CHAPTER V.

DESCRIPTIVE CROSS-SECTIONS AT PORTAGE LAKE.

N.B.—The numbers refer to the *absolute* thickness of the beds in full feet, and the sequence is from older to younger.

Cross-section I.

THIS cross-section is taken, without re-measurement, from the sketch of the exploration-trenches made by the Isle Royale Mining Co., under the superintendence of Mr. Mabbs. These explorations were filled with dirt and water when visited by the members of the Survey.

THE EASTERN SANDSTONE unconformable with the trap series, and dipping gently to the East.

? **Amygdaloid**; soft.
14. **Amygdaloid**; hard.
97. **Conglomerate.**
329. **Covered** by swampy ground.
43. **Amygdaloid**; light-colored.
40. **Amygdaloid**; light-colored.
82. **Melaphyr**; dark and rough.
82. **Melaphyr**; dark and rough.
82. **Melaphyr**; dark and rough.
82. **Melaphyr**; gray.
82. **Melaphyr**; dark and bluish; carries some fine copper.
82. **Melaphyr**; dark and bluish; carries some fine copper.
82. **Melaphyr**; gray.
46. **Melaphyr**; red.
34. **Amygdaloid.**
81. **Melaphyr**; red.
20. **Amygdaloid.**
64. **Melaphyr**; red.
64. **Amygdaloid**; red.
94. **Melaphyr**; black.
42. **Melaphyr**; red.
41. **Amygdaloid**; red.
83. **Melaphyr**; gray.
56. **Conglomerate.**

Cross-section II.

(Determined by triangulation and levelling by the Geological Survey, except where otherwise accredited.)

Hanging-wall of first conglomerate east of the "Mabbs' vein," determined by the Geological Survey.

21. "**Amygdaloid.**" From Mr. Mabbs' map of the Isle Royale Co.'s explorations.
77. "**Melaphyr**; gray." " " " "
82. "**Melaphyr**; dark." " " " "
82. "**Melaphyr.**" " " " "
2–6. "**Mabbs' vein.**" On the foot-wall barrel and mass copper in quartz and calcite. One mass weighed 2,200 lbs. The rest of the vein is stamp-work. Position determined by the Geological Survey.
62. "**Melaphyr.**"
111. "**Melaphyr;**" soft, jointed. From Mr. Mabbs' map of the Isle Royale Co.'s explorations.
147. "**Covered.**" From Mr. Mabbs' map of the Isle Royale Co.'s explorations.
20. "**Amygdaloid**; epidotic." From Mr. Mabbs' map of the Isle Royale Co.'s explorations.
31. "**Melaphyr**; dark, rough." From Mr. Mabbs' map of the Isle Royale Co.'s explorations.
39. "**Amygdaloid.**" From Mr. Mabbs' map of the Isle Royale Co.'s explorations.
148. "**Melaphyr**; dark." Float copper on the surface. From Mr. Mabbs' map of the Isle Royale Co.'s explorations.
148. "**Melaphyr**; bluish." From Mr. Mabbs' map of the Isle Royale Co.'s explorations.
152. "**Melaphyr and Amygdaloid.**" Float copper on the surface. From Mr. Mabbs' map of the Isle Royale Co.'s explorations.
23. "**Melaphyr**; dark and rough." From Mr. Mabbs' map of the Isle Royale Co.'s explorations.
17. "**Amygdaloid.**" From Mr. Mabbs' map of the Isle Royale Co.'s explorations.
12. Conglomerate. Position determined by the Geological Survey.
53. "**Melaphyr**; bluish." From Mr. Mabbs' map of the Isle Royale Co.'s explorations.
"**New Vein.**" Fissure vein of quartz, prehnite, calcite, copper. Position determined by the Geological Survey.
47. "**Melaphyr**; red, fine-grained." From Mr. Mabbs' map of the Isle Royale Co.'s explorations.
37. "**Amygdaloid.**" From Mr. Mabbs' map of the Isle Royale Co.'s explorations.
26. "**Melaphyr**; dark." " " " "
358. "**Covered.**" " " " "
1½. "Conglomerate." According to Mr. J. H. Foster, this bed is only ½ an inch thick on the north part of the Shelden and Columbian location.
Covered.

40. + **Melaphyr.**

Covered.

30. + **Melaphyr**; dark-green, mottled with purple; fine-grained to compact; slightly shimmering.

713. **Covered.**

4. **Amygdaloid**; chocolate-colored, with amygdules of delessite, of quartz, epidote, and prehnite.

16. **Melaphyr**; greenish-brown, fine-grained; contains grains of delessite. Towards the top it contains abundant amygdules of a light-green mineral resembling chrysoprase and passes into

4. **Amygdaloidal Melaphyr**; filled with amygdules of radiating prehnite. This rock passes rather abruptly into

1. **Amygdaloid**; with a dark-brown matrix. (This bed is very persistent in its character, being visible east of the Isle Royale copper-bearing bed on the "Shelden and Columbian," "Grand Portage," "Isle Royale," and "Huron" properties.)

69. **Melaphyr**; brown; fine-grained. Above the middle of the bed the trap contains round masses somewhat resembling boulders 4–8 inches in diameter, which are very amygdaloidal and have the cavities filled with prehnite. These masses increase in number towards the top of the bed. They are much harder than the melaphyr, and stand out an inch or more above the glaciated surface of the rock. Glacial furrows are sometimes forked at these harder points and continue separately beyond them. This bed passes into

15–50. **Amygdaloid**; ("Isle Royale lode;") a mixed green and brown amygdaloid; in places very epidotic with extensive segregations of quartz, calcite, prehnite, and is then richest in copper; in others, brown, with amygdules and seams of laumontite, calcite, etc., and is then poorest in copper.

18. **Melaphyr**; green; medium-grained and crystalline; contains much magnetite and a black, infusible mineral, and near the foot-wall some specks of copper. The weathered surface is dirty white and black, and exhibits magnetite and the infusible black mineral. This plane of contact is in places marked by a thin seam of epidote, which often branches out in irregular seams, and branches into the *underlying* rock.

81. **Melaphyr**; brown-green; fine-grained, contains abundant small flakes of red mica. The weathered surface is fine-grained, gray and rusty-brown from the mica.

277. **Covered.**

Fissure-vein; 6 inches to several feet; quartz and ankerite; carries considerable chalcocite and bornite. It has been struck in the "Shelden and Columbian" mine between the "Bloodgood" and "Skip"-shafts, and on both the "Grand Portage" and "Huron" properties.

38. **Melaphyr**; passing into

12. **Amygdaloid**; with amygdules of prehnite and quartz, and containing some copper.

31. **Melaphyr**; hard; fine-grained.

128. **Covered.**

? **Melaphyr**; coarse-grained and crystalline; resembles the coarse-grained crystalline melaphyr on the Dacotah location. See Cross-section IX.

Cross-section II. a.

80 + **Conglomerate**; either not present in II. or not observed by Mr. Mabbs.

Cross-section II. b.

(Determined by triangulation and levelling by the Geological Survey, except where otherwise accredited.)

Along the exploration, trenches on the Huron (formerly the Howard) property.

? **Melaphyr**; brown and green; fine-grained; the weathered surface is mottled gray green and dark red.

97. **Covered.**

? **Amygdaloid?** a brown and gray fine-grained rock, which, in places, has brown, porous portions surrounded by a yellow sandy material.

Covered.

Fissure-vein; prehnite and quartz.

47. **Melaphyr**; brown, hard, and compact, with scattered amygdules of delessite.

? **Amygdaloid?** a rock strongly resembling a conglomerate or breccia, of altered trap pebbles; the matrix contains prehnite and quartz.

216. **Covered.**

24. **Conglomerate**; in places the cement of this conglomerate is very hard, and filled with small round amygdules of calcite and laumontite. Sometimes these minerals have disappeared, and the cement then presents the appearance of a scoria. There is a thick flucan on the hanging-wall.

? **Melaphyr**; light green, with spots of dark-green delessite; soft; fine-grained.

Covered.

? **Amygdaloid**; green, compact, very hard and silicious matrix, with amygdules and segregations of quartz, epidote, and calcite; a pit was sunk on this bed.

157. **Covered.**

3.? **Conglomerate**; small pebbles of brown non-quartziferous porphyry lying in a fine-grained cement of very calcareous sandstone containing more or less epidote.

260. **Covered.**

24. **Conglomerate**; with a band of sandstone on the upper side.

255. **Covered.**

? **Amygdaloid**; ("Foster Mass vein.") ("Ancient Pit vein.")

85. **Covered.** From the notes of Mr. A. B. Wood.

5. **Amygdaloid.** From the notes of Mr. A. B. Wood.

85. **Covered.**

10. + **Conglomerate**; small pebbles of brown non-quartziferous porphyry, in a highly calcareous cement of comminuted porphyry; rich in magnetite. Carries some sheet-copper near the hanging-wall.

355. **Covered.**
7. **Amygdaloid;** light green, and filled with amygdules of quartz, chlorite, and some epidote.
150. **Covered.**
"Isle Royale" cupriferous bed.

Cross-section II. c.

(Determined by triangulation and levelling by the Geological Survey.)

(On the south part of the "Shelden and Columbian" location.)

? **Amygdaloid;** brown; soft; with irregular streaks of a compact brown material resembling hardened clay.
? **Melaphyr;** hard; fine-grained.
1. **Fissure-vein;** quartz, prehnite, and calcite.
35. **Melaphyr and Covered.**
? **Conglomerate?** grayish green rock with occasional pebbles.

Cross-section II. d.

(Determined by triangulation and levelling by the Geological Survey.)

? **Conglomerate.**

Cross-section II. e.

(Determined by triangulation and levelling by the Geological Survey.)

? **Melaphyr;** dark brownish green; fine-grained; contains considerable magnetite and fuses not very easily to a black and very magnetic globule. Towards the top of the bed it contains quartz amygdules, and then without any sharp line of separation becomes mixed with, and passes into
3–6. **Amygdaloid;** yellowish green, matrix of epidot and quartz, with quartz amygdules; this passes rather abruptly into
1. **Amygdaloid;** dark-brown, semi-vitreous matrix, with amygdules of quartz and chlorite, and seams of calcite; the weathered surface is green and brown; contains some copper.
50. **Covered.**
? **Melaphyr;** red and green; soft; contains little or no magnetite, scattered amygdules of calcite, also of quartz, sometimes carrying copper; fuses to black magnetic enamel. This bed frequently contains large and small masses of quartz and epidote, having amygdules of quartz.
? **Amygdaloid;** light green to bluish and brown green; silicious matrix, containing amygdules of quartz, with chlorite and seams of brown jasper.

Cross-section II. f.

(Determined by triangulation and levelling by the Geological Survey.)

? **Amygdaloid;** the lower half of the bed is greenish brown, hard, with amygdules of calcite, prehnite, and green-earth. The upper half is dark brown, and filled with minute amygdules of laumontite and prehnite.
58. **Covered.**
9. **Amygdaloid;** purple brown, compact and hard, with abundant amygdules of quartz; the matrix fuses with difficulty to a magnetic glass.
Covered.
? **Melaphyr;** mottled light and dark green; fine-grained.
Covered.
? **Melaphyr;** brown; very fine-grained, with some spots and seams of delessite, and occasional small amygdules of calcite.

Cross-section II. g.

(Determined by triangulation and levelling by the Geological Survey.)

? **Amygdaloid;** green; very fine-grained, and not very hard rock, fusible on the edges to black magnetic glass; probably a silicious chloritic rock.
Covered.
Amygdaloid; of varying character; in places brownish green, compact and hard, quartz epidote rock, with small amygdules of calcite; other portions are dark brown and soft, with amygdules of calcite, or calcite and green-earth.
This bed shows stains of carbonate of copper.
Covered.
Melaphyr; dark green, semi-crystalline, and slightly shimmering; contains considerable magnetite, and weathers rusty gray.
Covered.
Melaphyr; dark, almost black; compact and slightly shimmering, and tolerably soft. Near the "Capen vein" it is spotted with foliated delessite, and carries minute particles of copper; small pieces of the rock adhere to the magnet.
"Capen vein" (apparently a fissure vein). Seams of calcite, prehnite, laumontite, and fibrous chlorite, with copper in flakes and sheets. Several tons of copper were extracted from this pit.

Cross-section II. h.

(Determined by triangulation and levelling by the Geological Survey.)

On the north part of the "Shelden and Columbian" location.

? **Melaphyr;** dark green; hard, semi-crystalline, compact, near the "Capen vein" it becomes highly chloritic, and the joints are covered with smooth asbestiform delessite.

½—3. **"Capen vein"** (see description in Cross-section II. g). An adit was driven here and some sheet-copper found.

102. **Covered.**

17. + **"Ancient Pit" Amygdaloid.** (So called from the fact that a number of ancient workings were discovered on the "back" of this bed.) Portions of this bed are almost a homogeneous melaphyr, but the greater part bears a striking resemblance to a breccia, owing to the segregation of quartz, prehnite, and calcite in countless fine cracks, enclosing irregular fragments of the rock from the size of a pea to several inches in diameter. In some places the rock becomes epidotic, retaining the same structure and segregations. Some copper was found here.

168. **Covered.**

12. **Conglomerate.** (1st conglomerate east of the Isle Royale copper-bearing bed.) Some small pieces of copper were taken out of this bed.

Cross-section II. i.

(Determined by triangulation and levelling by the Geological Survey.)

"Ancient Pit" Amygdaloid; same character as in II. h.

Cross-section II. j.

(Determined by triangulation and levelling by the Geological Survey.)

? **Melaphyr.**

25. **Covered.**

? **Amygdaloidal Melaphyr;** dark green; hard; containing amygdules of prehnite impregnated with native copper.

Cross-section II. k.

(Determined by triangulation and levelling by the Geological Survey.)

14. **Amygdaloid;** bed irregularly occupied by bright green epidotic rock, abounding in grains of clear quartz, and a dark brown amygdaloid with amygdules of epidote and calcite, and of porous delessite or green-earth.

20. **Melaphyr;** green brown, fine-grained; towards the top it becomes

8. **Amygdaloidal Melaphyr;** with amygdules of delessite, and of delessite and green and rose-colored prehnite.

7. **Amygdaloid;** green brown, compact, with amygdules of quartz and chlorite, and larger amygdules and seams of green and rose-colored prehnite.

73. **Covered.**

Fissure-vein; direction north-west. Comby strings of quartz with calcite arsenurites of copper, chalcocite, and native copper.

12. **Covered.**

9. + **Amygdaloid;** this bed has been opened here by an adit, under the erroneous supposition that it forms the continuation of the Isle Royale copper-bearing bed, which really lies to the westward.

55. **Melaphyr;** brown, slightly mottled with dark green; fine-grained; it becomes green higher up and more distinctly crystalline, and near the top assumes abundant spots and grains of delessite.

5. **Amygdaloid** (probable continuation of the Isle Royale cupriferous bed); grayish green, compact, epidotic matrix, with semi-conchoidal fracture; filled with amygdules of prehnite. The upper portion of the bed, to the extent of 1 foot in thickness, is a well-defined band of dark brown amygdaloid with spike-shaped amygdules, standing at right angles to the plane of stratification, and filled with prehnite, which is frequently replaced by porous delessite.

20. **Melaphyr;** brown, fine-grained and hard; weathers dirty gray; towards the top it becomes

3. **Amygdaloidal Melaphyr;** with irregular grains of delessite, sometimes containing epidote, and amygdules of prehnite.

4. **Amygdaloid;** greenish gray, with amygdules of delessite, quartz, and laumontite. The upper portion of the bed is compact gray-green epidote, with tabular fracture filled with amygdules of quartz.

37. **Melaphyr;** passing into

6. **Amygdaloidal Melaphyr;** containing amygdules of prehnite. This passes into

1. **Amygdaloid;** brown, compact, with amygdules, and irregular masses of delessite, red feldspar, prehnite, quartz, and epidote. (Observed succession—1, delessite; 2, red feldspar; 3, quartz, epidote.)

9. **Melaphyr;** dark brown, fine-grained, weathers dirty brown gray.

20. **Melaphyr;** green brown, fine-grained, with many irregular grains of delessite, the weathered surface is brown white, pitted with rust-colored holes from the decomposition of the delessite grains. Towards the hanging-wall it becomes

7. **Amygdaloidal Melaphyr;** containing irregular small segregations of red feldspar (orthoclase ?), prehnite, and quartz. The feldspar contains casts of rhombohedrons of calcite.

3. **Amygdaloid.**

50. **Covered.**

Grand Portage Cupriferous Amygdaloid.

Cross-sections II. l; *II.* m; *II.* n.

(Determined by triangulation and levelling by the Geological Survey.)

Shafts on the Grand Portage Amygdaloid on the Shelden and Columbian, and Grand Portage locations.

Cross-section II. o.

(Determined by triangulation and levelling by the Geological Survey.)

? **Amygdaloidal Melaphyr;** dark, fine-grained matrix, with numerous amygdules of prehnite. Farther north and south this bed appears more amygdaloidal and somewhat cupriferous, and forms the so-called "True lode."

? **Melaphyr.**

Cross-section III.

(Determined by triangulation and levelling, etc., by the Geological Survey, except where otherwise accredited.)

? **Melaphyr.**
9. **Amygdaloid.**
8. **Amygdaloid;** with amygdules of prehnite.
8. **Amygdaloid;** (Frue "lode") bears copper.
10. **Melaphyr.**
11. **Amygdaloid;** green and hard, with amygdules of quartz.
12. **Melaphyr.**
8. **Amygdaloid;** green and hard, with amygdules of quartz.
10. †**Melaphyr.**
279. **Covered.**
? **Melaphyr.**
14. **Amygdaloidal Melaphyr;** purplish gray, fine-grained matrix, with uneven fracture, carrying grains of delessite, and large amygdules of prehnite; it contains bunches of epidote and on the hanging-wall a seam of epidote with amygdules of prehnite.
60. **Melaphyr;** gray green, hard, fine-grained, and indistinctly crystalline.
35. **Amygdaloidal Melaphyr;** gray green, and fine-grained; contains amygdules of prehnite. In some instances large amygdules of delessite show a tendency to the radiating structure of the prehnite, and in some cases the prehnite amygdules are entirely changed in the interior to delessite, the outer portion being partially intact. This bed contains many bunches of compact epidote, with amygdules of prehnite, and in the upper portion crystals of epidote are visible in the matrix.
40. **Melaphyr;** green, compact, with semi-conchoidal fracture; contains lamellæ of a red mica which resist the weathering.
Melaphyr Seam; indistinctly crystalline, containing prehnite in amygdules and impregnations.
32. **Melaphyr;** same as that below the seam.
15. **Melaphyr;** gray-green rock, with numerous red spots of mica; contains $\frac{1}{4}$ inch amygdules or grains of compact and radiating delessite. Near the hanging-wall it carries amygdules of prehnite and bunches of compact green rock, with amygdules of prehnite, epidote, and delessite. Still nearer the top it becomes
12. **Amygdaloidal Melaphyr,** with many small amygdules of prehnite.
37. **Melaphyr;** similar to the next underlying.
21. **Melaphyr;** dirty green, compact, and containing less red mica than the underlying varieties.
10. **Amygdaloidal Melaphyr;** green and hard, with amygdules of prehnite.
11. **Amygdaloid;** very hard epidotic matrix, with amygdules of prehnite and calcite.
129. **Covered.**
? **Amygdaloid.** (Position given by Mr. R. Shelden.)
79. **Covered.**

? **Amygdaloid.** (Position given by Mr. R. Shelden.)
17. **Covered.**
? **Amygdaloid,** bearing copper. (Position given by Mr. R. Shelden.)
Covered.

Cross-section III. a.

(Taken from notes furnished by Mr. A. B. Wood.)

Cross-section III. b.

(Determined by triangulation and levelling, etc., by the Geological Survey.)

32. **Amygdaloid.**
63. **Melaphyr;** gray brown, fine-grained and hard; contains scattering amygdules of delessite and much red mica.
24. **Melaphyr;** green, compact, speckled with red mica; contains some amygdules of prehnite.
Seam.
10. **Melaphyr.**
7. **Melaphyr;** same as the next underlying. Near the hanging-wall it carries abundant amygdules of prehnite.
? **Melaphyr.**
56. **Covered.**
? **Melaphyr;** green, compact and hard, with specks of red mica.
Melaphyr Seam; coarsely crystalline, greenish gray.
50. **Melaphyr;** same as next underlying the seam; weathers dirty gray; passes into
? **Amygdaloidal Melaphyr;** containing numerous small amygdules of delessite, and larger ones of prehnite, some of which last are partially changed into foliated and amorphous delessite.
10.* **Amygdaloid;** brown and green; contains a little copper.
? **Melaphyr.**

Cross-section III. c.

(From notes furnished by Mr. A. B. Wood.)

Cross-section IV.

(Determined by triangulation and levelling, etc., by the Geological Survey.)

? **Melaphyr;** gray green, hard, fine-grained, and speckled with ruby-red mica.
43. **Covered.**
Melaphyr Seam; coarse-grained and crystalline, and containing apparently feldspar, chlorite, hornblende or pyroxene, mica, and specular iron.
10. **Melaphyr;** green brown and fine-grained, with red mica and grains of delessite.
Epidote Seam.

12. **Melaphyr**; same as next underlying.
2. **Melaphyr Seam**; coarse-grained and crystalline.
8. **Melaphyr**; brown green, compact and hard, with some red mica, and weathering dirty white. Near the top it contains amygdules of prehnite and delessite.
Seam.
4. **Amygdaloid**; with epidotic matrix.
Seam.
Covered.

Cross-section V.

(Determined by triangulation and levelling, etc., by the Geological Survey.)

