill hole 4. The average dip of the top of the beds between is near 57°; assuming this the top of Win. d 5 would correspond to W. d 4. 1171 and the top of the first amygdaloid at Win. d 5. 77½ to Win. d 4. 1248, or 600 feet below the *base* of Win. d 4. 58, making the thickness of the belt of trap in which the hole starts 180 feet.

Dip of hole 38° to S. 24° 50′. Dip of strata 57.5°. For true thickness multiply by sin 105.5°=.9954 for width by sin 105.5° ÷ sin 57.5=1.19

Surface d 5. 0-d 5. 23.5 23.5

43. Trap d 5. 23½-77½+ that above 54 (54+126=180)
At d 5. 58 much broken with seams. – – I think from grain there is a small fault, making say 20′ repetition here. – – etc. From 64 to 75.5 fine grained. – – This ophite is well-marked and is coarsest at about 36,-about 3 mm., at 44 2 mm., at 53 1 mm.

44. Amygdaloid with copper in calcite d 5. 77½-89½ – – a well-marked contact.
d 5. 83.2 to 84 very hard, fine grained not amygdaloid trap, probably marks junction of two beds – – Very possibly the flow is from d 5. 76-84. d 5. 87 to 89½ epidote trap, fine grained at 92.
Trap to d 5 92 14 (14)

45. Somewhat amygdaloidal d 5. 92-98½, Dark trap — 101½ (10)
– – at 100 a coarse chloritic amygdaloid passing into a fine grained trap.

46. Amygdaloid d 5. 102-114 and – – feldspathic – – Trap -129 27 (27)
Am. has much calcite partially brecciated, – – chloritic fine grained.

47. Amygdaloid (epidotic) d 5. 129-140 and trap -208 79 (79)
From d 5. 202-206 fine grained.

48. Melaphyre conglomerate? d 5. 208-5. 213 (5)
Greenish material enclosing patches of brownish rock having much the appearance of conglomerate. – – This is a real conglomerate and the trap above is a real ophite but *not* a *marked* one. – – A well-marked altered gray sandstone; dip against core 72°; a little conglomerate at the base. This should be compared with the Allouez *conglomerate* and the Mesnard epidote.

49. Trap d 5. 213-5. 234 21 (21)
– – Coarse, few amygdules, also specked.

50. Amygdaloid epidote d 5. 234-242 and trap -250 (16)
– – Greenish, marked, compact.

51. Amygdaloid d 5. 250-257 and trap -262 (12)
– – A well-marked amygdaloid with flow contact at top.

52. Amygdaloid d 5. 262-266 and ophite -440 178 (177)
The Am. has something the appearance of a melaphyre conglomerate with epidote and considerable copper. At 414 the material is broken and the mottling not so apparent but it is probably the same bed – – but faulted by a fissure running at 60° to the drill hole at 415′ 8″. At 440 it is fine grained and probably the bottom. – – This is the first ophite that Mason notes. Its top is by scaling and at a 56° dip below the base of the conglomerate d 4. 581 785 ft. Can it be the Greenstone? The "Greenstone" is known to thin to the south and be nearly gone at Portage Lake. Much more likely it is the Mandan ophite or some similar lower bed? There is no sign beneath of the Allouez No. 15. At 300 2 mm., at 345 4-5 mm., at 365 7 mm. or so, at 398 3 mm., at 438 bottom *contact.*

53. Amygdaloid d 5. 440-444, and trap -504½ 64½ (64)
Trap is brownish – – and shows minute ophitic mottling well at the base. Top of the amygdaloid below d 4. 585+ 963 ft.

54. Amygdaloid d 5. 504½-508 and trap 524 20 (20)
– at 517 minutely mottled and ophite.

55. Amygdaloid d 5. 524-534.6 10+ (10)
With much calcite. This should be the amygdaloid d 6. 53½-62½ most nearly. With this correlation the dip appears to be again 57½° and the top of this amygdaloid would be 84 feet below the base of the large ophite, 1046 feet below the base of the last conglomerate. On the road N. 28° W. from the Winona power house about 3000 feet is an outcrop, porphyritic and clasolitic, which may correspond to the melaphyre conglomerates d 5. 208-266?

Winona drill hole 6. 1267.9 A. T.

Dip of the hole 38° to S. 29° 47′ E. Dip of the beds 57½°. For true thickness multiply by sin 105½=.995. For horizontal breadth by 1.19.

Surface deposits to rock d 6. 0 to 46 46 *vert.* thickness width

[54]. Trap d 6. 46-53½ 7½ true th. (7½) width 8
– – The bottom of d 5. 508 *to 524*?

[55]. Amygdaloid d 6. 53½-62½, and trap 181 122 (119) 145
– – 53½ is below the base of the last conglomerate (1046)

56. Amygdaloid, cupriferous d 6. 181-195 and trap -211 30 (29) 36
– – The trap is a well-marked ophite. There is copper in the hanging. The amygdaloid is brecciated and almost an amygdaloid conglomerate.

