

NO. 374. CLAY SLATE.

Same locality as No. 373.

Ref. Annual Report, ix, page 95.

Meg. Resembles No. 373, but is greener and more siliceous, almost cherty.

No section.

Age. Archean (Keewatin).

Remark. Later, a section of this rock was made by Marchand. It shows a composition essentially like those already described, viz.: Nos. 170 and 171, but much finer.

N. H. W.

NO. 375. SERICITE SCHIST. (*Sheared quartz-porphyr?*)

South side of Mud lake; S. W. $\frac{1}{4}$ N. E. $\frac{1}{4}$ sec. 3, T. 62-14 W.

Ref. Annual Report, ix, pages 95, 102.

Meg. A light greenish-gray, roughly schistose, aphanitic rock, with large quartz grains and highly altered feldspars,—a sheared quartz-porphyr(?)

Mic. The section shows a groundmass of fine grain holding large crystals of *feldspar* and *quartz*. This groundmass is composed of *calcite*, *sericite* and an indistinct very fine-grained mass, apparently of *actinolite quartz* and *feldspar*. A little *pyrite* is present. A noticeable part of the section is a fissured quartz grain, the fissures being filled with *calcite*. The feldspar phenocrysts are very highly altered, so much so that their species cannot be determined. They are in places hardly distinguishable from the groundmass and are apparently decaying into an aggregate closely similar to this groundmass.

One section.

Age. Keewatin.

Remark. The section was evidently cut about parallel to the schistose structure. This rock perhaps represents a quartz-porphyr which has not only been sheared, but is also highly decayed.

U. S. G.

NO. 376. QUARTZ-PORPHYRY (?) (*Sheared.*)

West end of Mud lake, at an old mining location; S. W. $\frac{1}{4}$ N. W. $\frac{1}{4}$ sec. 3, T. 62-14 W.

Ref. Annual Report, ix, page 95.

Meg. Similar to No. 375, but perhaps more compact. A gray rock coarsely schistose, with quartz, and mottlings of green, the greenish parts being apparently amorphous, with hardness about 4.

Mic. Very fine-grained matrix, embraces large *quartzes*, evidently the latter the form of quartz that characterizes a quartz-porphyr. In the matrix are *mica-pennine*, *calcite* and *feldspar*; the last in much decayed large crystals, with some conspicuous deposits of *pyrite*. The chlorite polarizes in blue, like pennine.

One section.

Age. Archean (Keewatin).

N. H. W.

No. 377. QUARTZ, CALCITE, ETC. (*Vein matter.*)

Same locality as No. 376.

Ref. Annual Report, ix, page 95.

Meg. Coarsely crystallized quartz, with calcite, pyrite, green carbonate of copper, evidently from the decay of some copper mineral and limonite.

Mic. The section shows much fractured grains of quartz, which make up most of the section, around and between which is a finely crystallized mass of *sericite*, *calcite*, and evidently *quartz* and *feldspar*; in fact, this material is quite similar to the groundmass of No. 375. Green, brown and red staining material has been deposited in the cracks of the quartz in places.

One section.

Age. Vein in Archean (Keewatin) rocks.

U. S. G.

No. 378. QUARTZ SCHIST. (*Sericitic.*)

Mud creek; N. W. $\frac{1}{4}$ S. E. $\frac{1}{4}$ sec. 4, T. 62-14 W.

Ref. Annual Report, ix, page 96.

Meg. Slaty, quartzose, fine-grained, rusty with the oxidation evidently of carbonate of iron.

Mic. The matrix of this rock appears much like that of No. 376, but the quartz is more fragmental, and the matrix contains more *calcite*, while the *pyrite* of No. 376 is here replaced by *siderite*, whose conspicuous, partly oxidized idiomorphic rhombs are everywhere present.

One section.

Age. Keewatin.

Remark. This seems to be a condition of the rock Nos. 375 and 376, but more sheared. The carbonate of iron was generated instead of the pyrite, and since there is no evidence to show that one was derived from the other, it is reasonable to assign them both to the date of the shearing.

N. H. W.

No. 379. CHLORITE SCHIST.

Vermilion lake, at the mouth of Mud creek; near the centre of the south side of the S. W. $\frac{1}{4}$ sec. 6, T. 62-14 W. "This rock is like that in a range of hills which continues all the way to Mud lake, along the north side of this stream, apparently confining the stream on that side, the slates running west-southwest at Vermilion lake."