36. **Amygdaloid**; very epidotic, and containing ½ inch amygdules of prehnite.
36. **Jasper**; apparently stratified, and more or less epidotic. In places, highly siliceous, with amygdules of quartz; in others a soft brown amygdaloid.
? **Melaphyr**; gray green, passing into
Amygdaloidal Melaphyr; with amygdules of prehnite and of epidote.
190. **Covered.**
? **Melaphyr.**
233. **Covered.**
5. **Conglomerate.**
170. **Covered.**
? **Melaphyr**; brown, with amygdules of delessite.
6. **Conglomerate.**
24. **Melaphyr**; with much epidote.
9. **Conglomerate.**
115. +**Melaphyr**; fine-grained; brown, spotted green and red.
168. **Covered.**
Amygdaloidal Melaphyr.
? **Melaphyr**; fine-grained.
70. **Covered.**
60. **Amygdaloid**; the lower part of the bed is a confused mass of epidote-quartz rock and brown amygdaloid; while the upper and larger part of the bed is a brown amygdaloid, in which amygdaloidal masses are enveloped in a brown, hardened, clay-like material, resembling portions of the South Pewabic and Hancock beds.
133. **Melaphyr**; fine-grained.
1. **Seams** of coarsely crystalline melaphyr, containing crystals of green triclinic feldspar, delessite, and specular iron.
56. **Melaphyr.**
3. **Conglomerate**; contains rare pebbles of quartz porphyry, similar to that of the Calumet conglomerate; also traces of copper.
8. **Covered.**
10. **Amygdaloid**; green; contains segregations and amygdules of quartz, prehnite and calcite, and some copper.
114. **Covered.**

3. **Amygdaloid**; green; contains amygdules of prehnite, quartz, and calcite.
62. **Covered.**
10. ? **Amygdaloid**; ("Montezuma lode.") Brown and green siliceous matrix, with amygdules of prehnite, and quartz and some copper.
102. **Melaphyr** and **Covered.**
5. **Amygdaloid**; brown amygdaloidal matrix, with large and small irregular segregations of quartz with prehnite.
99. **Covered.**
62. **Amygdaloid**; the *lower* portion of the bed, for a thickness of several yards, is a green and more or less epidotic and siliceous amygdaloid; the *upper*, and much thicker portion of the beds, is a soft brown amygdaloid, containing amygdules of red laumontite, and irregular seams and spots of a soft white mineral (Kaolin?)—perhaps a decomposition product of a zeolite.
127. **Melaphyr.**
? **Amygdaloidal Melaphyr.**
60. **Covered.**
? **Melaphyr.**
60. **Covered.**
? **Melaphyr.**

Cross-section V. a.

(North ½ of Sect. 2, Town. 54, Range 34.)

(Taken in part from the notes of Mr. A. B. Wood, and in part by triangulation and levelling by the Geological Survey.)

Cross-section V. b.

(Determined by triangulation and levelling, etc., by the Geological Survey.)
Amygdaloid.

Cross-section V. c.

From notes furnished by Mr. R. Shelden.

Cross-section V. d.

(Determined by triangulation and levelling, etc., by the Geological Survey.)
Amygdaloid; epidotic.

Cross-section VI.

(Determined by triangulation and levelling, etc., by the Geological Survey.)

Along part of the road from Portage Lake to the Huron Stamp Mill.

? **Melaphyr**; hard.
44. **Amygdaloid**; the lower portion of the bed is epidotic and hard; the upper portion is a soft brown rock, abounding in laumontite, and containing patches of epidote and quartz.

37. **Melaphyr**; hard.
33. **Covered.**
28. **Melaphyr**; hard.
17. **Amygdaloid**; soft brown, and abounding in laumontite.
? **Melaphyr**; hard.

Cross-section VII.

(Determined by triangulation and levelling, etc., by the Geological Survey.)

Along the banks of Dacotah Creek.

? **Amygdaloid**; soft; brown, and abounding in laumontite.
35. **Melaphyr**; grayish brown; fine-grained; earthy fracture; soft; contains much red mica.
21. **Amygdaloid**; a very irregular mixture of bright-green epidotic rock, containing grains of quartz, with a soft chocolate-colored rock containing amygdules of delessite and calcite, and larger bunches of calcite with radiating crystals of leonhardite. The epidotic portions of the bed are impregnated with copper.
? **Melaphyr**; grayish brown; soft; fine-grained; contains much red mica.

Cross-section VIII.

Position indicated by the Hon. S. W. Hill.

1½–2 ft. **Conglomerate**; considered by Mr. Hill to be the "Houghton" conglomerate. The trench in which it was formerly exposed was filled with rubbish when visited by the Geological Survey. According to Mr. Hill, it was well filled with copper.

Cross-section IX.

(Determined by transit survey, chiefly underground, by the Geological Survey.)

? **Amygdaloid**; portions of the bed fine-grained, greenish-gray to bluish-green, siliceous matrix; very hard (strikes fire with steel), and filled with amygdules of white quartz, more rarely of calcite; portions of the bed consist of soft, chocolate-colored material, with amygdules of calcite and of green-earth. Struck in bottom of a shaft; width not seen.
? **Melaphyr**; soft; greenish brown; fine-grained with spots of delessite, and thin filmy seams of laumontite. Struck in the end of an adit. No walls seen.
120. **Concealed** on south side of Portage Lake.
11. **Amygdaloid**; fine-grained, soft green-brown matrix, with irregular amygdules of delessite and green-earth, and of delessite and quartz. The upper portion of the bed is chiefly green-brown amygdaloid, with compact siliceous matrix and amygdules of more or less crystalline quartz, of quartz and epidote, and of calcite. Forms the east end of the adit.

19. **Melaphyr**; green; fine-grained; somewhat crystalline; tolerably hard; contains minute acicular crystals of triclinic feldspar and much magnetite.
7. **Amygdaloid**; towards foot-wall, soft brown-green matrix with earthy fracture; contains amygdules of quartz coated with delessite, and of quartz and epidote. It carries fine copper. The upper portion of the bed has a compact, gray-green, and very siliceous matrix, with amygdules of quartz and of calcite.
76. **Melaphyr**; the lower portion of the bed is green and fine-grained, the upper portion contains seams of laumontite.
5. **Amygdaloid**; light green; soft, with earthy fracture; contains amygdules of quartz, of delessite, and of quartz and epidote.
6. **Amygdaloidal Melaphyr**; green brown, soft, with earthy fracture; contains spots of delessite and amygdules of green-earth and of laumontite.
8. **Amygdaloid**; soft, almost earthy, green rock in the lower part of the bed, with brown streaks; contains flakes of delessite. The upper portion is more amygdaloidal, with amygdules of quartz and epidote, and forms, in places, a very hard and compact brown and green rock, with semi-conchoidal fracture. Some copper was found in the bed, and some rich boulders of exactly similar rock, in driving the adit through the sand near by. It has been supposed to be the continuation of the Pewabic copper-bearing bed.
? **Melaphyr**; very disintegrated, and containing laumontite. Thickness not known.
106. **This ground** is said to have been cut in the next adit westward, but as this was driven below the lake level, and full of water, it was inaccessible to the Survey.
? **Melaphyr**; mottled, grayish green and dark green; contains abundant spots of delessite, and minute indistinct crystals of green feldspar. Forms the eastern end of the adit on the south side of the lake-shore road.
7. **Amygdaloid**; very hard, siliceous, compact matrix, with conchoidal fracture; brown, speckled with green; contains amygdules of quartz, of calcite, and of laumontite.
13. **Melaphyr**; soft, with considerable laumontite.
15. **Amygdaloid**; brown, shaded with green; very hard, compact, siliceous matrix, with conchoidal fracture; contains abundant amygdules of quartz, more rarely of green-earth, of calcite, or of epidote and quartz.
29. **Amygdaloidal Melaphyr**; green, fine-grained, semi-crystalline rock, mottled with dark green delessite, and containing minute crystals of green triclinic feldspar, and amygdules of quartz and delessite.
22. **Amygdaloid**; brown, semi-crystalline matrix, with earthy fracture, containing minute crystals of triclinic feldspar, and filled with irregular spots of dirty green chlorite, and amygdules of calcite and laumontite. The upper portion of the bed is siliceous and compact, with better defined amygdules of quartz and delessite, and of quartz and epidote, and in places is highly siliceous and contains seams of quartz and amygdules of quartz and of prehnite.
60*. **Melaphyr**; coarse-grained and crystalline; consists of light green triclinic feldspar, and black green delessite, in apparently nearly equal proportions. It contains considerable magnetite. It closely resembles a similar rock, west of the Pewabic copper-bearing bed, on the Quincy and St. Mary's locations.

122. **Not exposed** on the south side of Portage Lake, but very possibly the same crystalline melaphyr, since this bed is between 200 and 300 feet thick on the St. Mary's.
12. **Amygdaloid;** green, and tolerably compact, hard matrix, with amygdules of quartz and of laumontite; the upper portion of the bed has a brownish-green and rather siliceous matrix, with abundant amygdules of laumontite.
25. **Not exposed** on the south side of Portage Lake.
3. **Amygdaloid;** light green, soft matrix, with earthy fracture, containing amygdules of delessite and of quartz.
25. **Not exposed** on the south side of Portage Lake.
? **Amygdaloid;** green matrix, with amygdules of quartz, laumontite, and calcite, in places highly siliceous; often the matrix is changed to a red jasper near the amygdules.
323. **Not exposed** on the south side of Portage Lake.

Cross-section IX. a.

(Included in IX.)

Cross-section IX. b.

(Determined by the measurements of the Geological Survey.)

In the trenches east of the South Pewabic Mine.

33. ? **Conglomerate;** porphyry pebbles, with grayish-red cement. The cement effervesces somewhat in muriatic acid, and fuses partially B. B. to white highly magnetic glass with black specks.
22. **Covered.**
? **Amygdaloid;** green brown; compact, and abundantly filled with amygdules of a soft pink zeolite. The matrix is very hard, and fuses on the edges of splinters to a highly magnetic glass. It contains films of magnetic iron.
25. **Covered.**
? **Melaphyr;** gray green, fine-grained, and soft, with scattered amygdules of quartz. Is quite soft, probably very chloritic. Contains magnetite; fuses with intumescence to a dark magnetic glass.
200. **Covered.**
? **Melaphyr;** gray green; amorphous, or crypto-crystalline matrix, porphyritic, through numerous long, flat crystals of green triclinic feldspar, and grains (pin-head to pea size) of almost black delessite. Contains irregular amygdules of a soft pink zeolite (laumontite), and considerable magnetite. Mixed with the fragments of this trap are those of a more even-grained and darker variety.
65. **Covered.**
10? **Amygdaloid;** matrix the same as in next rock to west; the irregular cavities either empty or coated with delessite, or crystals of quartz. Perhaps part of next bed west.

22 ? **Amygdaloid;** blue green; hard, round, and sometimes connected amygdules of calcite or quartz, or again of a flesh-colored, soft zeolite (leonhardite ?). The cavities are often bordered on one side by a dark-red jaspery substance. This red substance may be simply the result of oxidation of protoxide of iron in the bluish-green matrix, without further decomposition of the rock. It is accompanied in the debris on the side of the trench by a fine-grained, green, slightly amygdaloidal trap, with amygdules of quartz, and filled with minute green-white points.
400. **Covered.**
100. ? * **Melaphyr;** green; crystalline; light-green triclinic feldspar, and delessite in irregular grains, in apparently nearly equal amount. Contains grains of magnetite, also apparently some tabular crystals of specular iron ore. Closely resembles the bed 200–300 feet thick, in about the same position on the St. Mary's, and a similar bed on the Dacotah. Thickness not observed, but seems to be more than 100 feet. Neither wall seen.
470. **Covered.**
? **Melaphyr.**
8–12. **South Pewabic Amygdaloid;** almost uniformly chocolate brown. It is characterized by the very general presence of a fine-grained or compact brown material with conchoidal fracture, varying in hardness from quite soft to harder than steel; this substance effervesces in muriatic acid, owing to the presence of minutely associated calcite. The smallest splinters fuse on the edge, and become magnetic. This red material is so distributed as to resemble the cement of a conglomerate in which the more amygdaloidal portions resemble the pebbles, but this is merely a resemblance. The amygdaloidal portions are darker brown, often tinged with green; they are usually a few inches in diameter, and are filled with spherical amygdules of shot sizes, chiefly of quartz, calcite, delessite, green-earth, and copper; the matrix fuses to a black magnetic glass. The copper is disseminated as a coating of the amygdules, and in thin films in the cracks.
53. **Covered.**
21. **Conglomerate** ("Hancock West" conglomerate).
? **Amygdaloid.**

Cross-section X.

(Determined by underground compass survey by the Geological Survey.)

? **Melaphyr;** fine-grained green rock, with minute crystals of green triclinic feldspar, and spots of dark-green delessite and seams of chalcedony. It forms the eastern end of the easternmost adit on the "South-side" location.
22. **Amygdaloidal Melaphyr;** soft green rock, with earthy fracture, containing much delessite; it is traversed by minute threads of calcite, and filled with amygdules of laumontite.
4. **Melaphyr;** dark green, fine-grained, and hard, with minute crystals of green triclinic feldspar, and spots of dark-green delessite.
4. **Amygdaloid;** light green, rather hard and siliceous matrix, with semi-conchoidal fracture; contains amygdules of quartz and laumontite.
9. **Melaphyr;** contains laumontite.

2. **Amygdaloid**; light green, hard and siliceous, with amygdules of laumontite and quartz.
2. **Melaphyr.**
2. **Amygdaloid**; brown, speckled with green, very siliceous, with conchoidal fracture; contains amygdules of quartz and chlorite.
5. **Melaphyr**; with amygdules of laumontite near the hanging-wall.
4. **Amygdaloid**; brown and green, very siliceous, with conchoidal fracture; contains amygdules of quartz and some laumontite.
4. **Melaphyr**; dark green, fine-grained, and hard.
? **Amygdaloid**; dirty green, with earthy fracture, contains amygdules of leonhardite and of delessite, and minute specks of a soft flesh-colored zeolite. Parts of the bed are a very siliceous brown and green amygdaloid, with conchoidal fracture containing amygdules of quartz.

Cross-section XI.

(The eastern adit was surveyed by compass; the western adit by transit, by the Geological Survey; the remaining beds are given from the notes of Mr. A. B. Wood.)

On the "South-side" location.

5. **Amygdaloid**; grayish green, siliceous, filled with amygdules of laumontite.
23. **Melaphyr**; green and chloritic, becomes amygdaloidal towards the top of the bed, assuming amygdules of delessite and passing into the overlying bed.
4. **Amygdaloid**; green and hard; the cavities are either empty or filled with laumontite.
40. **Melaphyr**; dirty green, very fine-grained, with perfect conchoidal fracture, and containing much diffused magnetite. Near the hanging-wall becomes very amygdaloidal, the cavities being either empty or filled with delessite, or with quartz coated with delessite.
25. **Amygdaloid**; the matrix consists largely of a brown crystalline mineral, and contains abundant round and oval amygdules of quartz surrounded with laumontite. This rock resembles in places that of the South Pewabic copper-bearing bed, being then traversed by a chocolate-colored, very fine-grained material, which has an even earthy fracture, is easily scratched, and fuses readily to a dark-green, somewhat magnetic glass. This red material also contains irregular amygdules of laumontite enclosing quartz, and smaller flat ones of laumontite alone, so arranged as sometimes to give to the rock a laminated appearance.
? **Melaphyr**; dark gray green, and very fine-grained, with imperfect conchoidal fracture; it contains specks and threads of delessite, minute threads of laumontite and magnetite both diffused and in distinct grains.
82. **Covered.**
32. ? **Conglomerate**; ("Hancock West.") From the notes of Mr. A. B. Wood.
38. **Melaphyr.** " "
Epidote Seam. " "
135. **Melaphyr.** " "

20. **Amygdaloid**; the lower portion of the bed is a fine-grained, soft rock, speckled brown and yellowish green, containing amygdules and specks of a soft, greasy white mineral, and of delessite with calcite, and more rarely of laumontite. The rest of the bed is chiefly a dark chocolate-brown rock, filled with amygdules of calcite, or of laumontite, or of laumontite enclosing calcite. Druses occur containing crystals of analcite $\frac{1}{8}$ to $\frac{1}{2}$ inch in diameter, with super-imposed crystals of orthoclase.
47. **Melaphyr.**
5. **Amygdaloid**; dark purple brown, with large irregular vesicles which are either empty except a lining of red laumontite (?), or filled within this coating with calcite or with green-earth. This bed carries some copper.
27. **Amygdaloidal Melaphyr**; soft, and containing many large and small amygdules of laumontite and calcite.
5. **Melaphyr.**
10. **Amygdaloidal Melaphyr**; soft, with amygdules of laumontite and calcite.
44. **Melaphyr**; very dark colored, hard and compact, with conchoidal fracture, and containing minute crystals of green triclinic feldspar, and very little visible delessite, some diffused magnetite, and grains of a hard, black, infusible mineral.
9. **Amygdaloid**; dark green, soft, and consisting largely of amygdules of calcite and chlorite.
155? **Conglomerate**; forms the west end of the westernmost adit on the "South-side" location.
94. **Melaphyr.** From the notes of Mr. A. B. Wood.
13. **Sandstone.** " "
100. **Melaphyr**; coarse-grained. " "
19. **Sandstone and Conglomerate.** " "
51. **Amygdaloid.** " "
15. **Sandstone.** " "
66. **Melaphyr**; compact, gray. " "
? **Conglomerate**; width unknown, but very thick. " "

Cross-section XII.

(From the measurement of Mr. Graveldinger.)

On the Douglass location.

? **Amygdaloid**; epidotic matrix.
138. **Covered.**
? **Amygdaloid.**
13. **Melaphyr.**
? **Amygdaloid.**
46. **Melaphyr.**
? **Amygdaloid.**
12. **Melaphyr.**
? **Amygdaloid**; epidotic.
60. **Melaphyr.**
? **Amygdaloid.**
195. **Covered.**

? **Amygdaloid**; "soft."
11. **Melaphyr.**
? **Amygdaloid.**
61. **Covered.**
? **Amygdaloid**; "epidotic."
45. **Melaphyr.**
? **Amygdaloid**; light green; soft; contains amygdules of delessite and copper.
? **Jasper**; banded brown and green.
17. **Melaphyr.**
? **"Capen vein." "Mass vein."**
10. **Melaphyr.**
63. **Covered.**
? **Amygdaloid**; "Ancient Pit" bed; resembles the same bed on the Shelden and Columbian location.
168. **Covered.**
? **Conglomerate.**
525. **Covered.**
? **Amygdaloid,** in which is the Douglass mine.

Cross-section XIII.

(Determined by the measurements of the Geological Survey.)

On the North-star location.

31. **North-star Conglomerate.**
188. **Covered.**
6. ? **Amygdaloid,** resembling that of the Montezuma mine.

Cross-section XIV.

(Determined by the Geological Survey.)

At the Albany and Boston Mine.

? **Houghton Conglomerate**; rounded pebbles of medium size, of brown porphyry (non-quartziferous). The cement is, in places, calcite and laumontite (?) altered to red clay; in places, a very chloritic sand.
10. **Covered.**
38. **Melaphyr**; fine-grained, green, soft; abounds in delessite; crystals of green triclinic feldspar are visible.
9. **Amygdaloidal Melaphyr**; green brown, fine-grained, in places resembling the crystalline seams in trap west of the Isle Royale group, and carrying amygdules of delessite and others of prehnite undergoing change to delessite.
8. **Amygdaloid**; chocolate brown, finely crystalline to amorphous matrix; amygdules of prehnite changing to delessite; also of calcite.
12. **Melaphyr**; brown green, very fine-grained, soft.
Covered.

Melaphyr; greenish gray; finely crystalline.
Covered.
Amygdaloidal Melaphyr.
Melaphyr; very crystalline; contains flat thin crystals of brown and white triclinic feldspar, and grains of delessite or chlorite.

Cross-section XIV. a.

(Determined by the measurements of the Geological Survey.)

East of the Mesnard Mine.

? **Houghton Conglomerate.**

Cross-section XV.

In the open trenches on the St. Mary's location.

The positions of the conglomerates, and of the rocks lithologically described in this section, were determined by the Geological Survey; the remainder is from the notes of Mr. A. B. Wood.