57. Amygdaloid d 6. 211-216, and trap -304 93 (93) 110
The trap is brownish and an ophite up to 3 mm. mottles.

58 and

59. Amygdaloid d 6. 304-316 and trap – – ophite – – – 440 136 (135) 160
Amygdaloid is marked epidotic with copper in sludge. The trap – – two flows having a junction near 394; about 393 it is fine grained, hard and amygdaloidal – – at 357 3 mm., at 367 2-3 mm., from 780 on

is a f. g. chloritic amygdaloid and between that and 399 is well-marked Am. and contact. The trap below is feldspathic, faintly ophitic.

60. Amygdaloid d 6. 440-445 and trap -448½ and amygdaloid d 6. 452
12 (12) 14

61. *Conglomerate* d 6. 452-461 9+

Portions of this conglomerate have a very light matrix giving it a weathered appearance. Its top is below the top of d 6. 53½=d 5. 524 (397) feet and below the base of the conglomerate d 4. 581 (+60 ft.) is (1443) feet. A marked felsitic conglomerate.

This hole does not quite lap Hole No. 7 but is probably paralleled by Section B which is 5000 feet northeast of the line of section. It enables us to estimate the thickness of this conglomerate, which is the Shawmut or Johnson Creek conglomerate. It appears to be there (74) feet thick. If so, its base would be below the base of the conglomerate at the bottom of No. 4 (1517) feet.

This appears to correlate with the Houghton conglomerate No. (14)

Section B shows: horz. width

[56]. Trap 45

[57]. Epidotic amygdaloid – – Cf. d 6. 211-216 10

Covered

Trap – – Cf. d 6. 216-304 28

– –

[58]. Amygdaloid, laumontitic, calcitic and epidotic 4

Trap (61) 75

[59]. Amygdaloid from 182 to 187 – – cf. 6. 393 (57) 3

Trap to 240 65

Shawmut conglomerate to 328 – – cf. 6. 452+ (74) 88

"Johnson Creek conglomerate, thought to be the same as exposed on Misery River at the falls." – – It may be the conglomerate at the bottom of Hole 6 (d 6. 452-461+)

Trap to 365 (31)+ 37

This section is made in the N. E. ¼ Sec. 20, T. 52, R. 36, by J. B. McIntosh. The end of this section should overlap drill hole 7 a little. As near as I can judge the beginning of the rock in No. 7 (7.48) is 88 feet of thickness below the top, 14 feet below the bottom, of the "Johnson Creek" conglomerate. The foot trap to the Johnson Creek conglomerate would then be 14 feet thicker than shown in No. 7 or 130 ft.

Winona drill hole 7. 1268.54 A. T. Dip of hole 37° to S. 34° 08′ E. Dip of strata 63°⅓ to 66°. For true thickness multiply by sin 110°⅓=.984. For horizontal width by (.984/sin 63°⅓=.893)=1.10.

Surface deposits to rock 7.48+2=50 ft. vert. thickness hor. width 55

62. Trap d 7. 50- to 148=98 (96+14=110) width 154

Very coarse grained and weathered, large feldspar crystals standing out – – doleritic – – If this were the Kearsarge foot the conglomerate below would be the Wolverine sandstone No. 9. 50½ to 51½ epidotic; 74′ 9″ peculiar core of 2 inches light reddish clay seams in trap, – (clasolitic? L.). – – At 51 doleritic, massive feldspathic, not ophitic.

Seam of fluccan at d 7. 148. Slide fault.

63. *Conglomerate* d 7. 148 to 1527‴ 4.7

– – felsitic Calumet?

Another seam of fluccan. – – At the bottom very fine grained.

Melaphyre conglomerate d 7. 152′ 7″ to 166.0 13.3 18.0 (18)

– – is amygdaloid conglomerate of black scoria and red cement. Base below base of Johnson Creek conglomerate (128)

Amygdaloid d 7. 166-167.8 1.8 (1)

Fluccan at d 167′ 8″

There has evidently been a good deal of disturbance and sliding along this conglomerate, and the possibility that it is the same as one of those above repeated by faulting should not be overlooked.

64. Amygdaloid d 7. 167′ 8″ -172 and trap -232 64′ 4″ (63)

Amygdaloid much mineralized with some calcite; epidote vein carrying copper from 172-177; trap dark colored—at 199 ophite 2-3 mm.

65. Amygdaloid d 7. 232-237′ 5″

Fluccan at d 7. 237′ 5″

Trap d 7. 306 74 (72)

– – This trap is barely mottled.

66. Epidote vein, calcite and copper d 7. 306-312′ 7″

Amygdaloid with calcite – – well-marked – – d 7. 319′ 7″

Trap d 7. 343½ 37½ (36)

– – Notably ophitic 2 mm. at 330.