Ref. Annual Report, ix, page 96.

Meg. A soft, greenish-gray, very fine-grained schist.

Mic. The section shows a very fine-grained rock composed of numerous minute flakes of *chlorite*, *calcite* and *feldspar*. There are also gray areas, which, under a high power, are seen to be, in part at least, composed of very minute grains which are probably *epidote*. The section is more or less confused, the different minerals, especially the feldspar, having indistinct outlines, probably due to over-

lapping of the grains. In places the feldspar is in larger irregularly and indistinctly outlined areas, and contains the other materials of the rock poikilitically. These areas have undulatory extinction quite frequently. It is not improbable that *quartz* is also present, although none was determined certainly.

Age. Archean (Keewatin).

Remarks. This rock differs from others just described in that the feldspar areas are not so evidently the result of a fracturing of a larger grain. Here it does not seem improbable that the larger feldspar areas are the result of recrystallization *in situ*.

U. S. G.

No. 380. DIORYTE (*with quartz*).

Vermilion lake; one mile southwest from the mouth of the stream from Mud lake; S. E. $\frac{1}{4}$ N. W. $\frac{1}{4}$ sec. 12, T. 62-15 W.

Ref. Annual Report, ix, page 96; Annual Report, xv, page 306. This is the same rock as No. 875. Compare No. 403.

Meg. Massive, greenish-gray, medium-grained rock with some hornblende and a triclinic feldspar.

Mic. The section shows much dichroic, green *hornblende*, *calcite*, old feldspars which are plainly a *plagioclase* and *chlorite*, with a little *epidote* and *apatite*. Some of the feldspars are nearly lost in the products of their own decay, being charged with micaceous scales and sometimes holding micropegmatitic quartz. *Quartz* also exists as large isolated grains, and in one case an angular quartz is surrounded by a gray mass that has distinct crystalline orientation and which is probably a feldspar. This supposed feldspar, which is non-striated, also embraces two small *hornblendes*, and some *calcite*, and may be of secondary origin. The hornblende is generally idiomorphic toward the feldspar, as well as toward the calcite and the chlorite.

One section.

Age. Archean (Keewatin).

Remark. This is a peculiar rock in that the hornblende, as well as some quartz, antedated the feldspar and appear now as idiomorphic crystals surrounded by the feldspar. It seems to be a changed basic eruptive of the dioryte family. In the slide made from No. 875, the same features are visible, and further, it is apparent that the feldspars had two periods of growth, since they are zoned. It is the earlier feldspar generation that embraces the hornblende crystal mentioned above. Still another interesting feature is apparent in the section of rock No. 875, viz.: a quartz crystal, also embraced in a feldspar grain, has governed the orientation of pegmatitic quartz which has entered the surrounding feldspar.

N. H. W.

No. 381. PORODYTE.

Vermilion lake; probably near the north line of sec. 13, T. 62-15 W.
Ref. Annual Report, ix, page 96; Bulletin ii, page 123.

Meg. A grayish-green, fine-grained, rather soft rock, with quartz veins.

Mic. Dr. Wadsworth's description is as follows:

"The section is composed largely of debris that appears to be altered melaphyr, with a few argillyte fragments, quartz, a little *augite*, and much secondary *pyrite*. The groundmass of the section has sprinkled through it numerous gray and yellowish granular masses resembling *titanite* in the process of formation, but none are in sufficiently advanced a stage to be determined crystallographically. The melaphyr material is altered as in the preceding porodytes. Both sections of this rock show portions of a vein made up of irregular quartz grains containing liquid inclusions with moving bubbles. Portions of the rock material are arranged in wavy parallel bands, along the vein in one section, but these bands have no relation to the quartz grains themselves but pass through them indiscriminately, without regard to the boundaries of the grains."

Two sections.

Age. Archean (Keewatin).

U. S. G.

NO. 382. QUARTZ. (*Vein.*)

Same place as No. 381.

Ref. Annual Report, ix, page 96.

Meg. Vein quartz, with feldspar, pyrite, chalcopyrite and rock material.

Mic. The section shows much clouded quartz in grains closely interlocking. The cloudiness is due to minute grayish inclusions and to cavities filled with liquid.

One section.

Age. Vein in Archean (Keewatin) rocks.