Covered.
15. **Melaphyr.**
8. **Melaphyr.**
31. **Melaphyr.**
9. **Amygdaloid.**
63. **Melaphyr.**
40. **Amygdaloid.**
35. **Albany and Boston Conglomerate.**
40. **Melaphyr.**
38. **Melaphyr.**
17. **Melaphyr.**
10. **Amygdaloid.**
20. **Melaphyr.**
31. **Melaphyr.**
7. **Amygdaloid.** ("Albany and Boston Amygdaloid.")
29. **Melaphyr.**
6. **Amygdaloid.**
90. **Melaphyr.**
12. **Amygdaloid.**
10. **Amygdaloid.**
9. **Amygdaloid.**
32. **Melaphyr.**
81. **Melaphyr.**
11. **Amygdaloid.** (Supposed Pewabic cupriferous bed.)
25. **Melaphyr.**
9. **Amygdaloid.**

78. **Melaphyr.**
10. **Amygdaloid.**
42. **Melaphyr.**
6. **Amygdaloid.**
65. **Melaphyr.**
4. **Amygdaloid.**
11. **Melaphyr.**
4. **Amygdaloid.**
14. **Melaphyr.**
4. **Amygdaloid.**
226. **Melaphyr;** crystalline, granular; contains light-green triclinic feldspar; mottled with dark green spots and grains of delessite.
6. **Amygdaloid.**
112. **Melaphyr;** fine-grained brown rock, spotted with dark-green amygdules of delessite, sometimes enclosing quartz.
8. **Amygdaloid;** brown matrix; amygdules filled with greenish-white, soft, decomposition product; others lined with red-stained crystals of feldspar.
40. **Melaphyr;** greenish brown; fine-grained, hard; conchoidal fracture; contains many spots of bluish-green compact delessite; also of calcite.
52. **Amygdaloid;** very fine-grained, green-brown matrix, with large amygdules of delessite enclosing quartz; others of only foliaceous delessite; smaller bird's-eye amygdules of—1st, compact delessite; and within this, 2d, a thin ring of light green chlorite (?); 3d, the centre filled with foliaceous delessite. In places, the amygdules contain more quartz, sometimes red, or, again, filled with metallic copper. Often the matrix becomes quite siliceous, the cavities being filled with small crystals of quartz, on which rest scattered crystals of white feldspar. In places, the matrix adjoining the amygdules (generally on the under side) is changed to a red jaspery substance; in such cases, many of the amygdules contain a soft, white, decomposition product.
11. **Conglomerate** (Pewabic West); reddish, somewhat calcareous cement of sandstone; containing pebbles (generally under two inches diameter) of brown non-quartziferous porphyry, which in some instances show the beginning of amygdaloidal action. Contains numerous stains of carbonate of copper.
12. **Melaphyr;** ("with orthoclase." A. B. Wood.)
Amygdaloid, the only rock identifiable on the side of the trench, is a brown, almost black, subcrystalline amygdaloid; the cavities run into each other, and are filled, some with calcite, but mostly with a soft, white clay,—a product of decomposition of some previous mineral.
8. **Amygdaloid.**
8. **Amygdaloidal Melaphyr;** grayish green-brown; medium grain, with numerous large and small spots and amygdules of dark-green delessite.
15. **Amygdaloid;** brown; tolerably compact and hard amygdaloid, with amygdules of calcite, of a flesh-red zeolite (?), and others of chlorite.
15. **Melaphyr.**
24. **Amygdaloid.**
16. **Melaphyr.**
10. **Melaphyr.**

27. **Melaphyr.**
23. **Amygdaloid.**
21. **Melaphyr.**
9. **Melaphyr;** grayish green and black green; medium-grained; contains green triclinic feldspar, and dark green chlorite.
5. **Amygdaloid.**
17. **Melaphyr.**
23. **Melaphyr.**
4. **Amygdaloid.**
54. **Melaphyr.**
5. **Amygdaloid.**
22. **Melaphyr;** the exposed rock is much affected by weather; granular; contains gray altered feldspar, delessite, and small crystals of a resinous-looking mineral resembling nepheline.
17. **Amygdaloid;** green, with branching amygdules of light pink laumontite.
7. **Melaphyr.**
12. **Amygdaloid.**
19. **Amygdaloidal Melaphyr;** very fine-grained, brown rock; hard, with conchoidal fracture; spotted dark green with amygdules of delessite; contains small spots of calcite.
43. **Melaphyr;** dirty black-green, very hard, with perfect conchoidal fracture, contains minute crystals of triclinic feldspar; also scattered spherical amygdules of chalcedony, surrounded with delessite.
13. **Melaphyr;** compact; dark.
8. **Amygdaloid** ("Hancock-vein," A. B. Wood); chocolate-brown matrix, filled with large and small amygdules of flesh-colored zeolite (laumontite ?), rarely calcite.
23. **Melaphyr;** very fine-grained; green; hard; conchoidal fracture; small crystals of green and flesh-colored triclinic feldspar.
11. **Amygdaloid;** closely resembling the South Pewabic type in form. Amygdules form a large part of the rock, and are almost wholly of laumontite.
27. **Melaphyr;** fine-grained; green; amygdules of delessite or laumontite; more rarely quartz and delessite.
32. **Hancock West Conglomerate.** At or near the bottom there is sandstone, which splits in thin layers; contains much carbonate of lime and some magnetite. There is also a finer sediment, apparently very fine arenaceous clay. Pebbles (not generally more than 1 inch diam.) are chiefly of brown non-quartziferous porphyry, with compact matrix in which are small crystals of reddish feldspar. The cement of the conglomerate is very calcareous.
14. **Melaphyr.**
5. **Melaphyr.**
16. **Melaphyr.**
43. **Melaphyr.**
8. **Melaphyr.**
24. **Amygdaloid.**

Cross-section XV. a.

(Determined by the measurements of the Geological Survey.)

Being the exposures in the eastern part of the covered drain at the St. Mary's Mine.

? **Melaphyr;** hard; dark green, speckled with red.
35. **Covered.**
6. + **Amygdaloid** ("Ragged Amygdaloid"); chocolate-brown matrix, with large cavities of irregular shape, tending to give a brecciated appearance to the rock. The cavities are partially filled in the given sequence with, 1st, analcite; 2d, calcite; 3d, orthoclase; 4th, calcite.
25. **Melaphyr;** dark greenish-gray; fine-grained; hard; exhibits beginning alteration in the form of small greenish, soft, white spots; it becomes brown and less distinctly crystalline towards the hanging-wall, and assumes veins and amygdules of delessite.
18. **Melaphyr;** brown, speckled green. Towards the hanging-wall this bed carries more grains of delessite and some amygdules of prehnite.
? **Amygdaloidal Melaphyr.**
10. **Covered.**
? **Amygdaloidal Melaphyr;** brown; fine-grained, and hard; contains scattered small amygdules of calcite and delessite.
4. **Amygdaloid;** chocolate brown; soft; contains amygdules of calcite and delessite.
? **Melaphyr;** dark gray brown; fine-grained, hard; conchoidal fracture, with minute red specks of altered delessite? At a few feet from the foot-wall the rock becomes lighter in color, and, without losing in hardness, shows decided signs of change, becoming porous near the joints. In the centre of a polygonal block the delessite is fresh; towards the joints it is changed to a blood-red, soft mineral; nearer the joints the delessite has disappeared wholly, leaving only the empty cavities.
44. **Covered.**
? **Amygdaloidal Melaphyr;** resembling the last-mentioned, but containing amygdules of calcite.
? **Melaphyr;** greenish-brown, fine-grained; hard, conchoidal fracture; contains scattered spots of calcite, and grains of delessite which show minute red specks. Higher up it contains numerous amygdules of delessite.
? **Amygdaloid;** dirty-brown, fine-grained matrix, with small amygdules of calcite and orthoclase?
Covered.
? **Melaphyr;** speckled green and pink; fine-grained and hard. Higher up it is very decomposed, and contains many amygdules of delessite and laumontite.
18. **Covered.**
? **Amygdaloid.**
35.? **Conglomerate.** ("Albany and Boston.")
25. **Covered.**

4. **Amygdaloid** ("20-foot amygdaloid"); hard, light-green matrix, with empty round cavities and round amygdules of quartz.
? **Amygdaloidal Melaphyr;** dark green; contains amygdules of delessite and minute flesh-colored acicular crystals.
15. **Covered.**
6. ? **Amygdaloid.** ("**Epidote** lode.") Brown and green compact matrix, with amygdules of calcite, delessite, green-earth and quartz; often very siliceous; carries some copper.
? **Melaphyr;** dark green; fine-grained, soft; carries much delessite.
20. **Covered.**
? **Melaphyr;** brown green-gray; granular; hard; contains small spots of prehnite.
7. **Amygdaloidal Melaphyr;** gray-green; fine-grained, rich in delessite; carries amygdules of rosy and white prehnite.
? **Melaphyr;** brown green, spotted dark green with amygdules of delessite; fine-grained.
26. **Covered.**
? **Melaphyr;** similar to the last described.
4. **Amygdaloid;** chocolate brown; contains amygdules of green-earth and calcite.
8. **Melaphyr;** brown, with spots of delessite; fine-grained.
7. **Amygdaloid** (probably the "Albany and Boston amygdaloid"); violet and green; irregular hardness; contains amygdules of green-earth, quartz, and epidote.
10. **Melaphyr;** brown green; fine-grained; soft; contains many spots of delessite.
10. **Amygdaloidal Melaphyr;** green-gray; soft; the cavities are partially filled with minute pink and white acicular crystals of a zeolite.
8. **Melaphyr;** gray green; much altered; contains amygdules of delessite.
9. **Amygdaloid;** brown and green; hard matrix, containing amygdules of prehnite and quartz and some copper.
? **Melaphyr;** brown; granular; hard, with imperfect conchoidal fracture. Higher up it is gray and softer, and much altered.
27. **Covered.**
? **Melaphyr;** light gray-green, spotted with dark-green delessite; rather coarse-grained, and marking proximately the eastern limit of the coarse-grained crystalline melaphyrs.
22. **Covered.**
? **Amygdaloidal Melaphyr;** light-brown green, with spots and amygdules of delessite and quartz, and containing porphyritic crystals of a triclinic feldspar.

Cross-section XV. b.

(Determined by the measurements of the Geological Survey.)

On the "Mesnard" location.

10. ? **Amygdaloid;** resembling the "Ragged Amygdaloid." (See *Section XV.* a.)
70. **Covered.**

? **Amygdaloid.**
25. **Covered.**
30. † **Albany and Boston Conglomerate.**

Cross-section XV. c.

(Determined by the measurements of the Geological Survey.)

Near the "Powder-house," at the Albany and Boston Mine.

Cross-section XV. d.

(Chiefly from the printed report of the Pewabic Mining Company for 1865.)

In the cross-cut from the "Albany and Boston Conglomerate" westward to the 70-fathom level of the Pewabic Mine.

32. **"Albany and Boston Conglomerate."** Boulders and pebbles, ½ inch to 2 feet or more in diameter, in a tolerably fine-grained cement of green and red sand. The cement is very subordinate in quantity as compared with the pebbles; it is free from magnetite.

The predominating pebbles are of a red crystalline rock, of medium grain, of the granite family, chiefly of triclinic feldspar and quartz, with little or no mica, and some chlorite. Next in point of frequence are pebbles of a chocolate-brown porphyry, free from quartz, with a very compact matrix, in which lie numerous minute crystals of a triclinic feldspar of the same color as the matrix. This rock is the most common among the pebbles in the other conglomerates of Portage Lake.

Another characteristic variety of pebble is a dark-brown porphyry, free from quartz, with a very fine-grained base, containing crystals ⅛–½ inch long, of flesh-colored triclinic feldspar, which have generally begun to change chemically.

The conglomerate carries copper, though, so far as tested, not in paying quantity.

20. **Melaphyr.**
23. **Amygdaloid** (supposed continuation of the "Epidote" amygdaloid).
41. **Melaphyr.**
8. **Amygdaloid** (supposed continuation of the "Albany and Boston" amygdaloid). Carries copper.
80. **Melaphyr.**
16. **Amygdaloid.** ("Green Amygdaloid.") Carries copper.
69. **Melaphyr.**
29. **Amygdaloid.** ("Old Pewabic" Amygdaloid.) Carries copper.
104. **Melaphyr.**
10. **Amygdaloid.** (Pewabic—Franklin—Quincy copper-bearing bed.)
? **Melaphyr.**

Cross-section XV. e.

(From the measurements of the Geological Survey.)

In the Quincy "Hill-side Adit."

East end covered; large conglomerate boulders were found in the "drift," just before meeting with rock.

32. **Melaphyr;** rather fine-grained; dirty dark and light green, with rusty brown specks; hard; tough; fracture irregular; changes into
28. **Amygdaloidal Melaphyr;** fine-grained, dirty green color; numerous dark-green delessite spots; loosely textured.
12. **Amygdaloid;** mixed green and brown; some hard amygdules in places mostly of quartz and green-earth, in others of calcite and green-earth; epidote is present, and some laumontite: some amygdaloidal melaphyr occurs near the centre.
37. **Melaphyr;** fine-grained; dark brown, mottled dirty green; hard. The lower one foot is amygdaloidal. Above, it slowly changes to
31. **Amygdaloidal Melaphyr;** coarse; dirty green, spotted with dark green delessite; fracture very uneven.
1. **Amygdaloid;** narrow, poorly developed, hanging-wall not well defined; green; hard; amygdules of quartz and delessite, some laumontite.
73. **Melaphyr;** rather coarse, not closely textured; color, dirty green of different shades; fracture irregular; inclining toward amygdaloidal melaphyr in places. Toward the base it is dull brown and rather compact, with conchoidal fracture, while at 15 feet from the top it changes irregularly into a very compact rock; the color here is dull purple, indefinitely inclining toward, and mottled with, dull green; very hard; conchoidal fracture. Thirty-four feet horizontally from the foot-wall are two parallel seams, three feet apart; the upper one is 4 inches wide; strike about north; dip 40° east.
18. **Amygdaloid;** green; compact; hard; amygdules mostly quartz in green-earth or epidote; also calcite.
12. **Melaphyr;** very compact; color green, purplish; rather hard; elastic; highly conchoidal fracture; occasionally flesh-red triclinic feldspar crystals porphyritically imbedded; changes to
48. **Amygdaloidal Melaphyr;** in part with dirty greenish-gray base, sprinkled with small porphyritically imbedded flesh-red feldspar crystals, and numerous green delessite spots, and in part light green, with scattering brown specks, and delessite amygdules; tough; fracture uneven.
4. **Amygdaloid;** mixed green and brown; the green is hard, and usually with quartz and epidote; the green is generally softer, with calcite and delessite. Drifts of 15 feet either way near hanging-wall.
6. **Amygdaloidal Melaphyr;** base dirty greenish-gray, sprinkled with flesh-red feldspar crystals, and numerous green delessite spots; tough; fracture uneven.
5. **Seam** of laumontite, narrow.
8. **Melaphyr;** coarse-grained, rather crystalline; dark purplish-green; hard; brittle, yet tough, changes gradually into

14. **Amygdaloidal-Melaphyr**; base purplish-brown; rather fine-grained, growing coarser toward the bottom, where small flesh-red feldspar crystals are imbedded; amygdules of delessite at the bottom, of laumontite and green-earth, or delessite, near the top.

Cross-section XV. e.

(From the measurements of the Geological Survey.)

In the western half of the Quincy "Hill-side Adit."

10. **Melaphyr**; dirty brown, fine-grained, mottled with very dark delessite.
4. **Amygdaloid**; brown; hard; conchoidal fracture; siliceous amygdules of green-earth and quartz, and green-earth and calcite, and of green-earth alone. Contains some copper. Shaft sunk.
18. **Amygdaloidal Melaphyr**; green; fine-grained; crystals of green triclinic feldspar; numerous amygdules of very dark delessite; others of delessite enclosing quartz.
4. **Amygdaloid**; light green; siliceous; amygdules of quartz and calcite; some copper.
17. **Amygdaloidal Melaphyr**; very fine-grained; in places amygdules of laumontite; in others, of green-earth and quartz.
8. **Amygdaloid**; brown matrix; small amygdules of green-earth, and large ones of green-earth and calcite.
34. **Melaphyr**; brown green; fine-grained; brown triclinic feldspar and dark-green delessite.
6. **Amygdaloid**; light-green and brown; hard conchoidal fracture; very siliceous; amygdules of quartz, calcite, epidote, copper.
72. **Melaphyr**; fine-grained; green, through predominance of delessite. Some crystals of brown triclinic feldspar. Below this the rock is mottled dark and light green, and under the glass seems to consist of compact delessite, with amygdules of gray-green chlorite or green-earth, with a little quartz. It has the appearance of a feldspar-delessite trap in which the feldspar had disappeared, leaving cavities now occupied by secondary minerals. Towards the foot-wall, the rock is medium-grained, crystalline, brown, mottled with the usual dark-green delessite, and with light-green spots. It consists of crystals of brown triclinic feldspar, which are partially changed to a soft, light-green clay. Still nearer to the foot-wall the rock appears fresh; a medium-grained, dark-greenish gray mixture of gray to light-green triclinic feldspar, and dark-green delessite. Contains minute hexagonal crystals of specular iron. Resembles the coarse-grained trap west of the Pewabic lode, and on the St. Mary's.
13. **Amygdaloid**; bearing copper; shaft sunk.
46. **Melaphyr**; fine-grained, crystalline; consisting of brown triclinic feldspar and diffused delessite; contains amygdules of delessite and of green-earth.
4. **Amygdaloid**; compact and hard; green-brown matrix, with abundant small brown crystals of triclinic feldspar, and numerous amygdules of calcite, green-earth, and quartz.

31. **Melaphyr**; fine-grained; crystalline; conchoidal fracture; consists of brown triclinic feldspar and diffused delessite, with abundant amygdules (mostly spherical) of delessite.

Narrow Amygdaloidal Seam.

25. **Melaphyr**; to the eye a fine-grained crystalline rock with uneven fracture, and consisting of reddish triclinic feldspar, with delessite both diffused and in flakes and grains; general color brown, mottled and veined with dark green. Contains some magnetite. Passes towards the hanging-wall into the overlying amygdaloid.
7. **Amygdaloid**; brown, with light-green amygdules of green-earth and quartz and calcite, containing copper. Matrix contains crystals of triclinic feldspar.
24. **Amygdaloidal Melaphyr**; abounding in amygdules of delessite. In the body of this bed, there occur portions of regular amygdaloid, with amygdules of quartz and calcite with green-earth. Small cavities in the amygdaloidal trap are lined with delessite, and this with clear, slightly pink crystals of feldspar; at the hanging-wall this passes into
6. **Amygdaloid**; compact and hard; brown, mottled green, with amygdules of green-earth and quartz.
85. **Melaphyr**; fine-grained towards the foot-wall; middle of the bed medium-grained crystalline trap; crystals of green and brown triclinic feldspar; delessite near the hanging-wall, almost foliaceous from the abundance of delessite.
8. **Amygdaloid**; green brown, with amygdules of green-earth, and cavities lined with minute crystals of feldspar. Carries considerable copper.

CHAPTER VI.

UNDERGROUND CROSS-SECTION AT THE CENTRAL MINE.

Beginning south of the "Greenstone," and proceeding from younger to older.

C*		
$\overline{1}$	50 ft.	**Melaphyr:** dirty green; fine-grained and soft, with almost earthy fracture; ¼ to ⅛ delessite [essential], the rest chiefly triclinic feldspar much altered; contains impregnations of calcite and specks of a copper-colored micaceous mineral with a red streak. Little or no magnetite.
In Adit..... $\overline{2}$	18 ft.	**Amygdaloid:** chocolate brown; matrix predominant; micro-crystalline, hard; semi-conchoidal fracture; contains amygdules of *prehnite;* often colored red in centre by disseminated copper; also amygdules of calcite with prehnite. This bed passes into the underlying melaphyr (C $\overline{3}$).
$\overline{3}$	45 ft.	**Melaphyr:** dark red near the top; fine-grained; uneven fracture; has scattered amygdules of delessite and of a whitish steatitic mineral; lower down this rock becomes brownish green, very fine grained and hard, with conchoidal fracture, and contains scattered irregular particles of delessite, and in places amygdules of prehnite and calcite; large *bunches* of amygdaloid occur in this rock, with brown matrix containing round amygdules of calcite and green-earth; at the bottom of the bed the rock is mottled, brown and green, the green portions being mostly delessite, while the brown are similar to the lighter spots in the greenstone, consisting of triclinic feldspar, very much fractured; the rock here contains considerable magnetite and impregnated calcite. In small veins occurs the following series: 1. Laumontite. 2. Analcite.

* The numbers in the first column refer to Pl. XXIII. of Atlas, where the corresponding figures indicate the points from which the specimens were taken.

	C		
90 fathom level...	4	16 ft.	**Amygdaloid:** brown; fine-grained, compact, in places hard; contains bunches of prehnite with copper, also amygdules with calcite, veins of laumontite, and very irregular cavities coated with crystals of feldspar. This passes below into C 5.
90 fathom level...	5	55 ft.	**Melaphyr,** similar to C $\overline{1}$, very fine-grained, speckled brown and green; under the glass three ingredients appear about equally divided, viz., dark green delessite, a glistening white mineral, apparently altered feldspar, and a porous, red substance, possibly an altered product of delessite; the joints are glazed with delessite.
90 fathom level...	6	15 ft.	**Amygdaloid:** brown matrix, containing amygdules of calcite and delessite.
90 fathom level...	7	40 ft.	**Melaphyr,** similar to C 5; towards the middle and bottom of the bed it becomes hard, with conchoidal fracture, and brown color predominating through comparative absence of chlorite.
Adit level	$\overline{10}$	15 ft.	**Amygdaloid:** brown, compact matrix, filled with numerous amygdules, and seams of a light bluish green, soft, alteration product; the same bed has similar character at the 90 fathom level.
Adit level	11		
90 fathom level...	12 and 13	60 ft.	**Melaphyr,** identical with C 5. This very thick bed is remarkably uniform in character, and presents the same appearance in every respect at the 90 fathom level and the adit.
90 fathom level...	14	15 ft.	**Brown Amygdaloid,** with scattered amygdules of prehnite containing copper, and others consisting of a more or less porous light-green, chlorite-like mineral, perhaps an alteration product; the vein made mass copper in this bed.
90 fathom level...	15	37 ft.	**Melaphyr,** similar to C 5; small mass here in the vein.
90 fathom level...	16	17 ft.	**Amygdaloid:** very hard, compact, brown matrix, with amygdules of prehnite and others of calcite, with green-earth.
90 fathom level...	17	45 ft.	**Melaphyr,** resembling C 5, but with perfect conchoidal fracture; vein made a mass in this bed.