67. Amygdaloid d 7. 343′ 5″-345′ 5″

Epidote vein with copper -347′ 7″

Trap -354 10′ 7″ (10)

Amygdaloid d 7. 354-356

Trap -359 – – not a separate flow? – – 5?

68. Amygdaloid d 7. 359-366 and trap -407+ 44

Melaphyre conglomerate – – ? brecciated scoriaceous amygdaloid – – From d 7. 359′ 7″ to 361′ 7″ and from 363 to 366 also very hard and fine grained. Trap 366-407. End of typewritten records of holes by engineer. In the sections drawn this bed is entered as amygdaloid both in Win. d 7 & 8. It is hard to draw the line between brecciated amygdaloid and some conglomerates. This is especially true of the beds like the *Montreal lode* (Figs. 26 to 28) directly under the Houghton conglomerate. Correlating W. d 7. 354 and d 7. 356 with d 8. 62; d 7. 359 with d 8. 68; d 7. 366 with 74 we may infer that d 8.0 about corresponds to d 7. 294 (1773) feet below Win. 4. 585+ which gives a dip of about 66°.

Winona drill hole 8. 1265 A. T. 314 feet on the section from No. 7. Dip of hole 37°. Dip of strata, correlating d 8. 58 with d 7. 354 is 66° and this is confirmed by the dip of the sandstone. Correlating d 8. 605 with d 9. 88 it is 70°. Hence for thickness multiply by sin 105°=.966+ and for horizontal width by 1.03. Depth 649.6.

Surface deposits d 8. 0-50

– – Ophite 50-58, feldspathic faintly mottled.

67. Amygdaloid d 8. 58-62, with copper.

Trap d 8. 62-68

68. Amygdaloid d 8. 68-77. About 74 feet there appears to be some genuine *sediment*, indurated gray sandstone, etc., with datolite.
- – Feldspathic ophite.
Trap d 8. 77-196 136 132
- – At 110 coarse feldspathic trap, at 133 4-5 mm. but not conspicuously mottled. From 167 down it is more distinct and grows finer.
Epidote seam at 100 and a little quartz and copper between 144 and 156. - – This is apparently the flow at the bottom of 7 so that d 7. 366 =d 8. 74 about. There is the same couple of amygdaloids with a streak of trap between and signs of epidote and copper. Thus d 7. 354 = d 8. 58. Whether the seams just above should be grouped as gushes of this flow is not so clear.

69. Amygdaloid d 8. 196-208 and trap to 230 34 (33)
This bed is quite feldspathic.
Fluccan d 8. 230-232 2 (2)
Fluccans are generally a belt of red clay which seems to be the product of slipping and hydration on the overlying trap and they often occur just above conglomerates.

70. *Conglomerate* d 8. 232-282 50 (48)
The bottom 12 feet are sandstone. - – in fact it is mainly sandstone and marks beginning of numerous sediments, largely red sandstone, which must be correlated with conglomerates 12-9, the *Kearsarge* to Wolverine; in the traps there is also a difference. They show copper, are specked and not so markedly ophitic. - – The base of this is below

the base of conglomerate d 7. 166 (397)
Below the base of conglomerate d 3. 213=(825+1517+128+397)

- - - - (2867) ft.

Conglomerates d 3. 213 and d 8. 282 are about 3350 feet apart, thus the average dip we have assumed is 59°. This d 8. 231-236 is a conglomerate with much matrix. The bed is in general a sandstone, the bedding well marked with the dip 77° to the core.

71. Amygdaloid d 8. 282-287 and trap -438 156 (150)
With epidote and copper at d 8. 348-351, quartz and copper 370, distinctly an ophite—at 355 5 mm. From 281-283 is really an amygdaloid conglomerate.

72. Conglomerate and sandstone d 8. 438-450 12 (12)

Base of the above below base of d 8. 282 168 (163)
Base of the above below base of d 7. 166 (560)
- – The conglomerate has abundant matrix and small rounded pebbles. The red sandstones vary 13°-17° from being at right angles to the core.

73. Amygdaloid with epidote and copper d 8. 450-453—really quite good looking. Cf. the Calico lode at the Michigan mine.
Trap -467
Epidote seam with copper -473
Trap -476 26 (25)

74. Amygdaloid d 8. 476-480,—from 467 really.
and trap -482 6 (6)

75. Amygdaloid d 8. 482-486 and trap -492 10 (10)

76. Amygdaloid d 8. 492-494 and trap -496 4 (4)
Copper here.

77. Amygdaloid d 8. 496-505 and trap -508 12 (12)
At 503 specked amygdules.

78. Amygdaloid d 8. 508-513 and trap -516 8 (8)
At 510-512 amygdaloid conglomerate with gray sediment.

79. Amygdaloid d 8. 516-522 and trap -527 11 (11)
Copper in the amygdaloid sludge, also epidote.

80. Amygdaloid d 8. 527-532 and trap -538 11 (11)
Amygdaloid has epidote and copper, red at top, cold gray epidotic at bottom.