U. S. G.

NO. 383. GRAYWACKE. (*Debris of quartz-porphry.*)

Vermilion lake; N. W. $\frac{1}{4}$ S. W. $\frac{1}{4}$ sec. 13, T. 62-15 W. North bluff at the entrance to Armstrong bay.

Ref. Annual Report, ix, page 96.

Meg. The rock is very siliceous, and contains rounded, free quartzes. It is of a light color, and apparently destitute of structure such as schistosity. Yet, in the field, where a close jointage crosses the rock dividing it into sheets diagonal to the usual structure, when a specimen is taken from between two planes, so as to have one of these joints on each side, the specimen will persistently remain triangular, although it be broken till reduced to too small a size for preservation.

Mic. The quartzes are evident, but have not regularity of shape. They are evidently fragments of the quartzes of a quartz-porphry. They are embraced in a matrix which has a confused appearance, but throughout which are the forms of large feldspars, much changed by saussuritic growths. Some of these feldspars are so filled with minute grains that have resulted from alteration that they are almost lost as feldspars and seem to be parts of the matrix, and can only be detected as actual

feldspar forms by a darkening which spreads over them four times in each revolution between crossed nicols. They are not perfect, *i. e.*, idiomorphic, but are fragments of feldspars, and they appear to be mingled with many small fragments of the same kind. The groundmass, made up of more minute particles of feldspar and of quartz, is mainly homogeneous, as a groundmass, but sometimes it shows variations in the sizes and relative proportions of the feldspathic and quartzose elements, so that darker areas appear in the midst of the general mass. Such darker or coarser areas are themselves apparently of fragmental origin, *i. e.*, it appears that fragments of rock, though mainly like the average, yet varying somewhat from it in special characters, were included in this rock. What may be the cause of these variations it is not possible as yet to state. They are frequently considered the result of crushing and shearing of a homogeneous quartz-porphry, or of a siliceous tuff, or porodyte, whose fragmental elements originally differed slightly in composition, as well as in structure, but that explanation seems insufficient.

Two sections.

Age. Archean (Keewatin).

Remark. The determination of the true nature of this rock has an important bearing on the Stuntz island conglomerate, since it is apparently in the line of extension from that place. So far as the samples now at hand in thin section will show this nature, it is impossible to say positively whether this rock was originally an acid igneous one, *i. e.*, a quartz-porphry, or an acid tuff, *i. e.*, porodyte, but the question will remain open till other sections can be examined.

Later examination has shown that Stuntz island is composed of two sorts of rock, one a quartz-porphry, a massive crystalline rock, occupying the northern part of the island, and the other a coarse fragmental largely derived from the other, making the well-known Stuntz conglomerate. Rock No. 383 may be considered a finer and more siliceous phase of the conglomerate. In the field this was called porodyte, with the idea that it may have been an acid tuff.

N. H. W.

NO. 384. QUARTZ-PORPHYRY. (*Altered.*)

Vermilion lake; probably in N. W. $\frac{1}{4}$ S. W. $\frac{1}{4}$ sec. 13, T. 62-15 W.
Ref. Annual Report, ix, page 97.

Meg. A roughly schistose, soft, greenish-gray, very fine-grained rock. Contains a few large quartz grains, altered feldspars, and pyrite.

Mic. The section shows a much sheared and decayed quartz-porphry. The feldspars are broken, much decayed and are in places hardly distinguishable from the groundmass. The rock as a whole is very similar to No. 375. One large quartz, which is partially idiomorphic, shows embayments of the groundmass similar to those seen in unaltered quartz-porphries. On one side of a large pyrite crystal is a greenish

very slightly pleochroic mineral, which gives as an interference color greenish gray of the fourth (or higher) order as indicated by the color bands on the thin side of the section. The extinction is wavy. It gives an interference figure which is apparently uniaxial, although the optic axis is a little out of the field of the microscope. This interference figure is positive. The species of this mineral is not known.

One section.

Age. Archean (Keewatin).

U. S. G.

Remark. Later investigation has shown that a debris from a quartz-porphyrus will, when compacted and sheared, take the characters of this rock. A quartz grain showing embayments of the matrix may have carried that character with it from the original magma into the debris of the clastic, or, if the embayments have open wide mouths, as in this case, the fine debris of a clastic derived from quartz-porphyrus, entering such re-entrant angles, could hardly be distinguished from the original matrix.