	C		
90 fathom level...	18	22 ft.	**Amygdaloid:** matrix brown, in places hard; in the uppermost softer portions of the bed frequent amygdules of a white and green mineral with radiated structure, probably altered prehnite; in the harder portions frequent veins of prehnite and delessite carrying copper, also, in places, epidote, and cavities lined with feldspar.
90 fathom level...	19	5 ft.	**Melaphyr,** similar to C 5, with isolated small amygdules of delessite.
90 fathom level...	20	5 ft.	**Amygdaloid:** compact, brown matrix, with amygdules of epidote and others of red feldspar and delessite.
90 fathom level...	21	5 ft.	**Melaphyr,** similar to C 5.
90 fathom level...	22		**Amygdaloid:** matrix brown, containing irregular amygdules of prehnite, more or less altered, with calcite, green-earth, and copper; passes below into amygdaloidal melaphyr, containing irregular amygdules of prehnite.
90 fathom level...	23	12 ft.	**Amygdaloid,** in irregular bunches of prehnite with copper, the prehnite apparently undergoing change to delessite. In this bed the feeders of the vein consist of coarsely crystallized calcite, having irregularly distributed feldspar and delessite.
90 fathom level...	24		**Amygdaloid,** with amygdules of altered prehnite and feldspar and delessite.
90 fathom level...	25	10 ft.	**Melaphyr,** resembling 5, with less delessite.
90 fathom level...	26 to 34	10 ft. 10 ft.	**Porphyry Conglomerate,** with epidote cement containing disseminated copper in both pebbles and cement. Vein in this conglomerate carries large crystals o calcite.
90 fathom level...	35	16 ft.	**Amygdaloid:** South Pewabic and Ash-bed type; the amygdules are almost wholly calcite.
90 fathom level...	36		
90 fathom level...	37 to 39	45 ft.	**Melaphyr:** very fine-grained; in the upper portion purplish brown matrix, thoroughly impregnated with minute irregularly shaped particles of a soft white mineral containing small isolated impregnations of calcite. The middle portion of the bed is a dark gray micro-crystalline rock. Under the glass it is seen to be somewhat impregnated with delessite, and to contain, in scattered particles, a copper-colored micaceous mineral, which gives a dark red streak. The lower portion of the bed is minutely mottled, gray and green, is fine-grained, and contains a considerable amount of the red mineral above mentioned.

	C		
90 fathom level...	40	15 ft.	**Amygdaloid:** brown matrix filled with very small amygdules of green-earth, of green-earth and calcite, and of a very red feldspar; it carries finely disseminated copper. Feeders of the vein observed in this rock consist of prehnite with younger sheet-copper and calcite.
At No. 4 Shaft...			
90 fathom level...	42	68 ft.	**Melaphyr:** chocolate brown, very fine-grained, with even fracture, containing small crystals of triclinic feldspar in the matrix, and disseminated particles of the copper-colored micaceous mineral above referred to; and also isolated small amygdules of delessite at the 90 fathom level. This bed is intersected by a cross course, immediately beneath which there was found a large mass of copper.
90 fathom level...	43	20 ft.	**Amygdaloid:** green and brown matrix, with amygdules of green-earth, calcite, copper, and analcite.
90 fathom level...	44		**Melaphyr:** fine-grained, gray-green matrix, speckled red with the copper-colored micaceous mineral above referred to, and containing considerable magnetite; the joints of this rock are coated with laumontite.
90 fathom level...	45		**Amygdaloid.**
90 fathom level...	47	34 ft.	**Melaphyr:** fine-grained greenish-gray matrix, speckled red with the copper-colored micaceous mineral. Feeders of the vein as observed in this rock consist of red feldspar and calcite, with a green, talc-like mineral.
90 fathom level...	48		**Melaphyr,** resembles C 5, but harder and with perfect conchoidal fracture.
90 fathom level...	49	16 ft.	**Amygdaloid:** brown matrix, filled with amygdules of prehnite more or less altered, and of calcite with green-earth. Feeders of the vein as observed in this bed consist of prehnite filled with native copper.
90 fathom level...	51	43 ft.	**Amygdaloidal Melaphyr:** very hard, brown, fine-grained matrix, showing numerous minute crystals of triclinic feldspar, and containing isolated amygdules from $\frac{1}{2}$ to $\frac{3}{4}$ inch diameter of prehnite, apparently undergoing a change to delessite; below this passes into C 52.
90 fathom level...	52		**Melaphyr,** similar to C 5; on the 90 fathom level the vein in the members of this bed was exceedingly rich in mass copper, while at the 120 fathom level the vein was reduced in the same bed to a narrow brecciated mass, consisting of small pieces of wall rock surrounded and sustained by thin seams of laumontite.

	C		
90 fathom level...	53	28 ft.	**Amygdaloid:** soft, brown matrix, filled with round amygdules of calcite and altered prehnite.
At No. 2 shaft...			
		68 ft.	**Melaphyr.**
		25 ft.	**Amygdaloid.**
		45 ft.	**Melaphyr.**
120 fathom level...	54	50 ft.	**Amygdaloid:** matrix purple brown, in places very soft, almost uniformly filled with amygdules of prehnite.
200 ft. N. No. 2 shaft.			
120 fathom level...	56		**Melaphyr:** very hard, uniformly dark greenish gray, very fine-grained, with conchoidal fracture; exhibits under the glass scattered particles of a copper-colored micaceous mineral.
120 fathom level...	57		**Amygdaloid:** brown matrix with isolated amygdules of prehnite with delessite; approaches an amygdaloidal melaphyr; probably not a persistent bed.
120 fathom level...	58		**Amygdaloidal Melaphyr:** hard brown matrix, isolated amygdules of prehnite, delessite, calcite, and native copper.
120 fathom level...	59	68 ft.	**Melaphyr,** same type as C 5, though harder, with perfect conchoidal fracture.
and			
At No. 2 Shaft...	60		
130 fathom level...	61	9 ft.	**Amygdaloid:** soft brown matrix with irregular-shaped amygdules, with prehnite, analcite, and native copper.
75 ft. N. No. 2 shaft.			
	62	30 ft.	**Melaphyr:** dark green, very fine-grained matrix, apparently rich in delessite.
		9 ft.	**Amygdaloid.**
	63	30 ft.*	**Melaphyr,** same type as C 5.

* This is geologically the lowest point reached.

CHAPTER VII.

GENERAL STRUCTURE AND LITHOLOGY OF THE EAGLE RIVER SECTION.

By A. R. Marvine.

The width of the "Trap Range" of Keweenaw Point, measuring from Lake Superior at the mouth of Eagle River across to the unconformable sandstones forming the south-eastern border of the Point, is about six miles. Topographically it here consists of two ranges of hills, which conform in direction with the general trend of the strata and of the Point, and while rising gently on their northern, fall more steeply upon their southern slopes. Locally, these are known as the North, or Greenstone, and the South Ranges.

The former, at an average distance of two miles from the lake shore, attains a height of from 400 to 700 feet, when it falls abruptly, even precipitously, to the longitudinal valley separating the two ranges. The South Range occupies the remainder of the trappean series, and while rising to a height of 600 to 800 feet above lake level, has a more gently moulded contour than the North Range.

The drainage waters of the intermediate valley accumulate in the branches of Eagle River, and flowing east and west at the southern base of the North Range, unite at the Phœnix mine, where, turning, they pass through a break in the Range and flow northward across the formation to Lake Superior.

Except in scattered exposures, the South Range lies buried under glacial and modified drift, while the frequent exposures of the North Range, together with the channel of Eagle River, offer excellent opportunities for a geological section.

The accompanying section, in two plates, exhibits in detail the section of the rocks of the North Range taken at this point, while the geographical relations of the exposures correlated in the section are shown in the accompanying map.

The sections are numbered in Roman numerals, and their limits —with the corresponding numerals—indicated on the map. The map and sections may be still further connected by means of the lettered survey stations and the numbers of beds, commencing at the northern end, placed on each.

General Geological Structure of the Section.—In the immediate vicinity of a line drawn from the Phœnix mine to the mouth of Eagle River, the rocks are very regularly bedded, the strata having a trend of slightly more than sixty-two degrees east of north, and dipping toward the Lake, or north north-west, at an average angle of about thirty-one degrees, being somewhat steeper at the north, and less steep toward the south. Upon either side of this line, the strata, participating in the general bending of the Point, swing slowly around, until, in a mile or more, their strike differs by two or three degrees from that of the main line of section. Moreover, in leaving the section toward the east, a flattening of the strata takes place, the dip decreasing about a degree in a mile. It probably increases slightly toward the west. Besides the geographical widening of the formation toward the north, owing to this flattening of the strata, there is also a widening from the actual thickening of some beds, or from the wedging in of new ones. Even within the limits of the map the formation thickens considerably in going eastward.

This system of rocks may be divided into three groups: sandstones or conglomerates; melaphyrs, including amygdaloids; and diorites.

The latter stand alone, occurring in a single belt of 2,400 feet in width. Being much harder and more massive than the adjoining rocks, they form the highest and southern portion of the North Range. Locally, the term "greenstone" is applied to the finer varieties of the diorites, and "feldspathic trap" to some of the coarser varieties, thus distinguishing them from the melaphyrs or "traps."

Both above and below the belt of diorites, and perfectly conformable with it, are the melaphyrs. To the south, excepting occasionally intercalated narrow beds of conglomerate, they are said to extend to the limit of the range. Northward they extend to a distance of nearly 5,800 feet, or to within a quarter of a mile of Lake Superior. For the first 3,500 feet of this distance they

are comparatively free from any true sandstone strata, only four sandstone seams occurring. From this point northward, however, a series of sandstones occur, interbedded with the melaphyrs and amygdaloids. These, in their aggregate thickness, amount to over one-third of that of the including melaphyrs, but, as a rule, increasing in thickness toward the north, they there dominate over them.

Resting on this interstratified series of melaphyrs, amygdaloids, and sandstones is a wide belt of coarse conglomerate extending to and under the Lake. Some miles eastward of the main line of section, this conglomerate has a width of about a mile,* a trappean belt of about two-thirds the width resting upon it, which is in turn overlaid by another wide conglomerate. The United States Lake Survey chart represents a reef about 3,400 feet off the mouth of Eagle River, which at one point rises to within six feet of the water's surface, and as it is stated to be of "trap rock," it probably belongs to the outer trappean belt. This would make the conglomerate at Eagle River from 4,000 to 4,500 feet wide.

The diorites, as before stated, form a massive group of rocks about 2,400 feet wide, or 1,200 feet thick. They are heavily bedded in strata of from 20 to 150 or more feet in thickness, and without the interpolation, so far as known, of any amygdaloidal bands. Excepting a very massive bed at the base, and a thinner one upon the top, all the interior two-thirds of the series have a coarse-grained texture, especially so as compared with the adjoining melaphyrs. This texture varies from nearly that of the coarsest melaphyrs to beds in which the component crystals average one-eighth of an inch or more square, while the specific gravities are generally greater than those of the melaphyrs, and range from 2.89 to 3.03.

These beds are composed essentially of nearly opaque, lustrous, black to greenish-black, sometimes inclined to translucent resinous-brown, *hornblende*, and *triclinic feldspar*. Two kinds may be observed: the first, in which the feldspar is white, inclining to grayish-green, and sometimes red; fuses rather readily before the blow-pipe in coarse splinters; has a specific gravity, in one bed, of 2.73; weathers less easily than the hornblende; and is probably *Oligoclase*, or Albite. Its presence gives rise to handsome gray or greenish-

* See Foster and Whitney's Report on the Geology of the Lake Superior Land District, Part I., Map. Washington, 1851.

gray, and sometimes mottled rocks, which may be designated as the "lighter type." In the second variety of diorite the feldspar is very brittle, hard, colorless, or inclined to green, and sometimes to resinous brown, and is transparent; fuses before the blow-pipe only in very fine splinters; weathers more readily than the hornblende; and is probably *Anorthite*. Its presence, owing chiefly to the fact that the hornblende shows through it, gives rise to dark-colored, and generally dirty, resinous-hued strata, which may be designated as the "dark type." In both types a dark green chlorite, probably delessite, occurs to a greater or less extent, occasionally nearly wholly replacing the hornblende, from which it seems to be derived, thus transforming the bed into a coarse, loosely textured melaphyr, not especially like the typical melaphyrs above and below the diorites. Segregations are quite frequent, especially in the dark-type beds. In these the feldspar generally occurs in large crystals, but irregularly, and white and opaque, like that of the lighter type, and usually imbedded in hornblende, and intersected by it. Indurated green spots of quartz and epidote also occur, and occasionally prehnite and a bronze-colored mica. In the dark type also, larger crystals of the glassy feldspar often occur. These generally contain scattered particles of the usual ingredients of the rock, often to such an extent that the crystals themselves cannot be recognized except by the reflection of the light. This tendency to a larger crystallization in the mass is not so apparent with the hornblende, except when brought out upon the weathered surface of the rock, where the feldspar crystals have been removed, while the projecting hornblende crystals, often over an area of one or two inches square, all catch and reflect the light simultaneously.

The strata of the dark type predominate in the group, especially toward the bottom, form the more massive beds, and have, as a whole, the finer texture, never reaching the coarsest. The lighter type, on the contrary, occurs in thinner beds, which generally have a coarser texture, reaching the coarsest. Other things being equal, the latter are the more enduring of the two, but their comparative thinness and coarseness of texture generally reverses this character. The beds of the lighter type generally weather rather evenly, but with a rough surface, the color being a handsome gray, sometimes mottled, and speckled with projecting black hornblende crystals. The beds of the dark type sometimes also weather evenly and rough,

with projecting crystals, but generally the weathering is rugose, often very exaggerated, the depressions being rusty brown in color, smooth and free from crystals, while the projecting knobs, often an inch high, are whiter, but sprinkled with projecting black hornblende crystals, those on each knob generally all reflecting the light at once to the eye.

In one bed (No. 107) the two types are banded together in strata of from 5 or 6 inches to 5 or 6 feet in thickness, with no perfectly sharp lines of demarcation separating them. The lighter type layers were here exceedingly coarse, and their granular components could be separated quite well from one another.

The hornblende grains often showed very lustrous cleavage planes, some of which could be measured. In one of these, measured on the reflecting goniometer, the cleavage angle of Pyroxene (Augite), viz., 87° 5′, was obtained. Several gave the undoubted angle of hornblende, 124° 30′; while, in general, those which were not sufficiently perfect to measure accurately were not far from the latter angle. An analysis of this material was made which, though not wholly successful, showed conclusively that the mineral was hornblende,—the amount of lime in it not exceeding 10 per cent. Its specific gravity was 3.39,—that of the feldspar 2.73, and of the rock 3.02, showing that about 57 per cent. of the latter was feldspar and 43 per cent. hornblende.

Commencing several hundred feet from the base, there is a coarse-grained, hard, dark, resinous-hued bed. From here downward a gradual change occurs, the texture growing finer and finer, the feldspar element seeming to increase, giving a gradually increasing crystalline character to the bed, until the components finally become undistinguishable, and there is formed at the base 200 or 300 feet of an exceedingly brittle, elastic, hard, compactly crystalline aphanite, having a conchoidal fracture, and handsome clear green color, sometimes mottled vaguely with purple, and with occasional large, flat, transparent crystals of glassy feldspar imbedded in the mass. When mottled, the weathering is of a uniform rugose character, the silver-gray projections being composed of grains of glassy feldspar, sunk in which are minute crystals of hornblende, all of which on each knob, as on the larger, coarser knobs, before described, reflect the light simultaneously at the same incident angle. This shows that the rock is still of the diorite type,

and that, though changed in its physical character, it has not changed materially in its chemical. The specific gravity of the homogeneous aphanite is 2.95. For 15 feet above the foot-wall of the "greenstone" its eminently crystalline character is lost, the rock looking much like some fine-grained and compactly textured melaphyrs; the specific gravity, however, still being 2.92. The lower 3 or 4 feet are broken and fissile, and are followed by the red-clay seam called the slide, separating it from the melaphyrs and amygdaloids of the Phœnix mine, or those lying below the diorites.

Commencing at the base of the uppermost bed of the diorites (No. 91), the rock is precisely similar to the purple-mottled aphanitic greenstone, and has the same specific gravity, 2.95.

It gradually changes, however, becoming at first somewhat coarser-grained, and resinous in lustre, with specific gravity 3.01, and finally a fine-grained, brownish, homogeneous rock, in all respects like some melaphyrs, and with a specific gravity of 2.89. This is separated by a distinct plane from a fine-grained, dark-bluish, semi-columnar rock, which forms the base of the melaphyrs lying north of the diorites.*

Melaphyrs and Amygdaloids.—The limits and position of the melaphyr group upon the section have already been indicated. In general characters these melaphyrs are precisely similar to those in the Portage Lake District; and the results given in the description of that district as to their general lithological characters, chemical or mineralogical composition, accompanying minerals and their paragenesis, etc., are equally applicable, in a general way, to the melaphyrs of this district. In fact, the region lying north of the diorite group is in the same horizon as the western end of the Portage Lake section, and there is not only a strong resemblance, but, so far as traced, a general accordance between them; many beds in the two being lithologically, probably stratigraphically, identical.

* A much more complete knowledge of these diorites may be had by referring to the detail descriptions of the typical and peculiar beds of the series in Chap. VIII., as appended. Dark type, No. 92, p. 133; light type, No. 96, p. 134; coarse, inclined to melaphyr, with large red feldspar crystals at base, No. 94, p. 134; coarse, light and dark types banded, No. 107, p. 135; dark type, changing to aphanitic, No. 108, p. 136; aphanitic, changing to melaphyr-like form, No. 91, p. 133.

The melaphyrs lying above or north of the diorites do not separate themselves into any apparent natural groups, but for convenience of reference they may be divided into three series:—(*a*), Those extending from the diorites north to the bed next below the Ash-bed, or No. 66; (*b*), from No. 66 to the Upper Falls, or through No. 45; (*c*), the remainder of the melaphyrs northward to the wide conglomerate, and containing ten intercalated sandstones. The respective widths and thickness of these three series are—(*a*), 1840 (± 925)* feet; (*b*), 1,200 (618) feet; (*c*), 2,700 (1,417) feet, with sandstones aggregating above 860 feet.

(*a.*) The most characteristic and prominent beds of series (*a*)—mostly confined to its northern 580 feet—are composed of rather coarse and not closely textured melaphyrs; tough, but not brittle, and breaking with a rough fracture. The colors are dirty light green, strongly mottled with quite well-defined spots of dark green, causing them to approach amygdaloidal melaphyrs in structure, while they have a medium specific gravity of about 2.87. Their capping amygdaloids are not very strongly developed. South of these beds finer-grained, darker, and more evenly colored beds seem to prevail, but the covering of soil renders this the least known of any part of the section. Near the base a wide bed (No. 87, 350 feet wide), similar to those at the top, occurs, below which, and at the base, is a wide (175 feet), hard, homogeneous, fine-grained, clear bluish-black melaphyr, which has a quite well-defined and striking semi-columnar structure.

The middle division (*b*) of the northern melaphyrs has at both its base and summit a porphyritic bed, composed of small semitransparent crystals of greenish-white triclinic feldspar, generally without definite form, profusely sprinkled in a very fine-grained base of purplish—or purple lightly mottled green—color, and containing considerable magnetic iron. It is a hard, elastic, brittle rock, with rather smooth and semi-conchoidal fracture.

These are the only two marked porphyritic beds among the melaphyrs of the section, and are also somewhat more brittle and elastic than any others, approaching in these two qualities the aphanitic diorites. They also have a high specific gravity, 2.93 and 2.91,

* Numbers in parentheses indicate generally *thicknesses*, or distances measured perpendicular to the bedding.

respectively. Each has a scoriaceous amygdaloid upon its summit, separated from the main bed by rather a sharp line of demarcation. Situated between these two extremes are a variety of beds, mostly abnormal in composition. Commencing at the base there is the compact dark-bluish melaphyr, with the associated scoriaceous amygdaloids called the "Ash-bed;" then a semi-columnar trap with wide, coarse amygdaloid above; then a width of curious, coarse, easily decomposing beds of very irregular structure, followed by many very thin, but perfectly bedded amygdaloids with narrow intermediate amygdaloidal melaphyrs.

The northern series (*c*), extending north to the wide conglomerate, and containing sandstones aggregating probably 860 feet in width, has, for its predominant type of melaphyr, a rather fine-grained and compactly textured rock, breaking with an irregular to semi-conchoidal fracture, and somewhat brittle and elastic. The color is generally a dark but dull green vaguely mottled purple, the latter often predominating, having in it a mottling of green, and occasionally all is green, a darker shade mottling a lighter background. Though the purple element enters largely into the colors of these rocks they are inclined to dark shades, being darker than the normal green rocks of series (*a*), while the mottling, though striking, is not so well defined or spotted, nor of such dark green color. They are also finer grained, more brittle, not so tough, nor with so rough a fracture, and show a closer texture. The quantity of magnetite in this series seems quite small, and much less than in (*a*), while the specific gravity may average lower—2.71, 2.76 to 2.89.

As exceptions to this general nature we have one light green (No. 1) and two grayish beds (Nos. 9, 10), while No. 39 is of quite exceptional character.

In amygdaloidal melaphyrs delessite is nearly always the mineral that first occupies the amygdules, the matrix or base generally remaining much the same as the accompanying melaphyr. Laumontite generally follows closely after, but north of the diorites it occurs far less than in the Portage Lake District, series (*a*) being nearly free from it, (*c*) having but little more, though considerable occurs in (*b*). Calcite and prehnite occupy the position next most important to delessite in the amygdaloidal melaphyrs. In their most developed stages in series (*a*) calcite occurs in the delessite amygdules, nearly

to the exclusion of prehnite, but in (*c*), especially all through its middle parts, prehnite occurs in the amygdaloidal melaphyrs in most characteristic pink-and-salmon colored radiated amygdules, to the exclusion not only of calcite, but almost entirely of even delessite.

In the amygdaloids throughout, calcite largely predominates, but is often closely followed by prehnite (the latter generally enclosing the former), which is generally light green, semi-transparent, and botryoidal, and almost always accompanied by small amounts of copper.