81. Amygdaloid d 8. 538-550
Trap 550-563 12 (12)

82. Sandstone d 8. 563-590, conglomerate -605, then sandstone again to 615, dip 10°-17° 62 (60)
There are fault seams nearly at right angles to the bedding.
The base of this belt, mainly of sandstone, is also found in Hole 9. 88 feet (321)
d 8. 232 to base of d 8. 615 333 (321)
From the base of d 8. 450 to base of d 8. 615=988 is 165 (158)
From the base of d 7. 166 to base of d 8. 615=988 is 700

83. Amygdaloid d 8. 615-625+ Sec. 9. 88+
The trap under is ophitic
8. 563 may be the Minnesota conglomerate, and then 8. 232 would be the National sandstone. There is a resemblance also to Conglomerate 8 and 6.
Bed 8. 432 would then be the Calico lode. Here it is distinctly a conglomerate.
An approximate correlation with the Kearsarge lode is strengthened by frequent signs of copper.

Winona drill hole 9. 1258 A. T. Dip of hole 37°. Dip of strata (correlating d 9. 88 with d 8. 615) 70.5°. Whence for true thickness multiply by sin 107.5° =.954, for horizontal breadth by sin 107½ ÷ sin 70.5°=1.01.

Surface deposits 55

82. Sandstone and conglomerate (12′) d 9.55-88, 33+
Dip of bedding 73°, mainly sandstone,—that conglomerate is subordinate is characteristic.
The same as d 8. 553-590. The base of the sandstone is epidotic.
Below the base of d 8. 282 (321)

83. Amygdaloid d 9. 88-92 and trap -144, 56 (53)
At d 9. 116 epidote seam. The trap is very feldspathic or epidotized. (21)

84. Sandstone d 9. 144-166, 22
- – red, alternating, fine red mud bands and coarser. Dip of 73° to core well marked. (72)
Below d 9. 88 76

85. Amygdaloid d 9. 166-175 and trap -182, 16 (15)
Trap, epidotic, probably an alteration seam in the amygdaloid.

86. Amygdaloid d 9. 182-184 and trap to 195, 13 (12)

87. Sandstone and conglomerate d 9. 194′ 9″-217, 22 (21)
Last two feet amygdaloidal conglomerate, the rest the same red shale and sandstone as above.

Base of d 9. 217 below base of d 9. 88, 129 (123)

Base of d 9. 217 below base of d 8. 282 (444)

Base of d 9. 217 below top of d 8. 438-450 (12) + (165) + (123) =(309)

Discussion of Correlations.

These 310 feet are occupied by small flows and amygdaloids with some signs of copper and heavy sandstones, on the whole weak beds, and this d 9. 217 is the last sedimentary bed above the Winona lode. For nearly 2000 feet there appears to be no marked sediment. This should be an easily identified horizon. Wyandotte Holes 2 and 1 are evidently below it.

The predominance of sandstone rather than conglomerate at this level is also common at the horizon of the Wolverine sandstone, with which accordingly I am inclined to identify it. That also is underlain by a broad belt of traps with no important sediment.

The Wolverine is Marvine's No. 9. Numbering back (omitting melaphyre conglomerates) would make

No. 18=d 3. 203

No. 17=d 4. 581+ 60, which we have already correlated with No. 16 or 17.

No. 16=absent or exposed in the trenching section? 147 feet below d 4. 581 Cf. also d 5. 208.

No. 15=d 6. 452+ 74 (74)

No. 14=d 7. 148 to 166 (18)

No. 13=d 8. 232 to 282 (48) with fault slides and copper above and below.

No. 12=d 8. 438 to 450 (12)

No. 11=d 8. 553 to 615=9.55-88=(60) sandstone

No. 10=d 9. 144 to 166= (21)

This is too rigid a correlation with Marvine's numbers. It has been shown by Hubbard that the Kearsarge conglomerate probably covers 10, 11 and 12. Again there is a bed of ash or "jasper" above the Greenstone,—the Mesnard epidote. So that I am inclined to think that here a more probable correlation is to group the last three sandy beds as divergent splits of the Wolverine and correlate the *Allouez* as absent (but cf. d 5. 208) or present in the trench of Section A, just S. of the outcropping ridge which would then be the Greenstone.

- (832) feet interval.

Houghton conglomerate d 6. 452+ (74) - - - - - - - Marvine's No. 14.

- (128) feet interval.

Calumet conglomerate d 7. 148-166 (18) - - - - Marvine's No. 13.

- (397+321) feet interval.

Kearsarge conglomerate, and intercalated traps d 8. 232-450

Marvine's No. 10, 11 and 12.