N. H. W.

NO. 385. JASPILYTE.* (*Dark, slaty.*)

N. E. $\frac{1}{4}$ N. E. $\frac{1}{4}$ sec. 22, T. 62-15 W.; Southeasterly shore of Vermilion lake. (Compare Nos. 1958 and 1959, Annual Report, xxii, page 16.)

Ref. Annual Report, ix, page 97.

Meg. Dark siliceous slate, in thin, rigid laminations. Mainly in regular, thin sheets, but in some places confused, the slates running west to southwest, and nearly perpendicular, but sloping toward the south. This jaspilyte streak rises on to the hill, and can be traced for a quarter of a mile.

Mic. The section is apparently composed of silica only, in fine grains, yet with a few scattering rhombs of *siderite*. It is evidently from one of the white laminae of the rock.

Another section, made so as to traverse the structure, shows alternations of layers of *quartz* in fine grains and of *magnetite*. *Siderite* rhombs are frequent, as shown by their rusty coloration, but *calcite* is also distributed with the *siderite*. The latter is apparently converted, in some instances, to *hematite* which is sparsely distributed amongst the *magnetite*. Piercing the *quartzes*, and interlocked amongst them, are numerous needle-shaped, highly polarizing fibres whose elongation is positive (*i. e.* they have the axis n_e practically parallel to their greater dimension), but on careful measurement their extinction is found to depart from parallelism about 15° . Their pleochroism is hardly apparent. They are supposed therefore to be some form of non-aluminous amphibole, probably *actinolite* or *grünerite*. Two sections.

Age. Archean (Lower Keewatin).

N. H. W.

*This term was proposed by M. E. Wadsworth in 1880 in a discussion of the iron ores of the Marquette region. *Bulletin Museum Comparative Zoology*, Cambridge, Geological series, vol. i, p. 75. It is current in the Minnesota reports and has a definite significance and application in the discussion of the Archean iron ores of the Vermilion range. Wadsworth's idea that this rock had an eruptive origin, an idea which he included in his definition of the term, is the only objection we can see to the use of the designation as a petrographical term. The term *jasper* is also applicable, but has not the definiteness which *jaspilyte* implies.

No. 386. QUARTZ-PORPHYRY. (*Altered.*)

"On a small island near the southeast shore; rock like No. 384. Here the schistose structure, sloping southeast, runs S. 50° W. by compass, and is sometimes a little wavy." Vermilion lake; perhaps in the centre of the W. ½ sec. 22, T. 62-15 W.

Ref. Annual Report, ix, page 97.

Meg. A greenish gray, roughly schistose rock quite similar to No. 384, but having almost no visible quartz.

Mic. The section is similar to No. 384. The *feldspar* fragments are numerous and very much decayed. Only a few quartz grains are present. One section.

Age. Archean (Keewatin).

U. S. G.

No. 387. QUARTZ-PORPHYRY (?) (*Sheared.*)

"About a mile southwest of the last the rock varies to a schistose, chloritic syenite, of a light-gray color. This is apparently only a variation in the ingredients of No. 386. It is a firm rock, and at a distance appears like massive granite or syenite; yet, along the lake shore, it parts in a gneissoid manner. It rises higher than the adjacent hills, and is coarsely jointed, so that its rhomboidal parts rise like whitened sheep's backs. It extends perhaps twenty rods." Vermilion lake; near the centre of S. ½ sec. 21, T. 62-15 W.

Ref. Annual Report, ix, page 97.

Meg. A gray rock, somewhat sheared and thickly studded with porphyritic crystals of white feldspar. There are also less numerous and smaller, though abundant, porphyritic crystals of quartz. The groundmass in which these crystals are embedded, is sparse, aphanitic and dark gray. (See Nos. 874, 874 [A] and 1957.)

Mic. The section shows a rock which has been stretched or sheared, and this structure is shown both by the crushed and fissured larger grain and by yellowish lines which run roughly parallel in the section. The rock is composed of crystals and fragments of *feldspar* and *quartz* in a finer groundmass. The feldspar seems to be in part *orthoclase* and in part a plagioclase, probably *anorthoclase*. It is altering to *sericite*, and also in places contains minute crystals and grains of a colorless, strongly refractive mineral with low double refraction which is thought to be *zoisite*. The groundmass is of very fine grain, and is composed of *quartz*, *feldspar*, *sericite*, *calcite* and *actinolite* (?). Pyrite and also probably granular *epidote* are also present. The mineral referred to questionably as actinolite is in fibres, is usually yellowish, although sometimes colorless, and makes up most of the yellowish lines mentioned above. It is usually not pleochroic, but sometimes shows slight pleochroism, varying from colorless to straw yellow, the latter being the color of the ray which vibrates parallel to the length of the fibres. It may be that this mineral is muscovite, slightly colored, rather than actinolite, as the rough measurements made showed practically parallel extinction. (Compare No. 431.) Two sections.