Quartz follows next in importance, and those amygdaloids containing it in larger quantities are generally more or less indurated. The matrix of amygdaloids is seldom similar to the underlying melaphyr, being almost always very fine grained to compact, sometimes inclined to earthy, sometimes indurated and hard, and generally reddish-brown in color, with sometimes red crystals of feldspar porphyritically imbedded in it, while in the harder amygdaloids, the base is often green in color.

South of the diorites a few hundred feet of rock are exposed in the Phœnix mine. In the upper part of this series the melaphyrs, which all approach amygdaloidal melaphyrs, are of a rather coarse-grained, inclined to loose, texture, being rather soft and tough, and having a very uneven fracture. The feldspar is greenish-white, and occurs in elongated crystals, which are sometimes twins, and in the coarser varieties, appear spread like a network upon a background of dark-green delessite and pinkish feldspar, the delessite being separated into frequent and rather well-defined spots, while magnetic and specular iron are present in quite large quantities. In the finer-grained beds brownish-red largely prevails, with dirty white in the base, the colors, though dull, as in nearly all rocks, being well marked and in strong contrasts. At one or two points, the whole rock becomes a nearly uniform, decided, brownish-red color, and as no magnetic iron then seemed present, the color may be due to the decomposition of the iron ingredients of the original rock. In looseness of texture, and consequent rough and uneven fracture, these rocks somewhat resemble the typical melaphyrs of series (*a*), but in colors they are decidedly dissimilar. The amygdaloids are but little more than exaggerated forms of the amygdaloidal melaphyrs, the matrix not being compact but fine-grained,

and of a dull brownish-red color, with but little calcite or prehnite with the delessite amygdules. Toward the south the melaphyrs become finer grained and more compactly built, harder, more brittle and elastic, and with more even and conchoidal fracture, while the color darkens, a dark green predominating, indefinitely mottled with dark dull purple. There is but little or no magnetite. The mottling spots may be .3-inch diameter, though their limits are variable and indefinite, and they may merge into one another. In part of one bed (No. 120) they reflect to the eye, when the fractured face is held at the proper angle, a glistening or sheen, which causes them to strongly resemble a similar modification which sometimes occurs near the lower part of the aphanitic diorites. The latter, however, is harder, and in texture inclines to compact crystalline rather than to fine granular, while the color is a clearer green.* The specific gravity of the former is 2.84–2.87, of latter 2.92–2.95. The amygdaloids of this part of the mine are much better developed than those at the northern end, calcite predominating in some, prehnite in others, and delessite and laumontite in the amygdaloidal melaphyrs.

One amygdaloid (No. 111), lying about between these two series, is pretty well developed, and where examined contained much copper. The prehnite of the amygdaloids, especially in this part of the mine, seems to be readily attacked by the decomposing agencies at work, changing to a soft, white, amorphous chalk or kaolin-like material, the larger amygdules sometimes having a partly unchanged prehnitic nucleus and exterior.

Certain changes which have been suggested in the preceding pages as occurring in the melaphyrs may be of sufficient interest to warrant a more detailed description.

Being of the same general nature in all, it may be convenient, in examining them, to select those features presented by the characteristic rocks of series (*a*), the coarser character of which enables their components to be more readily detected and their changes examined, referring, when occasion requires, to other beds which may differ from those under consideration.

* At the Allouez mine these distinctions are nearly lost, and the "greenstone" is so changed that, were it not known to be the equivalent of the "greenstones" farther northeast, it would certainly be considered as a melaphyr.

Upon breaking the rock at various points, a rather rough fracture is obtained, indicative of a rather coarse and not very closely compacted texture, while the color is decidedly a green, generally a dirty light shade, mottled or even spotted with a dark shade.

The normal form, however, seems to tend toward a uniform shade lying between the two, though the mottling is even here hardly lost. This normal form does not necessarily lie at, nor next to, the bottom of a bed, for variations from it are somewhat irregular, though generally arranged parallel with the plane of bedding; but it seems never to occur near the top and adjacent to the overlying amygdaloid.

Taking the most uniformly colored rock, the glass discloses it to be composed of small crystalline grains of light green feldspar, thickly scattered in, or rather mixed with, a dark green, soft, amorphous, generally earthy, sometimes shining mineral, which is undoubtedly a chlorite, and which, according to Macfarlane's analyses, would seem to be delessite.

Here and there, but wholly subordinated to these two principal ingredients, are shining flakes, sometimes set in a dull reddish spot, which have a brown streak and iron reaction, and which probably are specular iron, while grains of magnetite occasionally appear. Still more sparingly, small black crystals, as if of hornblende, occur in the delessite, and sometimes flakes of rubellan (?).

The feldspar sometimes assumes a pinkish hue, which, with the green, produces a subdued but decided purplish shade. This change is seldom uniform, but confined to irregular spots, giving a rude purple mottling upon the green base, an extension of which produces a purplish base with a green mottling.

This tendency, however, is almost *nil* in the coarser (*a*) rocks, though always present in the typical (*c*) rocks; in fine-grained rocks a suggestion of it is almost always present, which sometimes, by going through almost imperceptible changes, may have a dull, uniform, purplish-brown rock.

Returning to the rocks of the (*a*) series, which to the eye approach a uniform texture and color, there is found, a few feet farther on, generally above, a tendency in the delessite to segregate into spots to the exclusion of the feldspar. These spots at first are of decidedly indefinite and irregular boundary, and tend to produce the effect of mottling; but farther on they are more definite

and less irregular in shape, though seldom perfectly round, till, finally, the well but not sharply defined spot of earthy-looking, dark green delessite stands on a background of nearly uniform shade or uniform mottling of shades. This background in these rocks is of a dirty light or grayish-green, and is composed mostly of feldspar, though much delessite still remains. In the change, however, the feldspar is apt to assume a pinkish shade.

It is through some such changes as these that the rock always passes in approaching the form of the amygdaloidal melaphyr, into which is an easy transition; the delessite spots becoming more definite amygdules, generally accompanied by the entrance into them of some laumontite, calcite, or prehnite.

The matrix generally remains much the same as the melaphyr below, though the feldspar is apt to become pink or red, and often porphyritically imbedded in a fine-grained mixture of feldspar and delessite, very occasionally in delessite alone. If laumontite and other minerals are present together in the amygdule, the former is always the oldest, following the delessite (see paragenetic series). The entrance of these minerals seems to be by a replacement of the delessite.

From a bed in the southern part of the Phœnix mine, containing generally delessite amygdules, many amygdules could be easily broken out intact. Some of these amygdules averaged an inch in diameter, somewhat irregular in shape, and outwardly of shining green delessite.

Upon breaking them open, however, they showed a variety of structures. One seemed to be wholly composed of what appeared like a crystalline granular mixture of white calcite and pink laumontite in a light green base. Much of this base is of dark green, as if of the original delessite filling, some of which still coats the amygdule, while the lighter green seems to contain prehnite. Laumontite crystals sometimes enclose dark delessite, while calcite sometimes encloses, in a thin coating, laumontite. The cleavage faces of the calcite particles throughout the amygdule all reflect the light at the same incident angle, showing a uniform tendency to crystallization throughout it.

In another amygdule much of the periphery was like the above, but, instead of filling the amygdule, it rapidly changed into pink prehnite, which in time became green in the interior, some spots of

delessite still remaining and particles of copper being present. In a third case, the outside was much like the first, except that the light green matrix was nearly all prehnite;—this changed into a prehnitic interior like the second. Again, a portion of the periphery was composed of very small grains of delessite and laumontite, changing along an irregular boundary into a radiated laumontite core. In the accompanying fine-grained rock may be seen incipient delessite amygdules of various sizes and stages of development, some having the usual laumontite core.

The gradual development of a delessite amygdule in a melaphyr seems undoubted. From the above facts it would seem that the genesis of the laumontite was also a true metamorphic change, and took place, not by the filling of a cavity, but by direct replacement of delessite; while the incoming of prehnite and calcite would seem also to belong to the same class of changes, probably by the replacement of laumontite.

In the characteristic amygdaloidal melaphyrs of the (*c*) rocks, it has been already noticed that while a purple green mottling is nearly always present upon the rather fine-grained and closely textured rock, it seldom seems to develop, as in certain beds of the (*a*) series, into delessite amygdules. The amygdules, instead, contain a salmon-colored radiated prehnite, in appearance strongly suggestive of radiated laumontite, but which shows, in many instances, a gradual transition through vitreous pink to transparent green, non-radiated prehnite. Though there is no direct proof of the genesis of this prehnite, the facts noticed above, together with the occurrence of laumontite associated with it in a few beds (Nos. 18 and 30) would indicate that it was all derived by replacement of laumontite, which, in turn, replaced delessite. Perhaps the very resemblance of the radiated prehnite to radiated laumontite may indicate a step in this change. It seems strange, if such transition has taken place, especially when its large extent is considered, that it should not have left an easily discovered record of the intermediate steps. The beds having this character, however, contain numerous sandstones, which would readily allow of the penetration of metamorphosing agents.

Some one of the transitions from melaphyr to amygdaloidal melaphyr, as have been described, almost always occupies a more or less wide zone between a melaphyr and its overlying amygdaloid.

It also often occurs within a melaphyr, though generally in a zone parallel with the plane of bedding. But besides these cases, it is also found *cutting directly across* the bedding, in which case it accompanies a vein, joint, or fissure, from which it may extend several feet either side, the intensity of the action being greatest near the vein. The change here is just the same in kind, and often in degree, which takes place beneath an amygdaloid, amygdules of delessite and laumontite being common, sometimes with prehnite and calcite, though generally not well developed. These facts, especially the latter, point to the conclusion that the transitions from melaphyr to amygdaloidal-melaphyr are of a truly *metamorphic* character, that they were impressed upon an approximately homogeneous rock by chemical action long after it was first formed, and that the amygdules which mark this change were thus slowly developed, and are not the mere fillings of pre-existing cavities.

In passing to the consideration of the amygdaloids, it becomes more difficult to clearly distinguish between that part of their structure which existed in the original rock and that which is due to subsequent metamorphism. From what we have seen, it seems almost possible that metamorphism, by carrying the process a step beyond the formation of an amygdaloidal melaphyr, might produce an amygdaloid. The differences between the two have already been sufficiently pointed out. After the number, irregularity, contents, or general development of the amygdules in an amygdaloid, their next most noticeable characteristic, and one much less easily accounted for by metamorphism, is the almost invariably fine-grained, compact, or even earthy nature of the base, no matter how coarse the underlying melaphyr may be. But the strongest proof would seem to be in the structure of the so-called scoriaceous amygdaloids. In these, patches or balls of amygdaloidal material are associated, even surrounded by, an imperfectly stratified material, which is undistinguishable from the true fine-grained sandstones.* This association is such that it seems as if it could in nowise be accounted for by metamorphism acting on sedimentary beds, but only by supposing a peculiar mixture of the materials at the time of deposition,

* The nature of this material is set forth in speaking of the sandstones, p. 113, as well as the association mentioned, which is also more especially noticed in detail descriptions of beds No. 45, p. 125, and No. 65, p. 129.

which mixture is not such as sediments assume. In these amygdaloids, also, there is sometimes a well-marked plane of demarcation between the amygdaloidal melaphyr—or the amygdaloid, perhaps—and the scoriaceous amygdaloid which rests upon it. The fact that in sandstones which are intercalated between two trap beds the upper parts, for several inches from the hanging wall, are often changed as if by heat, while at the bottom contact there is no such change, cannot be offered as an objection to the metamorphic theory, for it would be in just such regions that metamorphism would naturally occur. But the fact that sandstone material seems to have entered amygdules near the upper part of beds covered by sandstones; that it may fill a well-defined crack extending down into an underlying melaphyr (see p. 113 and p. 119), or that melaphyr may nearly surround pebbles apparently caught up from an underlying conglomerate (p. 119); these facts, as does the peculiar structure of the scoriaceous amygdaloids above noticed, seem to point to a very different origin for the melaphyrs than a sedimentary one.

It would seem, then, that the fine-grained nature of the amygdaloids, together with amygdaloidal cavities, probably originated with the bed, though both must have been strongly affected by that metamorphism which has produced the more prominent features of the amygdaloidal melaphyrs. The amygdules must, in many cases, have been much changed, in size and shape, and subsequently filled, by this agency, while the small feldspar crystals often found porphyritically imbedded in the amygdaloidal matrix may also be due to this cause. Whenever well exposed, the melaphyrs generally exhibit, from a few inches to a foot or more from their foot-walls, a modification similar to the amygdaloidal melaphyr of the same bed, with sometimes a true amygdaloid at the very bottom. These three often shade gradually the one into the other, and, as at the top, it is impossible to accurately draw the line between what is original structure and what due to metamorphism.

As a whole, then, the *structural* features of these beds remarkably resemble those of true lavas. They have been affected, however, and to a very great extent, by metamorphism, and this metamorphism has taken place in such a manner, has so heightened and carried on the original structure, as it were, that the ordinary

proof of their igneous origin, such as contact changes in adjacent sandstones, presence of amygdules, etc., fail, and it seems natural to consider this metamorphism as a *vera causa* for the whole structure. Certain extraordinary features, however, as noticed above, seem wholly incompatible with this idea, and when considered as true igneous rocks in which great and peculiar metamorphism has taken place, all the phenomena presented seem to be satisfactorily and naturally accounted for.

The general structural features of these beds long ago gave rise to the belief that they were of igneous origin, a belief now almost universal in the mining regions; while the metamorphic changes which have taken place in them since their formation are not generally recognized, if indeed suspected. These changes, however, have been both very many and very great; so great, in fact, that, as seen above, when once examined they seem almost sufficient to have developed all the peculiarities of the beds from sedimentary deposits.

The practical importance of the recognition of this metamorphism, and of a proper understanding of its methods and effects, will be apparent when it is recollected that to it is due all the economical value that the beds possess. The beds as originally formed probably contained the elements of its minerals, together with its copper and silver, more or less disseminated through their mass, as much so remains till the present day, or else they were so contained—at least in part—in overlying rocks, and in this form they could have been of no economic value; nor could any process taking place at that time have concentrated the minerals in the manner in which they now occur.

One hears of the melted copper being squeezed from the adjacent heated rock into the veins, and run into amygdules as bullets into a mould, the facts being ignored that—supposing the hydraulics of the case possible—these rocks, at the temperature of melted copper, would no longer be what they now are; and also that, at such a temperature and under a moderate pressure, a fissure, supposing it once formed, would be immediately welded solid again; while in amygdules copper is seldom, if ever, the only occupant, but occurs in them in company with minerals which are readily changed by heat, but which never show such change. The fact that chemically pure silver and copper constantly occur intimately united, but

never in the least degree alloyed with one another, proves that they could never have been so placed by the action of heat, for it is well known that in melting they would have alloyed instantly. Suppose that, in an amygdaloidal cavity or vein, transparent crystals of quartz stand upon crystals or masses of green prehnite, fitting into their irregularities and touching nothing else, and that no replacement has taken place, it is clear that in such a case the quartz must have been placed upon and adapted to the form of the prehnite after the latter had been placed in its position and had assumed definite form. Prehnite, however, will almost melt in the flame of a common candle, while quartz is one of the most infusible of substances, and could not possibly have been placed upon the prehnite by the agency of heat alone without the fusion of the prehnite and the destruction of its form, to say nothing of the various other chemical effects that would be induced. Moreover, the quartz, after melting, is found to have a different specific gravity than when crystallized.

This is but one of many cases. In fact the whole manner of occurrence of, and general relations between, the many refractory and easily fusible minerals which occur in a similar way in these rocks shows that great heat has had absolutely nothing to do with arranging them as they now are. The result must be looked for in some other cause. Does chemical action supply such a cause?

Many experiments have shown that carbonic acid and oxygen held in solution in water can readily attack alkaline silicates, and that these, or similarly obtained substances, even in apparently insignificant quantities, are powerful agents in changing rock masses, provided sufficient time be allowed for them to act. Water falling upon the earth soon obtains these reagents from the atmosphere, decomposing vegetation, soil and rocks, as proved by the fact that all spring water which has travelled any distance through rock-masses always contains them. In this form, these agents are generally recognized as producing many metamorphic changes, and are known to have produced effects quite antagonistic to those produced by heat.

All the phenomena tend to prove that it is by means of some such chemical actions as these, continued through long periods of time, that the metamorphism of these beds has been effected. It is such metamorphism which has developed the amygdaloidal mela-

phyrs, formed segregations, modified and filled the veins and amygdules, placing in them their minerals in the present relative positions; and, in the general process, the copper, like the other ingredients, was selected from its disseminated and therefore useless condition, and concentrated in veins, amygdaloids, and conglomerates till it reached a percentage of richness that gives to the deposits an economical importance.

This action has taken place certainly not at a high temperature, and possibly at a temperature no greater than that of the beds at present, while it may have been largely aided by that electric action which chemistry almost always induces, and which is known to be active at the present day. In fact the presence of the latter is proof that chemical action is even yet going on.

This metamorphism, then, being the means by which these ore deposits have been formed, it is evident that a knowledge of its laws and methods should lead to important practical results. It is not necessary for me to say that the studies in Chapter III. go a long way in discovering these laws, and it is hoped that they may be still further developed until wholly known.

SANDSTONES AND CONGLOMERATES.—Interbedded in the northern 2,300 feet of the section are ten sandstones, which aggregate about 860 feet in width, and which, as a rule, may be considered as increasing in thickness and coarseness toward the north.

Commencing with the southernmost one and going north, we have—

Bed No.	Width in feet.	Character.
35	55	Rather coarse.
28	18	Rather coarse; inclined to conglomerate.
26	50	Very fine, shaly.
21	33	Very fine, banded, and shaly.
19	45	Coarse; some conglomerate.
17	120	Medium fine, shaly; some conglomerate.
8	170?	Rather coarse; some conglomerate.
6	280?	Coarse as far as known; much covered.
4	10?	? ?
2	282?	Coarse; considerable conglomerate; much covered.
		Above the Melaphyr occur—
–1	129	Coarse; with considerable conglomerate, coarse and fine.
–2	Over 4,000	Coarse conglomerate.

These are apparently all composed of the same materials.

The predominant pebbles of the conglomerates are of a compact chocolate-colored, felsitic rock, generally with small, lighter-colored crystals of a triclinic feldspar, porphyritically imbedded in it. Next is a coarser-grained, crystalline, hard, reddish, felsitic rock. Pebbles of quartz-porphyry occur sparingly, and occasional pebbles of a rock somewhat resembling some fine-grained melaphyrs.*

The sandstones seem made up of the same ingredients; they are generally of shades approaching brick red. All contain much calcite as an impregnation. This often occurs, filling small lenticular cavities, which may occur grouped together for a few inches parallel to the formation, and may have replaced a constituent of the rock; it also fills veins where they intersect the beds.

Where observed, the hanging-walls of the sandstones were generally smooth and gently undulating, but occasionally quite uneven, while the upper two to twelve inches were somewhat changed, being harder or softer, or lighter or darker-colored than the mass of the bed. In one instance, at the top of Bed No. 2, this change was so great as to render the sandstone difficult to distinguish from the overlying greenish melaphyr, except for the unchanged pebbles enclosed in it. The foot-walls are sometimes smooth and undulating; the surface of the underlying bed, when not an amygdaloid, as was sometimes the case, seeming to have been worn smooth, as if by attrition; or else the sandstone seemed to fill inequalities in the underlying amygdaloid.

The sandstones were not observed to be changed near the foot-wall. In one remarkable instance, a crack or fissure was observed extending down into a melaphyr, which was filled by the overlying sandstone. The conclusion is inevitable, that the melaphyr had formed, hardened, and cracked before the sandstone was deposited.†

Lying south of the sandstones there are several others scattered along the section, but which occur as mere seams of only a few inches in thickness, and generally on the surface of, and intimately associated with, the upper part of the so-called scoriaceous amygdaloids. Though these seams are generally too fine-grained to distinguish the form of their component particles, and no pebbles were observed, yet they undoubtedly are true sandstones.

* See description of Beds Nos. –2 and –1, pages 117 and 118.

† For this and the irregular metamorphosed hanging-wall, see figures on p. 119.

They are of the same color, and in places often, though irregularly, banded or stratified—in one instance breaking shaly, with wavy laminæ. Both contain much calcite as an impregnation, often in small lenticular cavities. Before the blow-pipe they behave like the sandstones, the harder varieties fusing with difficulty, the finer ones more easily, in fine splinters, and without intumescence, to a green-black mass. In some cases, where foreign material seems present, some intumescence occurs, but less than with the melaphyrs. Their specific gravities are the same as those of the sandstones, and lower than those of the melaphyr, ranging from 2.56 to 2.70, reaching in one case 2.80 (compact shaly).

The conglomerate pebbles are probably heavier, one of the chocolate-colored, non-quartziferous, felsitic porphyry having a specific gravity of 3.02.

The red-clay seam, a few inches thick, underlying the "greenstone" at the Phœnix mine, and known as the "slide," is the equivalent of the Allouez conglomerate, which a few miles either way along the formation expands to a thickness of 15 or 20 feet.

The "Kingston conglomerate,"—which was exposed by Mr. A. H. Scott about 500 feet south of the centre of Section 33, Town. 57, Range 31,—lies about 5,870 feet horizontally from the "greenstone," and is about 45 feet wide. This is entirely different from the preceding beds, and belongs to the quartz-porphyry type of conglomerate, as does the Calumet conglomerate. The predominant pebble is of a hard, compact, brownish-red, felsitic rock, containing quite numerous flesh-red to pearly-white crystals of orthoclase feldspar, occasionally over .25 inch in length; and grains of colorless, transparent quartz, ⅛ inch in diameter and under, which appear black from non-transmission of light. It strongly resembles the Kearsarge conglomerate exposed near Calumet, and if the mean dip of the formation between the greenstone and the Kingston conglomerate were about 25°, it would be the same bed as the Kearsarge. The dip, however, is probably steeper, so that it probably lies 600–700 feet east of the Kearsarge.