(Cf. Houghton section)

Wolverine sandstone and intercalated trap d 9. 55-217 Marvine's No. 9 - - -

From d 9. 217 up to d 3. 213 is (123+321+2739) 3183 feet

From the Wolverine sandstone at Calumet to T. 5 b 12 is (3150 to C & H+972+880+180+40) say 5200 feet.

At the Arcadian the Wolverine sandstone is about 2835 feet below the Allouez and 3595 below the beginning of the section which is in the Ashbed series, about 251 feet above the Quincy lode and so 1300 feet below T. 5 b 12. This indicates a continuance toward the southwest if our correlations are correct of the diminution of the series which Marvine found. From d 9. 217 to the next marked conglomerate, the Winona which would then be No. 8 we find a thickness of about (1583'). At the Arcadian from No. 9 to No. 8 is (3015'), showing a thinning in something like the same ratio.

From the Wolverine to the Allouez (2835) would at the same rate of thinning bring the Allouez 1420 feet above d 9. 217. It is (2412) feet above d 9. 217 to the base of the conglomerate d 4. 581, but 963 feet below that (at d 5. 440 or 1447 feet above the Wolverine at d 9. 217) is the base of the first ophite noted by such as Mason, a bed 178 feet thick which may well pass for the Greenstone, or a bed immediately below like the Mandan ophite for the whole Hole 5 seems to belong in the Ophite or Central mine group. - - -

88. Amygdaloid d 9. 217-235 and trap -246' 29 (28)
- - not a contact.
Epidotic amygdaloid d 9. 246-250 and trap with red specks -273 27 (26)

89 and 90. Amygdaloid conglomerate d 9. 273-303 and trap -413 140 (139)
- - This amygdaloid conglomerate is like the Houghton conglomerate and the beds under it.
Epidotic at d 9. 303, 306, and 316 feet, and at 332 copper in epidote.

91. Amygdaloid d 9. 413-422 brecciated and trap -435 22 (21)
Copper in amygdaloid. - - The trap is fine grained glomeroporphyritic, not at all an ophite.

92. Amygdaloid d 9. 435-443 and trap -448, 13 (12)
Epidotic amygdaloid.

93. Amygdaloid d 9. 448-455 and trap -463, 15 (14)
Epidote, quartz and copper in amygdaloid.

94. Amygdaloid d 9. 463-473 and trap -488, 25 (24)
Epidote, quartz and calcite in amygdaloid - - trap a fine grained melaphyre.

95. Amygdaloid d 9. 488-500 and trap -520, 32 (30)
Epidote, quartz, calcite and copper in amygdaloid.

96. Amygdaloid d 9. 520-525 and trap -634, 114 (107)
Epidote and calcite in amygdaloid - - the trap is coarse feldspathic with chloritic spots.

From base of d 9. 217 (392)

Amygdaloid d 9. 634-648 and trap to 552′ 3″ ?

This amygdaloid seems to be really an amygdaloid conglomerate; the trap below is brecciated. This may probably be correlated with the top of d 10 and d 9. 648 may about correspond to d 10. 118, which would give a dip of 67.5°. But this is on the base of the amygdaloid rather than the top which is not so exact a correlation.

Winona drill hole 10. 1258 A. T. Dip of strata 72° 40′ to 67.5°, i. e., about 70°

as on the Winona lode. Dip of hole 37°. For true thickness multiply by sin 109° 40′=.947, for horizontal width by (sin 109° 40′ ÷ sin 72° 40′)=1.07.

Surface deposits 72

– – fine grained, not ophitic trap to 102, then brecciated -105 then fine grained greenish.

97. Amygdaloid d 10. 72-118 and trap -218, 146+
at d 123 and 125 epidote.
Correlating d 10. 72 with d 9. 634 we get a dip of 72° 40′
better d 10. 102 with d 9. 644
by 170½ faintly mottled; at about 218 a finer glomeroporphyritic base.
(146)

98. Amygdaloid d 10. 218-244 and trap -428, 210 (199)
Epidotic at d 10. 222-3 and at the base also cold gray 238 and dioritic at 395 – – (doleritic) at 325-330 amygdaloid streak, at 357-378 coarse faint mottling, a feldspathic ophite.

99. Amygdaloid d 10. 428-466 and trap -472, 44 (42)
– – A. 428-433 poor.

100. Amygdaloid d 10. 472-484 and trap 636′ 7″ – – at 489 doleritic and coarse augite barely visible, 5 mm., at 454 8 mm., at 615 4-5 mm., showing that it must continue some distance.

A cross-cut N. from the Winona shows also a big ophite as far as it goes, 114 feet horizontally, showing that this last bed is one continuous big ophite. The hanging wall of the Winona lode would according to scale have been met in 163 feet more at d 10. 800[1], i. e., the thickness would be (310)

Below d 9. 217 (698)+(392) (1090)

The Winona lode hanging is a slide fault, and is well marked by 6 inches of clay fluccan. Top of Winona lode below base of d 9. 217 about (1090)

The Winona lode varies from 30 to 60 feet wide, is say 32 feet thick and has a sharp well-marked hanging, but the foot is hard with bunches of trap in it. The dip is 70°. Its elevation is 1374 feet 8 in. A. T.