Age. Keewatin.

Remarks. This rock would be usually taken for a stretched quartz-porphry, and this is probably its nature. But the fact that in this immediate vicinity is the

Stuntz conglomerate, sections of the matrix of which have been called "sheared quartz" porphyry, causes us to hesitate about stating positively the nature of the rock (No. 387). See under No. 874, and under the description of the Stuntz conglomerate in vol. iv, pages 526-538.

U. S. G.

NO. 388. JASPILYTE. (*Gray.*)

Vermilion lake; perhaps near the centre of the E. $\frac{1}{2}$ sec. 20, T. 62-15 W.*
Ref. Annual Report, ix, page 97.

Meg. Fine-grained, gray, cherty rock.

Mic. The section shows fine, angular grains of *quartz*, with a few rhombs of carbonate of iron. The latter are idiomorphic and perfect as crystals (or nearly perfect), but the former are crowded upon each other. In one section the *siderites* are somewhat clouded by included magnetite, and quite frequently they embrace at their centres a powder of *magnetite*, which is also distributed in clusters elsewhere, giving the section a spotted appearance. It is probable that this magnetite antedates the siderite, only serving as nuclei on which the carbonate grew, while the limonite is seen to be a result, so far as it exists, of alteration from the carbonate, the crystals of which are stained by it. Two sections.

Age. Archean (Lower Keewatin).

Remark. The distribution of this magnetite powder in the individual quartzes causes the rock to resemble taconyte.

N. H. W.

NO. 389. ARKOSE.

Vermilion lake; S. W. $\frac{1}{4}$ S. W. $\frac{1}{4}$ sec. 20, T. 62-15 W.
Ref. Annual Report, ix, pages 97, 98.

Meg. Gray, compact, coarsely schistose, none of the minerals being well characterized. No quartz is distinguishable under the hand glass, but fine glittering surfaces are visible which are apparently of some mica. The rock has a vague and indefinable aspect, the coarsest grains, which are apparently feldspar and have a diameter of about one millimeter, fading out into the surrounding matrix. The rock is evidently of fragmental origin, as indicated by the perfect stratification described by the field notes.

Mic. The section consists essentially of feldspar (*plagioclase*), a little *quartz*, much isotropic chloritic substance, some *epidote*, *muscovite*, and a reddish-yellow stain which probably is iron oxide, and *calcite*.

The feldspar is sometimes distinctly twinned, and other crystals are destitute of striations. The grains are all much altered, and are specked with flakes of muscovite, which also is scattered irregularly through the finer grains. Two sections.

Age. Upper Keewatin.

*When these specimens were collected (1878), the United States land survey had not yet been extended over these localities. In making assignments of these localities in the terms of the "towns" and "ranges" of that survey a little allowance must be made for possible error as to the exact locations of the points at which the specimens were obtained.

Remark. This locality, and the rocks associated with this rock, are thus described in the Ninth Annual Report:

"A mile further west, and near the entrance to the bay that leads to the portage going south from Vermilion lake to Squagemaw lakes, the rock of this number, which is a gray, chloritic schist, is seen to have a nearly east and west slaty structure, varying to a little south of west. This slaty structure is intersected diagonally by alternations in the rock due to sedimentation, running nearly northwest and southeast. The kinds of rock exhibited by this alternation are as follows, from Nos. 389 to 394, both inclusive, the former being on the northeast side and the latter on the southwest side." Other rocks from this immediate vicinity are Nos. 1 to 7 (W.), Annual Report, xv, pages 19, 20.