VEINS AND FAULTS.—The system of rocks described in the preceding pages is intersected by numerous veins, in many of which movement or faulting has taken place.

Two principal systems seem to exist: first, in which the trend is about N. 15° W. to N. 25° W., with a nearly vertical dip, but

perhaps tending eastward; second, with trend perhaps averaging N. 16° E., dip also nearly vertical, tending eastward. Besides these, several veins have been noticed trending nearly with the formation, but having a much steeper dip.

Upon the first system more or less faulting has generally occurred, though some of the better defined veins show none. In those cases where opportunity was had to measure the amount of throw, the distance varied from a few inches to about 75 feet, the eastern side always having moved northward. In the large faults of this system, however, which are generally occupied by the larger transverse valleys, or breaks in the range, the detritus in which hides the actual fault and its amount of throw, the throw is obviously in the opposite direction,—the east side moving south,—and it is generally sufficiently great to more than counterbalance those faults which have thrown the strata in the opposite direction. The formation, which is slowly changing its trend—in going east—more and more to the southward, at some of these larger faults makes a sudden bend of a few degrees in the same direction, so that these large faults act both by offsetting and bending, in increasing the general curvature of the formation.

Faulting was not noticed in the second system, and a fault of only a few inches in one case in the third.

But movement has taken place upon the formation along certain planes of bedding separating the strata. The so-called "slide"—lying a few feet above the "Ash-bed"—is a case in point, the rocks above having slid down upon those below probably about 150 feet.

Motion also seems to have taken place upon the "slide" at the base of the Greenstone—the horizon of the Allouez conglomerate, here occupied by a clay seam—but probably to no great extent, it being said that veins are not displaced by it. Movement may have similarly occurred at other points as yet undiscovered.

The veins of the district were of course formed long after the consolidation of the beds, and probably when they were being lifted into their present position. They have subsequently been filled with the various minerals which now occupy them, wholly by infiltration and chemical, probably aided by attendant electric, action, and in a systematic and natural sequence, as shown by the paragenetic table. The more successful mines seem to have been worked

in the first system of veins, on one of which the present Phœnix mine is now working. The "old Phœnix," however, on a similar vein, but farther north, was not successful. The work upon the Robbins and Armstrong lodes, both of the second system, was not remunerative in either case.

Besides vein-mining, considerable work was formerly done on the "Ash-bed," but without success. There is no apparent reason, however, why there should not exist beds in this region, either of amygdaloid or conglomerate, as near Portage Lake and elsewhere, which it would be profitable to mine for copper. A better examination of the "amygdaloidal floors" already exposed in the vein-mines might lead to profitable returns.

A system of vein and bed mining could be carried on simultaneously with considerable economy, the one helping the other: the beds generally carrying a low but nearly uniform per cent. of copper, the veins more generally containing larger but more erratic and uncertain "masses."

CHAPTER VIII.

DESCRIPTIVE CROSS-SECTION OF THE EAGLE RIVER DISTRICT.

By A. R. Marvine.

The following chapter gives a detail description of the various beds which compose the Eagle River cross-section. Attention having been called in the preceding chapter to the more prominent features of the section, this chapter is intended only to be of service in prosecuting any mining enterprise, in which it would be useful to know the distances and the nature of the rocks to be passed, or of use in correlating or comparing in detail with any sections which future surveys may make in other parts of the copper region.

The initial point of measurement and numbers is at the foot-wall of the wide northern conglomerate and sandstone, lining the lake shore, or, what is the same thing, the hanging-wall of the northernmost melaphyr of the section, as exposed at the lower fall and dam just above the town of Eagle River. From this point the beds are numbered in regular order going south, while occasional larger numbers upon the left give the total *horizontal* distances of certain points, also measured from this initial point. Common Arabic numerals, also on the left, are used to express the *horizontal* widths of beds in feet, while numbers standing alone in parentheses always express actual *thicknesses* of beds, or parts of beds, measured *perpendicular* to the plane of bedding.

–2. **Conglomerate**; over 4,000 feet wide; variably bedded thick and thin; large pebbles predominating in some strata, coarse sandstone in others; latter sometimes cross-stratified, sometimes inclining to a shaly structure. Generally coarse, with predominant pebbles from 3 to 8 inches diameter, often 1 foot and more, cement being smaller pebbles and coarse sand. No angular fragments, many not perfectly rounded, those rounded affect oval form. Majority composed of (*a*) non-quartziferous porphyry; matrix, predomi-

nant color, liver to chocolate brown, compact to subcrystalline; crystals, subordinate, sometimes nearly absent, always scattering; small, generally $\frac{1}{50}$ to $\frac{1}{20}$ inch long; generally somewhat lighter colored than the base. Flesh-red crystals .1 to .5 inch long sometimes occur in chocolate-colored matrix. The crystals in these seem to be of triclinic feldspar. Subordinate to these occur (*b*) pebbles of a coarser, but compactly crystalline flesh-red

+ 4000 felsitic rock, the light reflecting from the many small cleavage planes of the fractured crystals which form the rough broken surface. Numerous black specks of unknown nature occur (quartz?); exceedingly hard, and hence often in large pebbles. So far as seen these two varieties compose most of the bed. Very occasionally there occur (*c*) pebbles having a dull brick-red, hard, compact inclining to jaspery matrix, in which are pretty thickly scattered crystalline grains of black quartz from .02 to .20 inch diameter, together with flesh-red to pearly crystals of feldspar, probably orthoclase, from .1 to .6 long. The quartz appears black from non-transmission of light, being in reality colorless. It is invariably fractured upon breaking the pebble, and lies about flush with the fractured surface, which is uneven, and generally exhibits a rude hexagonal outline. Pebbles of a rock (*d*) very closely resembling some fine-grained or compact melaphyrs also sparingly occur. The matrix and sandstone layers are apparently composed of the same ingredients as the pebbles, small quartz grains sparingly but pretty generally occurring. Calcite, generally white, opaque, with rhomb cleavage, frequently occurs impregnating the mass, and filling the cavities and the veins where they pass into the bed.*

–1. **Sandstone;** generally coarse but varying from harder, thicker, coarser beds, generally more or less cross-stratified, to finer, thinner, shalier

129 ones. Bands of pebbles occur, and much calcite is present; composition
(68) same as above; general color, dull brick red.

— o — *Junction*, well defined, slightly undulating, quite smooth; no contact change in either bed.

1. **Amygdaloid,** inclining to amygdaloidal melaphyr; amygdules not abundant, scattered, containing calcite, sometimes with laumontite and a light green green-earth. Matrix same as underlying accompanying **Melaphyr,**

85 which has a medium coarse-grained texture and semi-conchoidal inclined
(48) to uneven fracture. Prevailing color a light grayish green, rudely mottled with dull flesh red. The dark green chloritic element is very subordinate; glistening black specks of specular iron occur, and much disseminated white calcite. Specific gravity, 2.94. Tendency toward amygdaloidal zones in the bed; lower two feet amygdaloidal.

— 85 — *Junction*, very irregular. For two feet the underlying sandstone is
(48) changed and indurated, being, in places, hardly distinguishable from the overlying melaphyr, except for enclosed pebbles which are not changed.

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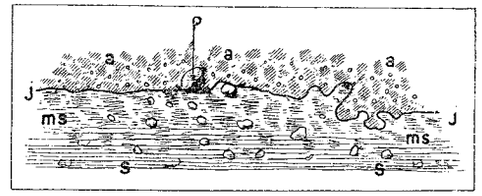
* It is in a vein in this horizon that the impure manganese occurs, at Manganese Lake, near the extremity of Keweenaw Point.

Some pebbles rest upon the hanging-wall which are quite enclosed in the overlying amygdaloidal melaphyr.



a a—Amygdaloidal melaphyr.
s s—Sandstone with pebbles.
j j—Junction of a and s.
m s—Metamorphosed top of s, with unchanged pebbles.
p—Pebble surrounded by a.

5 2. **Sandstone;** coarse, some conglomerate. Same as No. –1.
(3)

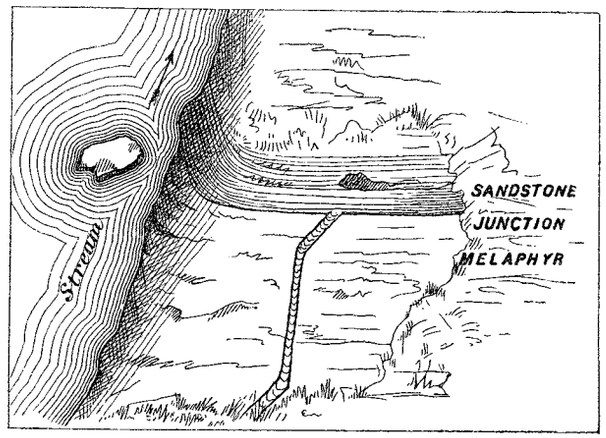
70 *Covered* (probably sandstone).
(37)

55 **Conglomerate** and sandstone. Same as No. –1.
(30)

148 *Covered* (probably sandstone).
(78)

4 **Sandstone;** rather coarse. Same composition as the preceding.
(2)

— 367 — *Junction*, slightly undulating. No change or metamorphism in the ad-
(198) jacent beds. Extending from the junction down into the underlying



melaphyr—about eight feet being exposed—is a fissure or crack with sharply defined edges and two abrupt bends, giving widths of two and four inches. This crack is filled with sandstone similar to that above, but somewhat finer and slightly decomposed or softened. There is an appearance of irregular, but rudely curved stratification, about parallel, as a whole, with the formation.

3. **Melaphyr,** inclining to amygdaloidal melaphyr; medium coarse texture. Color dull reddish purple, sprinkled with numerous small green spots; former mostly feldspar, latter delessite. Some amygdaloidal portions have delessite spots of larger size, enclosing radiated laumontite.

50 (26)

4. **Sandstone.** Same as –1.

10? (5)

5. **Melaphyr,** inclining to amygdaloidal melaphyr; resembles No. 3, slightly finer,—more purple; occasional calcite amygdules, and small feldspar crystals porphyritically imbedded in the base.

40 (21)

Covered, probably sandstone.

175 (89)

6. **Sandstone,** similar to preceding; rather coarse.

40 (21)

Covered.

160 (83)

7. **Melaphyr,** inclining to amygdaloidal melaphyr, rather irregularly. Upper 15 feet are of dark green decomposing melaphyr. The lower 10 (5) feet are of irregular **Amygdaloid**; decomposing; the harder parts composed of a rather compact dark reddish-green base, containing small scattered flesh-red feldspar crystals, and irregular, generally elongated, amygdules of delessite, containing calcite and sometimes accompanied by small amounts of prehnite and laumontite. Enclosed in this amygdaloid are some irregular patches of fine-grained light gray melaphyr.

25 (13)

Junction, well defined, straight; rocks adjacent rather soft, and weathering; slight stains of carbonate of copper.

867 (456)

8. **Sandstone;** upper few inches somewhat changed by the overlying rock. Same composition as the preceding sandstones. Ten feet quite consistent, followed by ten feet shaly; rest not well exposed; some conglomerate occurs.

90 (47)

Covered, probably sandstone.

88 (45)

9. **Melaphyr;** medium to fine grained; color light grayish, from minute light-green and dark-red component spots; fracture uneven, inclined to smooth; rather hard and elastic; many small calcite cleavages glistening over the fractured face; no magnetite. Lower ten inches are amygdaloidal; calcite with some laumontite amygdules, increasing toward the foot-wall.

14 (7)

Junction, well defined.

1059 (555)

10. **Amygdaloid;** base reddish-brown; compact, not indurated; amygdules very irregular, from .05 to .50 inch longest diameter, composing about 40 per cent. of the rock and filled with calcite accompanied sometimes by small amounts of green-earth and some prehnite for about ten feet, and then gradually changing through rather fine-grained.

20 (10)

Amygdaloidal Melaphyr to **Melaphyr** at fifteen feet; general color greenish-purple, composed of light-green feldspar crystals and small red specks; fracture uneven; occasional calcite amygdules.

26 (14)

11. **Amygdaloid,** and **Amygdaloidal Melaphyr,** similar to No. 10, but not well developed.

12. **Amygdaloid,** 15 (8) feet, similar to that of No. 10; 50 per cent. amygdules.

50 (26)

Amygdaloidal Melaphyr, 30 (16) feet, and **Melaphyr,** 5 feet; color greenish-gray; finer grained and harder than No. 10; fracture somewhat uneven. Lower foot amygdaloidal, calcite amygdules.

13. **Amygdaloid;** narrow, 5 feet, but well developed; base fine grained; purple; amygdules mostly calcite, at top with considerable green and white prehnite and scattered specks of copper and some datolite. **Amygdaloidal Melaphyr;** 20 feet; base somewhat coarser grained; dull dark green, mottled purple; fracture uneven; amygdules scattering; laumontite, sometimes surrounding a green-earth core; some of delessite and calcite.

40 (21)

Melaphyr; 15 feet; inclining to amygdaloidal, with delessite spots; lower foot quite amygdaloidal.

1195 (626)

14. **Amygdaloid;** 10 (5) feet; very fine-grained to earthy, reddish-brown base; amygdules irregular, not ramifying, reaching .3 inch diameter, and forming about 30 per cent. of the rock; some of calcite with delessite lining; rest partially, some wholly, filled with prehnite, some of which are further filled with calcite; ramifying seams of prehnite occur, with some copper.

30 (16)

Amygdaloidal Melaphyr; 20 (11) feet; medium fine grained; mottled dirty green and purple; scattering amygdules of delessite and laumontite.

15. **Amygdaloid;** 4 (2) feet; similar to No. 14, but subordinate; some

87 (45)

Amygdaloidal Melaphyr and **Melaphyr;** 75 feet; medium fine-grained; irregularly mottled green and purple; irregular to hackly fracture; much like melaphyr of No. 14.

1312 (687)

16. **Amygdaloid;** 25 (13) feet; mixed soft and hard, former predominating; upper part, as usual, much the best developed; irregularly associated with and changing to amygdaloidal melaphyr; the base of the amygdaloid is very fine-grained to compact; greenish to red brown; amygdules irregular and ramifying, forming 20 to 40 per cent. of the rock, mostly of calcite and prehnite, small amounts of copper generally accompanying the latter.

43 (22)

Melaphyr; 12 feet; medium coarse-grained; intermingled dull-green and purple ingredients, giving a mottled greenish-purple color, relieved by numerous small greenish-white feldspar crystals, which sometimes are .1 inch diameter.

120 (63)

17. **Sandstone;** medium fine-grained; specific gravity 2.56; mostly rather heavily bedded, some thinly bedded and shaly, and some conglomerate layers; color dull brick red; not well exposed.

18. **Amygdaloid** (?); narrow; mostly covered; not well observed.

Amygdaloidal Melaphyr; 17 (9) feet; characteristic; base rather fine-grained; indefinitely mottled dull green and purple, former sometimes prevailing, giving a dark, dirty, dull-green color, and sometimes the latter, giving a handsome purple hue to the rock; fracture generally uneven, sometimes approaching conchoidal, not rough; rather tough and elastic. In this base are sprinkled amygdules reaching .5 inch diameter and averaging about .3 inch. These occur from very occasional to where they are irregularly scattered, but averaging .5 to 1 inch apart, being generally more numerous toward the upper part of the bed. These amygdules are all filled, and almost invariably with prehnite, sometimes having calcite in the interior. Very occasionally the prehnite has its characteristic green hue; but this only occurs near the centre. More often it has a flesh pink color and vitreous lustre and fracture, either radiated or not, in the latter case strongly resembling rose quartz. It is in this form, inclining to green, that it may enclose calcite, and in which it resembles the characteristic prehnite amygdules of the "Isle Royale"
24 (13) series of rocks near Portage Lake. But the most characteristic and predominant form that the prehnite assumes is one in which the color has less red in it than pink, being a whitish salmon color, without a vitreous lustre, while a well-developed radiated structure gives a fracture as if from interrupted cleavage. It much resembles laumontite, but is harder. The radiations diverge from a point on one side, like a palm-leaf fan, or from two, or even three, points, the systems meeting along curved lines. In a flat-sided amygdule, the radiant point will be at the corner, the rays being at first parallel to the flat side. Occasionally, immediately about the radiant point, salmon-colored prehnite occurs, changing into the rose colored variety toward the extremity; and more often a dull, earthy green band runs through the amygdule, concentric with the radiant point. The outer surface has often a thin coating of delessite; but as often the prehnite is in direct contact with the base. This contact is intimate, never perfectly smooth, but always uneven, sometimes very irregular, and never suggestive of a filled-up cavity, but rather—as in most amygdaloidal melaphyrs—of a segregation. The base but seldom exhibits a changed appearance near the amygdule, though, as a whole, it is apt to differ somewhat from the underlying melaphyr.

Melaphyr; 4 feet; same as the base of the above; slightly coarser.

(20) *Covered;* possibly occupied by an amygdaloid, etc., like the preceding,
11 probably by melaphyr.
10 (5) **Melaphyr;** like that of No. 18.

19. **Sandstone;** rather coarse; some conglomerate layers; mostly covered;
±45 (24) neither wall observed; same as the preceding sandstones, and, like them, having carbonate of lime generally present.

20. **Amygdaloid;** 10 (5) feet; soft, decomposing; mostly covered; calcite
70 (37) predominating. **Amygdaloidal Melaphyr,** followed by some **Melaphyr;** same as No. 18.

21. **Sandstone;** mostly covered; very fine; some thinly banded light and
±33 (18) dark red; in parts slightly indurated, tending toward jasper; no junction visible.

119 (62) 22. **Amygdaloid;** 10 (6)? soft; decomposing; mostly covered.

Amygdaloidal Melaphyr; 30 (16); specific gravity, one piece, 2.72; and **Melaphyr;** 79 (40); specific gravity, 2.77; same as No. 18.

14 (7) *Covered;* probably occupied by an amygdaloid (No. 23) and amygdaloidal melaphyr similar to the preceding.

14 (8) 23. **Amygdaloidal Melaphyr;** 5 feet; and **Melaphyr,** same as No. 18.

17 (9) 24. **Amygdaloidal Melaphyr;** 5 feet; and **Melaphyr,** 12 feet; same as preceding, inclining to purple.

25. **Amygdaloid;** 20 (10) feet; some hard; matrix compact, purplish brown, with occasionally whitish-red crystals of triclinic feldspar, sometimes 2 inches long, imbedded in it. Near hanging-wall are irregular bunches of calcite, some prehnite; amygdules often reaching .25 inch diameter,
30 (16) and rather irregular; forming 50 per cent. of the rock near the top; mostly of calcite in thin pellicle of delessite, and sometimes enclosing green prehnite with little copper; amygdules with red lining (feldspar?) enclosing quartz, and often copper, occur in the harder parts.

Amygdaloidal Melaphyr, inclining to melaphyr, 12 (6) feet; similar to that of No. 18; amygdules small, not well marked.

26. **Sandstone;** in part very fine-grained to compact texture, inclined to shaly
±50 (26) structure; laminæ $\frac{1}{8}$–$\frac{1}{4}$–$\frac{3}{8}$ inch thick; remainder thicker bedded and coarser; specific gravity, 2.68; composition same as the preceding, having occasional black quartz grains, and the usual calcite impregnation.

1921 (1008) *Junction;* smooth; slightly undulating; no apparent contact metamorphism.

27. **Amygdaloidal Melaphyr;** 10 (5) feet; poorly exposed; amygdules of delessite and some prehnite in a green base, which beneath becomes

Melaphyr; 15 (8) feet; rather fine-grained; irregular fracture; of dark and light green components; similar to that of No. 18, but without the
79 (42) purple element of the color. At 25 (13) feet from the hanging-wall it becomes amygdaloidal, with many amygdaloidal-like segregations of delessite, which are somewhat indurated but inclined to earthy; centre light green, circumference dark green, the base being strongly inclined to purple. Amygdules of quartz-like and radiated salmon prehnite also occur occasionally. Without having well-defined walls, two or three more amygdaloidal zones occur parallel with the bedding, with the greener melaphyr between. Lower 10 feet are of the darker, mottled, dirty green **Melaphyr,** somewhat coarser than the rest.

18 (9) 28. **Sandstone;** rather coarse, inclining toward conglomerate; similar to No. –1; non-quartziferous, chocolate-colored, felsitic rock, with occasional small feldspar crystals, predominating.

2022 (1159) 11 (6)

29. **Amygdaloid,** inclining toward amygdaloidal melaphyr; 6 (3) feet; matrix dark, purplish brown; fine-grained; amygdules not predominating, mostly of some delessite with calcite and some green prehnite with little copper.

Melaphyr; 5 feet; medium fine-grained; like the purple varieties of the preceding melaphyrs; foot-wall not well defined.

30. **Amygdaloid**; 4 (2) feet; hard, fine-grained, purplish-brown base; amygdules forming about 25 per cent. of the rock, irregular, but neither large nor ramifying; generally contain calcite enclosing prehnite, often the latter alone or enclosing quartz. The prehnite is usually colorless, inclining to light green, and fills also small veins in the rock. It is nearly always—the quartz sometimes—accompanied by little copper.

53 (27)

Amygdaloidal Melaphyr; 16 (8) feet; same type as No. 18, base somewhat coarser, though component crystals are still nearly undistinguishable; green predominates over the purple. Amygdules contain radiating prehnite, but salmon color not marked, often colorless, white; subfibrous, but lustre vitreous. Unlike No. 18, however, these are generally surrounded by laumontite, and many wholly filled with it.

Melaphyr; 33 (17); same as base above; slightly coarser and greener than No. 18.