Winona lode to d 9. 217 = 1090

——— Compare these ratios with

Arcadian lode to Wolverine ss 2450
7.166-9.217=841

Calumet congl.-Wolverine ss at Arc.=1735.

The Winona is probably the Arcadian Isle Royale lode, and the traps of this part of the section have diminished going southwest. It is probable that there is not so much diminution in the upper part[2] of the section as the beginning of the Arcadian section appears to be not so very far from the horizon of the Winona d 4. 581.

– – Since no drill core section is given from the Winona lode for some distance down we will supplement from records elsewhere.

From the Elm River cross-cut we have:

101. Winona amygdaloid 23 and trap 43, 66 (62)

102. Amygdaloid 11, and trap 40 51 (49)

[1]By the grain one would, however, infer a thickness of not over 218.′

[2]In fact if, as I believe, the Chippewa felsite of the Porcupine Mts. is a member of the Ashbed group, there will be an actual thickening.

103. Amygdaloid 18, and trap 87 105 (99)

104. Amygdaloid 19, and trap 90 109 (103)

105. Conglomerate which at Elm River was 205 (194) is exposed by trenching on the Winona for a width of 140 feet about 384 feet in horizontal width below the Winona lode. The elevation of the trench has not been exactly determined, but it has probably about a thickness of (180)

(493)

Base below top of Winona lode about (1583)

Base below top of d 9. 217 lode about

This is (3015) feet at the Arcadian, and the top of this bed marks a lower era of sedimentation, the culmination of volcanic activity apparently lying above, between this and the Greenstone.

This section is continued at Elm River as follows:

Amygdaloid (10) and trap (35) (42.5)
Amygdaloid (24) and trap (115) (131.5)
an ophite with a scoriaceous top
Amygdaloid on which drifting was done (23) and (trap) 45 (63)
Amygdaloid (17) and trap (79) (91)
Amygdaloid (4) and trap (80) (79)
Amygdaloid on which they sank (11) and trap (40) (47)
Conglomerate (6?) (118)

(572)

At the Winona, trench J gives: (105)

106. Trap 112 feet wide (70)

107. Amygdaloid 10 and trap in trench I 74 ft. (13)

108. Conglomerate (7?)
This does not appear in K.

109. Trap in trench K not less than (165)

(353)

110. Conglomerate exposed directly beneath the trenches and in pits near drill hole 13, from 384 feet horizontally from the Winona for 140 feet breadth and more. Perhaps also the conglomerate in No. 13 down to Win. d 13. (252)

62. Omitting it (605)

Thus the base is below Conglomerate 8

This conglomerate on the whole I think should be correlated with Marvine's (6) which is (815) feet below (8) at the Arcadian, (722) at the Atlantic section (16).

The records of Holes 11, 12 and 13 are largely from Capt. Peterson's book and the drawn cross-section as many of the boxes of samples were badly decayed.

Tests of some of the mine waters of the Winona mine are given in Chapter VII.

Sp. 20359 is a specimen of a datolite nodule from the Winona mine. A section under the microscope shows quartz crystals which themselves contain crystals of copper and cavities with fluid and bubbles. The little crystals of copper tend to occur in lines running through the quartz and extending out over the larger masses which are crowded between the quartz. Datolite and copper together separate areas of quartz which extinguish together. The quartz is clearly older than and idiom-

orphic against the datolite and there is a hexagonal basal section of quartz imbedded in the aggregate of datolite and reddened with copper inclusions and separated from the datolite by a line of copper. Yellow epidote crystals are sharply older than the datolite and also idiomorphic against the quartz. The epidote is, then, the oldest mineral formed, the datolite the youngest, while the quartz and copper were precipitated at more nearly the same time, though the copper certainly formed later and tended to replace the quartz. It is possible that this might account for all the copper, though I hardly think it.

Winona drill hole 13. 1373 feet A. T. 515 feet horizontally above Hole 11 and 80 feet vertically, 1135 (1066) feet from the hanging of the Winona Dip 36°. Suppose the dip of the strata to be 70° for true thickness multiply by .961.

Begins, it is said, just under Conglomerate (6).

Surface (standpipe) 0-34

110. Amygdaloid conglomerate d 13. 34-62 28[1] (27)

Base below the base of No. 8 (1066+59-493) (632)
below the top of the Winona lode (1125)
Cf. Elm River d 3. 302+ and Elm River d 4. 258+

111. Amygdaloid vein d 13. 62-67 and trap -102, trap -150′ 6″ (cf. E 4 b 3)
– – Trap is a well-marked ophite, 2-3 mm. at 75; 3-4 at 95; finer at 112.

112. Vein trap d 13. 150′ 6″ to 190′ 6″, trap -203, -264, 202 (192)

113. Amygdaloid d 13. 264-265-277, and trap -323-370+-108 (104+)
Cf. E 5 b 1 or 2 and E 4 b 4 say (110)

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An exposure in a trench of epidotic amygdaloid 370 ft. horizontally and 30′ vertically lower is nearly reached, which implies a dip of 68¾°.

– – Amygdaloid and almost conglomerate at 169; epidote to 184 f. g. trap to 201 gradually growing coarser to 226, 4 mm. and then finer, 2 mm. to 250. The amygdaloid then well-marked, ophite 3 mm. at 302 and at 343 at 364 1 mm. or so.

114. The section from the bottom of 13 to the top of 11 is supposed to have been sufficiently exposed by trenching, being one heavy bed of ophite with 8 feet of epidotic amygdaloid on top, its foot extending down to Hole 11. 99. It is laid open in trenches C, A, B.

The large ophites at this horizon are also found in E d 5.

Winona drill hole 11. 1295 A. T. 515 feet from Hole 13 and 80 feet lower. Consequently if the strata dip 70° the top of d 11 would have to correspond to d 13, 532 or (452) feet below the amygdaloid conglomerate. Dip 36°. Whence for dip of strata of 70° to get the thickness multiply by .916.

There is a very considerable distance along the strike between 11 and 13 and consequent chance of error owing to veering of the strike or cross-faults between.

Surface (standpipe) d 11. 0-35′ 5″

[1]This may be counted as the base of (6) or as a scoriaceous amygdaloid with the underlying.

114. Trap d 11. 35-89, mottled to 96′ 7″, fine grained -99 (243)
Amygdaloid d 11. 99-101 (2) ?
This is probably the base of the big ophite exposed in trenching which would be below 13. 63.

115. Conglomerate d 11. 101-133 and sandstone -168, 67 (64)
Dip varies from core 70° to 72° indicating a dip of 72° to 74°.
Base of d 11. 168 below base of d 13. 62 (613)

Below base of Winona congl. (1245)

Cf. Elm River d 4. 51-258. Is this Conglomerate 5. It is largely and mainly sandstone.

116. Amygdaloid d 11. 168-178 or 182 and trap -183. 15 (14)
Brown

117. Amygdaloid conglomerate d 11. 183-198′ 9″ and trap -235′ 4″, and to -274 91 (88)
Vein brown. An ophite. Plain mottling at 230 3-4 mm.

118. Amygdaloid d 11. 274-286 and 305′ 9″ and trap -342 (?mottled) -396, trap -457, epidotic -460, 186 (178)
Well-marked up to 3 mm. at 320, at 388 7 mm., at 442 1-2 mm.
Vein copper cores and washings. An ophite.

119. Conglemerate d 11. 460-536, amygdaloid conglomerate 544-546, hard gray sandstone -544 (80)
Some copper noted near top of conglomerate. 480-482 sandstone also at 518 and 535 feet. The conglomerate has bands of red sandstone in it. Dip about 70° against hole. Is this Conglomerate 4?
Base below base of d 11. 168 (360)

Base of Winona (1605)

120. Amygdaloid d 11. 544-546 and trap -555 11 (11)
The trap is soft.

121. Amygdaloid vein d 11. 555-599, soft trap with copper -602 and trap to the end 606+ 51+
This is probably the ophite at the top of No. 12. The box has a lot of other amygdaloids, conglomerates, etc., which is probably from some other hole.

The combination of sediments and ophites reminds one of the Atlantic cross-cut and the base of the Arcadian section, and is very different from what we find above Conglomerate 8.

Winona drill hole 12. 1265 feet A. T. It is 546 feet horizontally and 30′ vertically lower than No. 11, i. e., the top is equivalent to d 11. 545. It is 364 feet more to the S. E. corner of the Winona property. Dip of hole 36°. Capt. Peterson's record is given,—it varies but slightly from Mason's cross-section.

Surface, standpipe 50, casing 55. – – Begins in an ophite 2-3 mm. – –

121. Ophite 70′ 2″, trap -71′ 9″ veins -75, trap -89′ 9″, vein is hard with epidote, -116′ 5″ trap -135′ 3″ trap.
–138′ 4″ hard green epidote. – – Amygdaloid.
–155 trap. – – Mason classes 69-72 and 93-101 as amygdaloid. The bottom is equivalent to d 11. 700 and the full thickness is d 11. 700-555 (140)

Below d 11. 168 (510)

122. Ophite; amygdaloid d 12. 155-171 – – a gray-green amygdaloid conglomerate, trap -179, -223′ 5″
-253, 98 – – an ophite with mottles 4 mm. at 221.