31. **Amygdaloid**; upper foot having from a very fine-grained to compact, inclined to hard, base of dark greenish-brown color, and containing irregular and ramifying amygdules and bunches of calcite. This graduates into 18 (9) feet of softer and less amygdaloidal material, with coarser and purpler matrix, in which calcite is subordinate, and spots of dark and light

29 (15)

green delessite or green-earth, or both, predominate. Laumontite and radiated pink prehnite also occur. This graduates into

Melaphyr; 10 (5) feet; rather fine-grained; handsome purple, irregularly mottled dark green, with uneven and often rough fracture. Same type as No. 18.

24 (13)

32. **Amygdaloid**; 10 (5); **Amygdaloidal Melaphyr**, 6 (3), and **Melaphyr**, 10 (5) feet, like No. 31.

20 (10)

33. **Amygdaloid**; well developed, calcite and prehnite, often in bunches for 1–2 feet, then less irregular for 10 feet, followed by

Amygdaloidal Melaphyr; like No. 31, but with more salmon-colored prehnite.

27 (14)

34. **Amygdaloid,** and **Amygdaloidal Melaphyr,** same as preceding.

55 (28)

35. **Sandstone**; rather coarse, similar to the others.

36. **Amygdaloid**; mostly covered, 6 to 8 feet soft, decomposing; red prehnite and delessite, followed by 2 feet of harder amygdaloid. This is inclined toward a scoriaceous character, in which occurs very irregularly banded or

41 (21)

thinly stratified material, which is wholly undistinguishable from that in some of the finer sandstones, though somewhat indurated. It often partially encloses irregular bunches or balls of calcitic amygdaloid, while it is impregnated by calcite as is the sandstones. Below this are two feet of soft, blackish green, crumbling delessitic rock, with laumontite scattered through it; crumbling shaly. A normal **Amygdaloid,** inclining to amygdaloidal melaphyr, follows, 28 feet; base dirty light grayish green; delessite, calcite.

Melaphyr; 12 (6) feet; forming base of bed; dirty gray green predominating; occasional delessite spots.

37. **Amygdaloid**; 4 (2) feet; dark, chocolate-colored particles in light-green base, forming grayish-green colored matrix; amygdules of calcite in pellicle of delessite; occasionally of pink and salmon prehnite.

30 (16)

Melaphyr; same as matrix above.

20 (10)

Covered; probably occupied by a coarse, soft amygdaloid—No. 38?—like No. 36.

38. **Melaphyr**; 27 (14) feet; exceptional; quite coarse-grained; fracture somewhat uneven; composed of small, but generally indistinct, crystals of flesh-red triclinic feldspar, and dark-green, to lighter bluish-green amorphous delessite; colors well marked. A soft, dark, chocolate-colored mineral is present in small quantities; no magnetite; particles of metallic copper occasionally appear through the mass, generally in the feldspar crystals; specific gravity 2.79.

27 (14)

39. **Melaphyr**; rather fine-grained; uneven fracture; mottled indistinctly and irregularly dark green and dull purple, former mostly predominating and giving rise to a dirty, dark-colored rock.

150 (80)

103 (54)

Covered; much very amygdaloidal débris.

42 and 43. Space mostly covered; two melaphyrs showing, each probably with an overlying, very amygdaloidal bed. **Melaphyrs** incline to dark color; some being nearly black or greenish black, mottled with very dark, indistinct purple.

95 (50)

44. **Sandstone,** with

45. **Amygdaloid**; 24 (12) feet; forming a "scoriaceous amygdaloid;" composed of irregular bunches or "bomb-like" masses of calcitic amygdaloid, 1.5 feet to .5 inch diameter, filled in with a very fine-grained to compact brick-red material, which often shows fine, but irregular, bands or lines, apparently of stratification. This material increases in amount toward the top of the bed, where it often quite encloses and surrounds the smaller, irregularly round, amygdaloidal balls. The strata-like bands are more evident when the material is in larger amounts, and they often seem to separate or open out to enclose the imbedded balls. In appearance it is undistinguishable from the finer-grained sandstones, though, perhaps,

containing more calcite, which is more often collected into small, generally lenticular, cavities, which are sometimes more numerous in rude, narrow bands, parallel with the bedding, than is the case with the sandstones.

154 (86) **Amygdaloid,** or **Amygdaloidal Melaphyr;** 10 (6) feet; very fine-grained; purplish brown; containing small white and red crystals of feldspar; amygdules of green-earth and calcite, when together, latter contains the former; very little copper. Graduates into

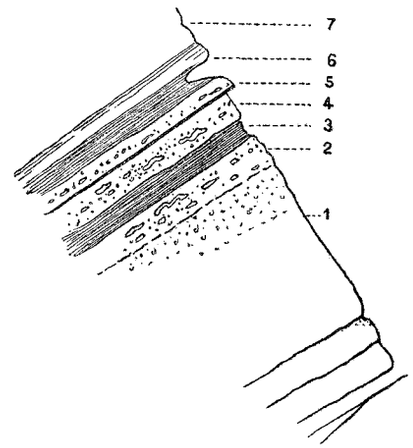
Melaphyr; 120 (68) feet; exceptional; very brittle and elastic, and harder than the average melaphyr, with sub-conchoidal and rather smooth fracture; specific gravity, 2.91; consists of a very fine-grained to compact purplish base, in which are profusely scattered small, semi-transparent, light-green crystals of a triclinic feldspar (labradorite ?), occasionally showing striation, but seldom definite form. Considerable magnetite is present, which, with small flakes of specular iron, occurs scattered here and there, often connected with a small spot of discoloration of the rock to dark brown, as if from hydration. The chloritic ingredient is occasionally segregated out in amygdules, in which flakes of copper sometimes occur. Weathered surface smooth, color gray, with feldspar white. Lower 4–6 inches of melaphyr broken up, rock more compact than above, feldspar crystals red, rock brown. With this, but mostly below it, are 4–5 inches of finely amygdaloidal rock, base compact; purple; red feldspar crystals; amygdules mostly calcite, some green-earth.

2861 / 1503 *Junction.* The line over the broken-up material is strongly marked, while the real foot-wall of No. 44, though a true plane of separation, is not so apparent.

46.	**Amygdaloid;**	(2)	feet; **Amygdaloidal Melaphyr** and **Melaphyr**	(27).	
47.	"	(1)	"	"	(8) feet.
48.	"	(2)	"	"	(4)
49.	"	(2)	"	"	(8)
50.	"	(1)	"	"	(15)
51.	"	(2)	"	"	(7)
52.	"	(2)	"	"	(4)
53.	"	(4)	"	"	(9)
54.	"	(4)	"	"	(10)
55.	"	(5)	"	"	(10)

3100 / (1630) These ten beds, though thin, are well defined. With some variations they are much alike, and may be described as follows, taking No. 47 for the type: Commencing near the middle of one of the amygdaloidal melaphyrs—No. 1 of the adjoining section—we find a rather soft, but tough, medium fine-grained, but not closely textured rock, breaking with an uneven and rough fracture. Upon the purplish-brown base are numerous dark-green, poorly defined, delessite spots. The purple-brown base is composed of the light green or pinkish feldspathic element, and small chocolate colored specks, apparently a decomposition product of an iron mineral, probably specular iron, glistening points of which still remain. Amygdules not numerous, in some beds almost wanting, generally of

delessite, occasionally stellated, sometimes of calcite, laumontite, and green-earth. This grows more and more amygdaloidal in ascending, passing into an irregular, somewhat harder belt, having a finer-grained to compact matrix, with an even reddish-brown color, and amygdules of calcite and green-earth and some prehnite. This changes rather abruptly to a band—No. 2—a few inches wide, of the same base, but very



1. Amygdaloidal melaphyr.
2. Very amygdaloidal; calcite, prehnite.
3. Soft, decomposing, delessitic zone.
4. Same as 2, and top of bed.
5. Hard; not as well developed as 2 and 4.
6. Soft, fissile; delessite and laumontite.
7. Amygdaloidal melaphyr, same as 1.

amygdaloidal, green botryoidal prehnite predominating, with calcite; amygdules very irregular, reaching 5 inches long; the larger ones generally lying parallel with the plane of bedding, and mostly confined to the centre of the narrow belt. No. 3 follows, soft, easily decomposing, dirty brown, containing much delessite; about 6 inches wide; overlain by No. 4, also about 6 inches wide and like No. 2. Its top is the real "hanging-wall" of the bed, having an even, free, plane of stratification separating it from the bed above. The lower two or three inches of this upper bed—No. 5—are rather hard and somewhat like Nos. 2 and 4 below, but not so well developed. It graduates into No. 6, which is very soft, inclining to fissile, and easily decomposing, having in its lower part abundance of radiating laumontite and delessite, the latter prevailing above but decreasing in amount till about a foot or more above the "foot-wall," when a rather sudden change takes place into the melaphyr or amygdaloidal melaphyr above. The prehnite is almost invariably accompanied by small amounts of native copper. This double structure of the amygdaloids occurs in most of the beds, but is absent in some, and some of the amygdaloids are much better developed than others; while the individual distances may be somewhat incorrect.

67 (35) *Covered;* probably containing two or three beds similar to the above.

18 (9) 58. **Melaphyr.**

58 (30) 59. **Amygdaloidal Melaphyr,** varying irregularly to amygdaloid or melaphyr, and generally much decomposed.

11 (5) 60. **Melaphyr.**

185 (95) 61. **Amygdaloidal Melaphyr,** same as No. 59.

11 (6) 62. **Melaphyr,** inclined to semi-columnar structure.

These five beds form an exceptional series. No. 58 resembles the melaphyrs of the last-described series, a rather coarse, soft, easily decomposing, uneven fracturing rock of dull reddish-brown color, spotted dark green. No. 60 is finer, harder, uneven but smoother fracture; color greenish, mottled reddish brown, and of more even tint. No. 62 is very fine-grained, elastic, but tough, inclined to semi-columnar structure, and of dark blackish-green color, with occasional crystals of glassy feldspar. These three melaphyrs graduate most irregularly into the two intermediate zones, Nos. 59 and 61, the easily decomposing nature of which, however, renders them difficult of observation. Throughout there is much melaphyr similar to the enclosing beds, but seemingly mixed with it are large amounts of most irregular material, sometimes occurring in vein-like seams, or in wide irregular bands, paralled to the bedding. Some of these are composed almost wholly of coarse delessitic material, patches of which are filled with ramifying, connecting amygdules of pink laumontite and calcite, which may even become the predominating ingredients of the rock, rather than amygdules. Others, somewhat harder, have but little laumontite and more calcite and prehnite, with a little copper; but these minerals are more confined to cavities and spots, and appear more like accidental than essential ingredients of the rock, as is the case sometimes with the delessite and laumontite. Stellated groups of small quartz crystals occur in vugs. Still various amounts of compact melaphyr are frequent, balls of which may be pried from out the crumbling mass, leaving irregular cavities behind. One or two zones show a material consisting of dark glistening delessite and grains of feldspar, which crumbles away into a sand and encloses balls of harder melaphyr.

345 (1810) *Junction, "Slide";* strongly defined, somewhat uneven. The "Old Phœnix workings on the Ash-bed" show the "Armstrong Vein," thrown horizontally along this junction about 260 feet (Merryweather's map). Considering the dip and strike of the vein, and supposing the movement to have taken place directly down the bed, it would appear that the beds above had slid down upon the beds below about 150 feet.

·5 63. **Sandstone;** seam, 1–6 inches thick; very fine-grained to compact; reddish-brown to chocolate color; occasional fine lines of stratification; undistinguishable from the fine sandstones, and, like them, melts before the blowpipe flame on their edges, without intumescence, to green-black glass; specific gravity, 2.61. Fills irregularities on the surface of amygdaloid below.

64. **Amygdaloid;** 12 (6) feet; made up of several thin beds; the upper ones very amygdaloidal; 60 per cent. amygdules, calcite, little prehnite, not very irregular, base compact, reddish gray. Near the amygdules, generally on their lower side, often only there, the base is changed, to an indurated, amorphous, chocolate-colored material, resembling the sandstone above, but harder, and intumescing before the blowpipe, like most melaphyrs.

108 (55) **Amygdaloidal Melaphyr;** 40 (20); in several beds; base varying from very compact to rather fine-grained; former even light-green color; latter same, finely mottled darker green; amygdules small, rather numerous, contain laumontite and calcite.

Melaphyr; 50 (26) feet; very fine-grained; elastic, rather brittle; rather smooth, inclined to semi-conchoidal fracture; color, dark, greenish black inclined to brown; decided semi columnar structure.

fault

—35 —(18) 65. **Amygdaloid;** about 180 (92) feet, variable; scoriaceous; locally called the **"Ash-bed";** upon it, and on the "Old Phœnix Vein" where it intersects the ash-bed, much mining has been done, but without ultimate practical success.* Débris on the surface and water in the workings mostly hide the bed. It seems to be composed of three or four indefinite zones or "floors," one of which is strongly marked, separated by, and intermingled with, compact melaphyr similar to that forming the base of the bed below. These zones often appear to be made up of more or less round and various-sized balls of amygdaloid, often distinctly surrounded by the melaphyr, a pretty well-defined line of demarcation sometimes separating the two, but often very irregular and not well defined. Again they are enclosed in a brownish-red, fine-grained material, similar to the medium and finest grained to compact sandstone. It is in places distinctly but irregularly stratified, but no pebbles have been observed. Specific gravity of the coarser, 2.70; of the finer, 2.66. When the melaphyr surrounds the balls, its dull bluish color sometimes changes to a reddish hue, resembling that of the supposed sandstone material, but, unlike it, containing occasional incipient delessite amygdules, and scattering red feldspar crystals. It fuses, like the parent melaphyr, before the blowpipe rather readily on the edges of large pieces, and with intumescence, while the finer sandstone-like material is not readily fused, with hardly any intumescence, the coarser being almost infusible. In one specimen the fine sandstone material was associated with small layers of ash-colored, porous, tuff-like material. The amygdaloid itself has generally a dark, chocolate-colored base, with amygdules often quite filled with delessite, but generally of calcite and the other minerals, crystallized datolite being common in veins intersecting the bed. Copper is scattered through the bed.

± 280 (143)

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* Merryweather's map of the "Old Phœnix workings on the Ash-bed" gives this bed as about 70 feet wide, but variable. The survey measured 90 feet upon it without seeing either wall. At Copper Falls it is over 150 feet wide.

Melaphyr; 100 (51) feet; lying below the preceding, as well as associated with it. Texture very fine-grained to very compact; fracture smooth, sub-conchoidal; color, at a little distance, a soft, even, neutral, bluish tint, which inspection shows, as with most melaphyrs, to be composed of a delicate mottling of green and purplish red. Throughout, more or less definite green spots appear, sometimes increasing in number and definition, giving an amygdaloidal character to the rock. Small shining particles of copper are quite numerous, and considerable magnetic iron is present. Specific gravity, 2.98; large probably on account of the copper and iron present.

3803 (1990) 66. **Amygdaloid;** 14 (7) feet; scoriaceous; matrix brown, fine, with flesh-red feldspar crystals; amygdules small, very numerous, mostly calcite; change abrupt to

Amygdaloidal Melaphyr; 14 (7) feet; very fine purplish base, composed of green and dark-red particles, with porphyritically imbedded numerous small flesh-red crystals of triclinic feldspar, in which occasionally are

88 (45) flakes of copper. Amygdules are of black-green delessite, containing green prehnite and quartz, generally some copper, near the top; delessite alone near the bottom, earthy on the exterior of the amygdules, often stellated or radiated, and shiny within; specific gravity, one piece, 2.84. Changes to

Melaphyr; (31) feet; hard, brittle, elastic; fracture rather smooth, sub-conchoidal; color even, purplish, or lightly mottled green, with numerous small crystals of whitish-green, inclining to pink triclinic feldspar, porphyritically imbedded; considerable magnetic iron; specific gravity, 2.93. Similar to No. 45. Lower foot is amygdaloidal.

67. **Amygdaloid,** inclined to amygdaloidal melaphyr; 6 (3) feet; composed of three rather distinct layers; base very fine-grained; purplish; porphyritic, with small, flesh-red feldspar crystals; amygdules mostly delessite, some calcite and prehnite, little copper. Changes to

Melaphyr; inclined to amygdaloidal melaphyr. In descending, the feldspar changes from flesh-red to dirty white, and then to light green, com-

109 (56) posing, in a few feet, with some generally disseminated delessite, the greater part of a rather coarse-grained, dirty gray-green matrix, spotted with numerous dark-green, delessite spots, the porphyritic character no longer existing, and with but little magnetite and no observable specular iron. It is tough, non-elastic; fracture uneven and rough, giving the impression of a loose texture. Specific gravity, 2.88. The delessite spots give an amygdaloidal-melaphyr character to the rock, which exists throughout the bed.

68. **Amygdaloid;** fine-grained, hard; quartz, with other minerals, present.

Amygdaloidal Melaphyr; a mixture of small red feldspar crystals and much delessite, latter mostly collected into frequent spots reaching .2 inch diameter. In descending, as in No. 67, the feldspar loses its depth of

shade, becomes light dirty pink and green or white, and semi-transparent, and forms, with apparently about an equal amount of delessite, a more even granular mixture of a dirty pinkish color, profusely spotted with greenish-black segregations of delessite.

82 (42) **Melaphyr.** In descending still further, about fifteen feet from the hanging-wall, the feldspar mostly becomes of a light-green color, giving to the base a dirty gray-green hue, sometimes slightly mottled with purple, and a more compact fine-grained texture, while the dark-green delessite spots become smaller and smaller. In the fullest development of the melaphyr these spots lose their definition, forming an irregular, undefined, but evenly distributed mottling of dark green upon a lighter green background, and even this may be nearly lost. But little magnetic iron is present. Specific gravity of finest, 2.87. Fourteen (7) feet from the foot-wall a distinct head, parallel to the bedding, occurs. The lower foot is inclined to amygdaloidal, pink feldspar, larger delessite spots.

69. **Amygdaloid;** 12 (6) feet; hard; green and brown mixed; former compact, jaspery, few amygdules; latter very fine-grained; amygdules mostly of prehnite, with little copper; but often of quartz or calcite, generally free from chlorites. Softer, less developed toward bottom. At about 12 (6) feet from the hanging-wall, and along a pretty well defined plane of demarcation, is an abrupt change to

132 (67) **Amygdaloidal Melaphyr;** (5) feet; same as in No. 68, but with laumontite accompanying the delessite near the top. Changes to

Melaphyr; same as No. 68; approaching the even-shaded variety toward the base. Thirty feet from hanging-wall is an *amygdaloidal melaphyr* zone; 25 feet from foot-wall is distinct "head" or joint, parallel with the formation, forming a fall in the river. Lower foot is amygdaloidal melaphyr.

70. **Amygdaloid;** 2 (1) feet; base fine-grained, purplish-brown; amygdules

22 (11) chlorite or green prehnite, with calcite and some quartz. Small orthoclase crystals resting on prehnite.

Amygdaloidal Melaphyr; 18 (9) feet; rather fine-grained; purplish and green speckled; delessite amygdules; texture rather loose; fracture rough.

4236 (2211) 71. **Amygdaloid;** (4) inches; same as No. 70, with **Melaphyr** below, same as No. 68.

30 (15) *Covered;* amygdaloid?

47 (24) 72. **Melaphyr;** (25) feet; same as No. 68; rather coarse purplish base, mottled green.

46 (24) *Covered;* amygdaloid in part?

28 (14)

86 (44) 73. **Amygdaloidal Melaphyr**; 20 (10) feet; base like No. 68; radiated pink prehnite in amygdules; followed by **Melaphyr**, like No. 68.

64 (32) *Covered.*

76. **Amygdaloidal Melaphyr**; 15 (8) feet; mostly covered; greenish; laumontite and calcite.

35 (18) **Melaphyr**; very fine to compact, even bluish-green tint, like that of No. 65 ("Ash-bed"); débris indicates amygdaloid, probably scoriaceous.

30 (15) *Covered.*

78. **Amygdaloidal Melaphyr**; poorly exposed; like No. 76, followed by a

70 (35) **Melaphyr**; very fine grained; blackish green; elastic.

125 (64) *Covered;* the first sandstone south of the "Ash-bed" at Copper Falls may pass here.

82. **Amygdaloidal Melaphyr**, and **Melaphyr**; latter predominating near the base; very fine-grained; fracture quite smooth, inclined to conchoidal; similar to the melaphyr of No. 65 ("Ash-bed"), except the purple element of the color prevails, giving a dull purplish-brown color.

50 (25) Occasional crystals of salmon-colored feldspar occur, and few dark delessite spots. These, more particularly the delessite, increase, but irregularly, toward the summit, where calcite and quartz occur with it. This amygdaloidal tendency is not regular; often confined to irregular areas. Narrow zones of amygdaloidal action, two to six inches wide, accompany seams, cross the bed N.W. to S.E. For 12 to 18 inches from the foot-wall the bed is very amygdaloidal.

·5 83. **Sandstone**; 3–4 inches; irregularly banded; intimately associated with

84. **Amygdaloid**; 10 (5) feet; somewhat scoriaceous; resembling No. 45, but less developed; less developed toward the bottom; occurring in patches in underlying

100 (52) **Melaphyr**; 90 (47) feet; very fine to compact; bluish green; similar to that of the "Ash-bed." Near the foot-wall it is dull purplish, with red feldspar crystals scattered porphyritically, and spots of dark-green delessite, as in No. 82.

85. **Sandstone**; few inches, or wanting; shaly or laminated, wavy; associated with

32 (16) 86. **Amygdaloid**; 10 (5); scoriaceous; matrix brown, compact; amygdules mostly calcite, some prehnite and quartz, little copper.

Melaphyr; 21 (11); rather fine-grained; dirty dark-green color; uneven fracture; weathers into balls, and with a tendency to semi-columnar structure.

Junction; marked, occupied by thin seam, but very irregular.

87. **Amygdaloid**; 13 (7) feet; pretty well developed near the top; base fine-grained, reddish brown; sometimes indurated; porphyritic with minute flesh-red feldspar crystals; amygdules somewhat irregular; quartz, enclosed in delessite; with very little copper. Graduates into an

302 (154) **Amygdaloidal Melaphyr**; 45 (23) feet; composed largely of small flesh-red crystals of feldspar (triclinic) in a rather coarse base of smaller gray-green feldspar crystals and delessite, the latter being also collected into numerous prominent green spots. By the omission of the flesh-red feldspar, or by its change of color to light green, and by the more even distribution of the delessite, together with a more compact aggregation of the mass, this gradually changes to

Melaphyr; 244 (124); spotted. Like No. 68, but of somewhat more exaggerated form.

192 (97) *Covered;* in part probably occupied by an amygdaloid.

90. **Melaphyr**; 172 (87) feet; exceptional; semi-columnar in structure; a very fine-grained, inclining to crystalline, rock; brittle, elastic, rather

172 (87) hard; fracture uneven to sub-conchoidal, and rather smooth; clear uniform bluish-black color, with faintly purple element. Considerable magnetic iron. Specific gravity, 2.89. Weathers smooth; drab color.

5646 (2927) 91. **Diorite**, *aphanitic;* very fine-grained, changing to sub-crystalline; rather brittle, but very tough; fracture uneven, quite rough; color greenish black, but showing through the transparent feldspar; component gives a dirty brownish tint, inclined to resinous. Near top of bed hardly distinguishable from some melaphyrs; except the tendency to a resinous hue, and lack of any columnar character, it is much like melaphyr 69. In descending through the bed, the resinous character at first increases, occasional

187 (94) crystals of glassy feldspar occurring; fracture irregular to hackly, and specific gravity increasing. Near the bottom it again grows finer, becoming quite compactly crystalline, the resinous and brown appearance disappearing, and a clear green color with purple mottling taking its place; purplish spots rather large, and reflecting light. The green is not the dead, nor shiny delessite green in melaphyrs. Near the bottom the rock is like the mottled crystalline "greenstone" near the base of the diorite series. Specific gravity near the top 2.89, near middle 3.01, near bottom 2.95.

92. **Diorite**; *dark type;* a fine-grained, glistening, crystalline aggregate of black or greenish-black hornblende, and brownish or greenish transparent feldspar, the shining of the former through the fractured edges of the latter, giving a dark dirty-brownish color, and resinous lustre to the rock.

25 (13) Considerable dark green chlorite (delessite?) is present, and some magnetite; tough; fracture irregular and rough; specific gravity 2.89. The bed contains irregular patches or segregations of coarser material, in which the feldspar is white, opaque, its crystals forming an irregular network on a black background of hornblende; latter often of high lustre, and

accompanied by, seemingly changed into, a soft dark green chloritic mineral (delessite ?). In these prehnite and a radiated bronze-colored mica are present.

93 ? **Diorite**; *dark type;* same as preceding, but coarser. Feldspar sometimes in larger crystals, or nearly square plates; cleaving, transparent, glassy, or resinous; melts before blowpipe only in fine splinters. Weathers in large flattish knobs, which are sprinkled with small protruding shiny black
25 crystals of hornblende, all of which upon the same prominence generally
(13) catch and reflect the light at the same incident angle, as from a large but irregularly interrupted cleavage face; color of depressions rusty brown; of prominences, whiter.

94. **Diorite**; *light-colored type;* inclining to coarse melaphyr; a coarse, crystalline, irregular-textured bed, containing numerous segregations of coarser material composed of prehnite with feldspar, or of green indurated spots of quartz and epidote (?). The bed is composed mostly of white, inclined to red, generally elongated, crystals of feldspar, lustrous hornblende, and a soft dark-green chlorite, probably delessite, which often
96 predominates over the hornblende and is apparently derived from it;
(48) loosely textured. In places it strongly resembles the melaphyr of bed No. 87 or No. 68. For several feet near the base (absent near station D_1) the feldspar is red, sometimes pearly, and occurs in long intersecting crystals, often over an inch long, and twinned. Sometimes the surface, and near the composition plane of twins, will be red, and the interior pearly. This feldspar here forms about 40 per cent. of the rock, more than half the remainder being chlorite; specific gravity about 2.94.

95. **Diorite** (observed at station D_1, absent at D_2); *dark type;* much like Nos. 92 and 93. Dark colored, resinous; hard, tough; fracture uneven,
40 medium fine-grained, but compactly textured; some chlorite present.
(20) Weathers rather evenly and not rugose; rusty brown with protruding hornblende crystals.

96. **Diorite** (directly beneath No. 94 at station D_2); *light-colored type*, typical. A rather coarse-grained, but compactly textured, crystalline aggregate of white and greenish-white, opaque, triclinic feldspar, and black, often lustrous, hornblende, with occasionally a little chlorite. Color greenish gray, but the whiter and more opaque feldspar is more or less
72 confined to certain spots, thus giving a large and handsome mottling of
(36) grayish white on a greener ground. The hornblende crystals in many of these lighter colored spots, reflect light at the same incident angle. Hard, tough, somewhat brittle; specific gravity 2.90. Weathers rather evenly, color rusty gray, mottled white, with projecting crystals of black horn-
60 blende, which are more prominent on the lighter spots.

(30) 97. **Diorite**; much like No. 92. Some chlorite and bronze mica present.

15 98. **Diorite**; similar to No. 96, somewhat darker colored, with mottling very
(8) indistinct.

90
(45) *Covered.*

99. **Diorite**; *light type*, much like No. 96; rather fine-grained, color dark greenish-gray, not mottled; feldspar mostly greenish, hornblende not
170 generally lustrous, considerable chlorite; fracture neither very rough nor
(85) uneven. Weathers even rusty brown, generally without projecting hornblende crystals. Has frequent hard, compact, indurated, green segregations. Thirty feet covered.

114 100. **Diorite**; *dark resinous type*, like No. 92 or 93, or No. 106. Quite resinous.
(57) Weathers in large but flat prominences, like No. 93.

25
(13) 101. **Diorite**; *lighter type*, much like No. 99, somewhat coarser.

168
(84) 102. **Diorite**; *dark type*, same as No. 100.

53 103. **Diorite**; *lighter type*, similar to No. 96, but not mottled, and with a some-
(26) what closer structure; chlorite very subordinate.

104. **Diorite**; *dark type*, much like No. 100, but less brown and resinous. Much
125 amorphous, and rather hard chlorite is associated with the hornblende.
(62) Specific gravity, 2.91. Weathers like No. 100.

105. **Diorite**; *lighter type*, mostly covered; unusually coarse-grained; feldspar white, opaque; hornblende, in part hard, with highly lustrous jet-like
± 50 cleavage faces, but mostly dull and softer, with some changed into soft
(25) amorphous, chlorite; bands of dark diorite also occur. Weathers very roughly, with protruding snow-white decomposing crystals of feldspar; also smoothly, with little hollows, each with hornblende segregation at bottom. Bed much like No. 107.

106. **Diorite**; *dark type*, with but little chlorite; rather coarse; color very dark, but not very resinous; frequent larger crystals of transparent feldspar; excellent example of the dark type. On the more exposed points this rock weathers in a very exaggerated rugose manner; the depressed portions
138 are rusty brown and comparatively smooth, the numerous rough projecting
(69) knobs, often an inch high, and rising quite abruptly and irregularly, are lighter colored, and dotted black with projecting crystals of hornblende, nearly all upon each projection reflecting the light simultaneously. Coarse crystalline segregations, containing larger crystals of white opaque feldspar, are quite numerous.

— 7140 — *Junction*, a well-marked plane of separation.

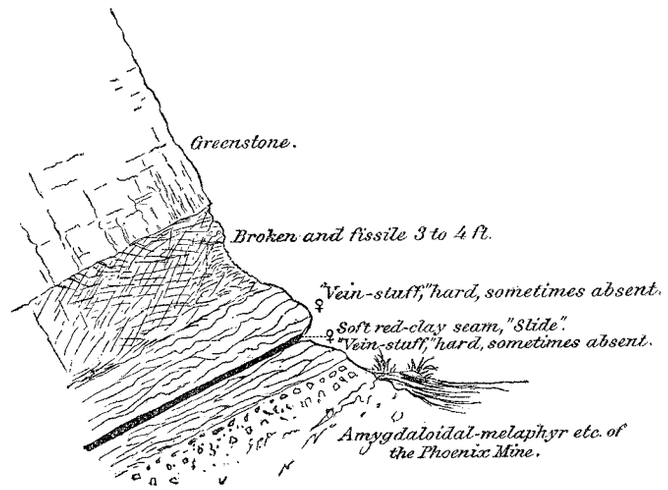
= 107. **Diorite**; *white* and *dark types*. This bed is composed of both types of diorites in alternate strata of from 5 or 6 inches to 5 or 6 feet in thickness, separated by rather abrupt, but neither sharp nor free, planes of demarcation. The wider and predominant beds of the white type are of an unusually coarse granular character; feldspar white or slightly greenish; hornblende mostly highly lustrous, and some chlorite; specific gravity of the rock 3.03, of the hornblende 3.39, of the feldspar 2.73. In places, nearly all the hornblende is changed to a dark-green chlorite—delessite—

when, if the feldspar crystals are small, the rock resembles a coarse melaphyr; and if, as at one point, delessite occupies, at the same time, spots formerly occupied by larger hornblende crystals, it may appear like an amygdaloidal melaphyr, as the upper part of melaphyr No. 87, for instance. Again, some of the white bands tend toward a gneissoid structure, the flattish feldspar crystals being arranged approximately parallel
83 with the bedding. In this case the feldspar and hornblende are most
(41) compactly gathered together, the former being greenish and forming 54 per cent. of the rock, the latter highly lustrous and forming 46 per cent. of the rock, chlorite being absent; fracture thin, rather smooth; specific gravity 3.02. In this gneissoid-like rock the hornblende is gathered together in frequent black spots, 4 inches or more in diameter. In weathering, each of these segregations forms a little pit, the rest of the surface being even; color, white, speckled black, the feldspar crystals protruding slightly.

The dark type bands are the narrower, being generally .5 to 2 or 3 feet thick; being softer than the whiter bands, they weather in, with smooth, rusty-brown surface. Rather fine-grained, tough; fracture rough; color, dark blackish, resinous. The lower stratum is of the white type, but finer grained than those above, and like No. 96, but not strongly mottled.

108. **Diorite**; *dark type;* coarse, changing to aphanitic ("greenstone"). At, and for a hundred feet from the summit this bed is, for the dark type, quite coarse-grained; color very dark greenish black, inclined to resinous; glistening highly from the large amount of transparent, resinous-hued, glassy feldspar, as well as from the hornblende ingredient, though most of the latter is not lustrous; chlorite is generally present. It is hard, and very brittle, though tough, a hard, quick blow shivering the rock with an uneven and rough fracture. Larger crystals of light resinous-hued glassy feldspar quite frequently occur, but they often contain the other ingredients of the rock scattered in them, and often make themselves known only by reflecting light from areas which seem at first to be composed of an ordinary mixture of the ingredients. The hornblende also exhibits this character somewhat, but much less than the feldspar, possibly as not having highly lustrous faces. It is well brought out on the weathered surface, however. This surface weathers in large, flattish, rounded knobs; the depressions being smooth and rusty brown, the knobs lighter colored, with numerous small, projecting, black hornblende crystals. These, often over a space of nearly two inches square, all catch and reflect the light simultaneously. In descending through the remainder of the bed, the rock, with some local reversions, gradually grows finer-grained, though more particularly does it gradually become more crystalline in its texture, and very compactly built, while the feldspar seems to increase in
825 amount, in places apparently impregnating the rock and almost producing
(412) a crysto-crystalline structure. The change in fineness is reached in the
W. of Rob- lower 200 feet. The fracture has become much more even and smoother,
bins Lode. the rock is remarkably elastic and brittle, while the black resinous color

has gradually changed to a clear, handsome dark green, sometimes vaguely mottled with an indefinite purple, from which mottling a more glistening sheen may reflect than from the adjacent rock. Specific gravity of the homogeneous aphanite 2.95. The weathering also changes; in the middle parts being smoother and whiter but less regular than at the top; the hard, white, irregular feldspar segregations standing slightly out, the small hornblende crystals being slightly sunk and mostly noticeable by reflection. In the more crystalline variety, near the bottom, the weathering is uniform again, having the surface covered with numerous small characteristic knobs, often silver gray in color, composed of grains of glassy feldspar, from which, as at the top of the bed, light reflects from hornblende crystals, but here the latter are very minute, and each is sunk slightly below the surface. The presence of these shows the dioritic character of the aphanite, and that it has not become a melaphyr. For 20 feet above the foot-wall most of the eminently crystalline character is lost, the rock becomes fine-grained to compact, of a duller green color, and resembling some fine compactly textured melaphyrs; specific gravity 2.92. The lower 3 or 4 feet of the "greenstone" is broken up and fissile.



— 8090 — **The Slide**; a soft red clay seam, one to four inches thick, the equivalent of
± (4120) the Allouez conglomerate. Above and below it may occur several inches
At the Phœ- of hard vein-like material, red and green, with quartz, calcite, prehnite,
nix mine. and epidote, with some copper pretty generally scattered through it, and sometimes being present in nearly workable quantities. The Waterbury mine was worked upon the slide, but without success.

The following section is from the *Phœnix Mine;* thicknesses of beds approximate.

In the **Shallow Adit.**

32

109. **Amygdaloid**, narrow and indefinite, and **Amygdaloidal Melaphyr**; character obscured, apparently by the adjacent "slide" and vein. It contains much calcite, often in small veins; and scattering amygdules of delessite, prehnite, and calcite in a base similar to the underlying **Melaphyr**; rather coarse-grained, not closely textured; very irregular fracture. Composed of small but elongated crystals of reddish-white or pale-green feldspar, and very dark-green, shining delessite, which is often aggregated
85 into mottling spots, and sometimes colored red at numerous points, pro-
(42) bably from changing magnetic or specular iron, considerable of both being present in parts of the bed. It is coarsest at a point near the middle of the bed; whitish and dark green, spotted dark brown, with numerous incipient dark-green, delessite amygdules; colors marked. Specific gravity 2.87. Above, it is somewhat finer and greener, and at one point below nearly all of the delessite seems changed to a quite bright red, probably from change of iron minerals, no magnetite being there present. Near the foot-wall it again assumes its normal composition. Sixteen feet south of the "slide" is a narrow vein strike, with formation dip 45° S., lined with calcite in flat fundamental rhombic crystals on which rest small, pyramidal crystals of apophyllite terminated with the basal plane.

110. **Amygdaloid**, inclined to *Amygdaloidal Melaphyr;* matrix much as above;
48 color brownish red; composed of small but elongated (often twinned)
(24) dirty white to transparent greenish feldspar crystals, in a reddish-brown, mottled green base; contains scattered amygdules of calcite and decomposing prehnite enclosed in delessite; graduates into **Melaphyr**; like 109, but finer, and with less magnetic iron.

111. **Amygdaloid,** inclined to *Amygdaloidal Melaphyr;* narrow, like 110, but finer; changing to **Melaphyr** like 110, but finer and more compact.

Section in **Sixty Fathom Level,** *Phœnix Mine*, commencing at north end and probably just above the last-described bed, or No. 111. The prehnite occurs in the amygdules like the calcite, often with calcite, enclosed in delessite, and is generally changed to a soft, amorphous, kaolin-like material. In larger amygdules, decomposition has often attacked the
165 outside and inside, leaving unchanged prehnite between. The process of
(82) "winding," as the miners call it, goes on very rapidly in this part of the mine. The white decomposed prehnite does not effervesce with acids, and hardly differs, before the blowpipe, from prehnite. Matrix, as above, medium fine-grained; colors marked; purplish-brown, mottled green; texture not close.

Melaphyr; colors same, mottling fine. Near the centre of the bed is a coarse zone; feldspar in a network of whitish, elongated, often twinned crystals in a red and green base; green delessite also in frequent spots; considerable specular, some magnetic, iron; grows finer, harder, and more compactly textured in descending, becoming darker colored, green, indefinitely mottled indistinct purple. At 23 and 42 feet respectively from the foot-wall is a nearly vertical seam of laumontite.

112. **Amygdaloid**; quite well developed; base compact; reddish brown; amygdules irregular; near the top often united, and for a few inches below tending to form, here and there, zones of increased amygdaloidal action
62 parallel with the bedding. While irregular amygdules often have their
(31) longer axes perpendicular to the plane of bedding, more often they are parallel with it. They contain prehnite, sometimes enclosing calcite; former often decomposed; in places, much copper occurs. Changes rather abruptly to

Amygdaloidal Melaphyr; 20 (10) feet; base fine; reddish-brown, some green; amygdules delessite, rather numerous; shades insensibly into **Melaphyr**; growing darker and more uniformly colored, being finely mottled red and green at the base, where it is fine, quite dense, and somewhat brittle and elastic.

113. **Amygdaloid**; 4 (2) feet; like No. 112, but not so well developed, and with
48 but little copper. Changes rather abruptly into

(24) **Amygdaloidal-melaphyr,** and **Melaphyr,** like 112, but rather darker and greener. At 26 feet north of foot-wall is a vein of laumontite 2 inches wide, approximate strike S.E., dip 75° S.W.

114. **Amygdaloid**; 8 (4) feet; inclined to amygdaloidal melaphyr; matrix fine, reddish or purplish; amygdules mostly delessite, but near base mostly radiated laumontite, enclosed in delessite.

30 **Melaphyr**; fine grained, compactly textured; color dark, dull purple,
(15) finely mottled darker green; becoming more compact toward base. Thin laumontite seam, with narrow accompanying amygdaloidal action, 10 feet from hanging wall.

18 115. **Amygdaloid,** nearly *Amygdaloidal Melaphyr*, narrow with **Melaphyr**
(9) below, same as 114.

24 116. **Amygdaloid**; 4 (2) feet; better developed than last; base fine-grained to
(12) compact; brown red; amygdules, mostly calcite in delessite, some prehnite. **Melaphyr** below, like 114.

117. **Amygdaloid**; 8 (4) feet; inclining to amygdaloidal melaphyr, and not well defined; base fine, red brown; amygdules mostly delessite; some
57 radiated laumontite. Below is a **Melaphyr**, like that of No. 114, having
(28) at 34 and 13 feet, respectively, from the foot-wall, a tendency toward an amygdaloidal character.

118. **Amygdaloid**; 12 (6) feet; base compact, brown red; amygdules of calcite, with delessite exterior; irregular, inclined to large size and scattering. **Amygdaloidal Melaphyr**; 8 (4) feet; rather hard, fine, com-
40 pactly textured; delessite spots in a dark purplish background. **Mela-**
(20) **phyr**; much like No. 114; but more compactly textured, and the purplish ground being sometimes inclined to a hard metallic appearance.

119. **Amygdaloid**; 8 (4) feet; not as well developed as preceding; base greener; amygdules of calcite and delessite above, of laumontite and delessite below, changing into

115 (57) **Melaphyr**; like 114; rather hard, brittle, elastic; fine-grained, close-textured; color of brown and dark and lighter green particles, with green delessite spots. More uniform colored at base, compact, with conchoidal fracture; no magnetite. Ten feet from foot-wall is a seam; strike little east of north; dips 75° or 80° to west; laumontite and chlorite, accompanied by change of melaphyr to amygdaloidal melaphyr; amygdules of delessite and some calcite.

120. **Amygdaloid**; 4 (2) feet; base compact, earthy looking, but not soft; color reddish or chocolate; amygdules calcite, prehnite, some quartz; changes to hard **Amygdaloidal Melaphyr**; almost melaphyr, like No. 119. At 28 feet from hanging-wall is an amygdaloidal melaphyr zone, better developed than that below the amygdaloid, which changes to a **Melaphyr** like those adjacent; fine, hard, brittle, rather dark colored.

36 (18)

121. **Amygdaloid**; 8 (4) feet; base very fine; color dull red brown; amygdules of prehnite, and with little copper; changing through **Amygdaloidal Melaphyr**; 6 (3) feet; to **Melaphyr**, a wide bed; near the top inclines to brown-red color; near the middle it is a fine-grained and closely textured rock, with conchoidal fracture. The color is a clear shade of dark green, mottled purple, the dark purplish areas being larger than usual, though with indefinite boundaries, about .3 inch diameter. A spot often reflects light from all its parts at the same incident angle, causing the rock in this particular, as well as in other characters, to strongly resemble the similar modification which often occurs in the aphanitic diorite, or greenstone. It contains but little magnetite, and its specific gravity is less. Near the foot-wall the color is a nearly uniform shade of purplish brown. "*Crocker Shaft*" is about 120 feet north of foot-wall.

206 (103)

122. **Amygdaloid**; 5 (2.5) feet; not well defined; prehnitic; followed by **Amygdaloidal Melaphyr**; brown, fine; large, scattering; delessite amygdules, sometimes containing laumontite, or prehnite, or calcite, or all; sometimes in a granular mixture; extends to south end of sixty-fathom level, or 56 feet.

In **twenty fathom** level, "Bay State," a wide melaphyr, supposed to be 121, has a foot-wall at about 223 feet south of "Taylor Shaft." Below is 122. **Armygdaloid**; not well defined, with wide, chocolate-colored **Amygdaloidal Melaphyr** below, followed by a wide **Melaphyr**, like 121; color generally redder.

320 (160)

123. **Amygdaloid**; like preceding, followed by **Melaphyr**; hard, fine-grained, purplish green, dark, containing but little magnetite; extends 18 feet, reaching southern end of 20 fathom level.

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