123. Ophite; amygdaloid 12. 253-261 – – conglomerate for a foot or two; red trap with quartz -264, trap -272, with quartz to 274, trap -286-322, – – all these ophite 69 (66)

124. Amygdaloid with calcite – – red and white, well-marked, d 12. 322-329-355′ 4″ – – at 352 4 mm. ophites – – at 341 with lumps in relief, at 360 ophite, at 370 7 mm., at 410 2-3. – – trap -367′ 6″, green with copper -370′ 1″ trap -440″ 3″ 118 (114)

125. Amygdaloid d 12. 440′ 3″-447′ 10″, sort of vein trap -459 19 (18)

126. Amygdaloid vein d 12. 459-484, trap -486′ 8″ – – really indurated sandstone to 485, then amygdaloid, possibly Conglomerate 3.

127. Amygdaloid vein -495, trap -500, vein trap with some copper to 502 feet, trap -553-573, 114 – – fine grained, not ophitic. (110)
– – Amygdaloid conglomerate.

128. Amygdaloid vein 573-601′ 6″, soft trap -609, 36 (35)
– – with sediment.

129. Amygdaloid vein 609-621, trap -626′ 11″, the *end* 18 (17)

below d 11. 544 (equivalent to d 11. 1172) (602)

Below d 11. 544 in Hole 12 we apparently pass into the horizon of the Elm River Holes 5 and 6 while 1, 3 and 4 and the cross-cut are as evidently above. The base of the section can not be far from the Baltic lode and conglomerate (3).

Note d 12. 367-502, etc.

§ 23. WINONA TO LAKE. (Pl. XIII.)

The next property to the Winona, jointly managed and operated with it, is the King Philip. The Winona lode, which we correlate with the Isle Royale-Arcadian has been continuously followed between them. This brings us on to Plate XIII, the region of the Lake mine in which drilling has been so continuous that though the map was prepared for the report for 1907 and indeed a special edition issued, it was not up to date by the time that report was written and is not now. It will be noticed that above the Winona conglomerate 8 there is (1,400 feet) over a quarter of a mile up to Winona d 9. 217 in which are no conglomerates and that (above and) below they are abundant so that counting to 13.62 we have (730) feet largely sedimentary. Even below that in Winona d 11 are conglomerates. With that in mind there are outcrops enough to trace the horizon pretty safely down to Sec. 15, T. 51 N., R. 37 W. It must be remembered that while one may curve the formations along gracefully through Plates XI, XII, and XIII, the curves only indicate our ignorance in drift covered country; that there are probably straight bits with breaks at intervals, which little by little the diamond drills will expose. Opposite Section 15 in the upper part

of the formation comes in a felsite, a red, fine grained acid rock found by Hubbard and Fuller, which may be continuous to the Wisconsin line, and is an important horizon for correlation. It appears to be the felsite of the Porcupines or as it is called in Gordon's report on Black River, the Chippewa felsite. The early geologists called it jasper, red trap (a fitting name), etc., and the flow lines were taken for relics of sedimentary banding. I have supposed it to belong in the horizon of the Ashbed group.[1]

The drilling now going on also[2] enables us to bring the horizon of conglomerates south of the Evergreen Bluffs back so far as the middle of Section 29, T. 51 N., R. 37 W., and thus helps in correlation with those south of the Winona and King Philip. The position of this felsite on Section 17 associated with conglomerates, and only about half a mile below the course of the Great Copper Harbor conglomerate on Sections 4 and 33 of the township N. and nearly two miles above Conglomerates 8 to 6, makes it clear that it corresponds to the felsite on Section 19 of the same township, and to Holes 1, 2 and 3 or higher in the Winona cross-section. A little beyond, in Rockland, felsite comes about 3,000 feet below the Great Conglomerate and just at the base of a series of "Ashbed"-like rocks, exposed along the railroad in Section 8, T. 50 N., R. 39 W. and above a series of ophites. This would then bring it in the horizon of the "Mesnard" which appears to be a bed of fine ash such as would be the wide spread equivalent of a volcanic eruption of acid rocks. This is my correlation but would imply a correlation with Winona just above Winona drill hole 5. But this would make the distance from the felsite to the conglomerates south of the Evergreen Bluffs on the Lake property too great. Moreover, if these conglomerates are 8 and 6 and the National sandstone and Minnesota conglomerate are normally above them, then the Kearsarge lode should be developed in the Michigan and similar mines. There is no labradorite porphyrite associated and the correlation of the "Calico" lode and the Kearsarge lode has not been suggested by any one else.

We may assume that the dips opposite the Indiana are very flat. They certainly are flatter than at the Winona, but even a dip of 36° (that at the felsite) all the way would convert 9,300 feet (which is the least we can assume the distance across the strike from the felsite on Section 8, T. 51 N., R. 37 to the conglomerate on Section

[1]The recent discovery of felsite way down in the Indiana, opens a possibility that it is an intrusive neck or feeder to this felsite, but I am inclined to believe that it is one of the lower series of felsites, like that of Mt. Houghton, associated with Conglomerate 8. Our correlations would then be strengthened.

[2]News Bureau, March 12, 1910.