Another section bears the No. 389, but as it differs considerably from the foregoing it is supposed to have been misnumbered. It is probably from the Lower Keewatin of the region. The following description is given, since the section shows well some important characters:

Mic. The section consists essentially of feldspar (*plagioclase*) and *muscovite*, with *siderite*. The feldspar is of the clear variety which in small fragments is difficult to distinguish from quartz. It is not crowded with kaolinic scales, but has dust-like particles which cross it in lines, but hardly impair its translucency. Some of the larger grains interlock in such a manner as to indicate secondary growth, and in one case a large grain has partially enveloped another by forming about its projecting corner. It is distinctly twinned on the albite plan. A section cut perpendicular to n_p gives an extinction angle of 73° , which agrees well with Fouqué's extinction for *andesine-oligoclase*. Although this translucent feldspar prevails, or exists almost alone, in one section, there is still another which is quite different in its inclusion of what appear to be *mica* scales set in every conceivable angle with reference to the structure of the grain, and of the scales themselves. These are also of some plagioclase, but as the single grain in this slide has no cleavage nor crystalline character on which to measure extinction the species cannot be determined. The *siderite* is distributed irregularly, both as single rhombs and as shapeless aggregates of many grains. It has a uniaxial interference figure, slight absorption and rather strong refraction index approaching that of epidote. Its double refraction is similar to that of calcite. It has a clear glassy color, when unaltered and in simple crystals, but much of it in compressed masses appears of an ashen-gray color. When it is altered it becomes brown or reddish with the resulting oxide of iron. Its cleavages are conspicuous. Except for the rustiness that sometimes permeates it, and its ashen color, it can hardly be distinguished from calcite in ordinary light, but its high refractive index, in convergent light, is also a good diagnostic.

Age. Archean (Keewatin).

N. H. W.

Remarks. We are forced to conclude that by some means a secondary feldspar and siderite have been developed to the almost total exclusion of the original feldspar. The dynamic stress through which the rock, in common with all the rocks of the region, has passed, is probably responsible for these new minerals. N. H. W.

NO. 390. CLAY SLATE.

Same locality as No. 389.

Ref. Annual Report, ix, page 97. (See remarks under No. 389.)

Meg. A rather soft, gray or greenish-gray, aphanitic clay slate.

Mic. The section is very fine grained. It is composed essentially of *calcite*, minute flakes of *sericite* (or muscovite) and *chlorite*, and a very minutely granular, rather indistinct aggregate which probably contains both quartz and feldspar.

One section.

Age. Archean (Keewatin).

U. S. G.

NO. 391. GRAYWACKE.

Same locality as No. 389.

Ref. Annual Report, ix, page 97. (See remarks under No. 389.)

Meg. A light gray, or greenish gray, fine-grained rock. A few grains of quartz and occasionally a feldspar are all the minerals that can be seen macroscopically. The rest is a flaky, indistinct, talc-like (but harder than talc) base.

Mic. The section shows scattered grains, rounded and subangular (sometimes quite angular), of *quartz* and *feldspar* in a much finer grained background. The quartz grains are not sharply outlined, but their peripheries are closely cemented to and interlocked with the small grains of the groundmass. The feldspar is clouded and kaolinized and is not always very distinct from the groundmass. The species of the feldspar could not be determined, although it seems likely to be largely *orthoclase*. No polysynthetic twinning lamellæ were seen, but there were indications of a few simple twins, apparently by the Carlsbad law. The groundmass is composed of a fine-grained aggregate, similar (but a little coarser grained) to No. 390. *Calcite*, *sericite*, *chlorite*, *quartz*, and probably also feldspar, form the chief constituents of this groundmass. There are collections of very minute grains, which cannot be determined, but which are perhaps *epidote*.

One section.

Age. Archean (Keewatin).

Remarks. The similarity of the groundmass of this rock to others from Vermilion lake, the slates and schists, is quite decided. Without the larger grains of quartz and feldspar the rock could be termed a clay slate or perhaps a sericite schist. It is also to be noted that in many respects this groundmass resembles the groundmass of the highly sheared and altered "quartz-porphyrines," U. S. G.

No. 392. CLAY SLATE.

Same locality as No. 389.

Ref. Annual Report, ix, page 97. (See remarks under No. 389.)

Meg. A very fine-grained, dark gray, clay slate.

Mic. The section is similar to No. 390, but is much finer grained and contains little or no calcite. It is composed essentially of very minute flakes of *chlorite* and *sericite*, and minute grains, probably of *quartz*, with also probably *feldspar*.

One section.

Age. Archean (Keewatin).

U. S. G.

No. 393. PORPHYRY (?) (*Sheared.*)

Same locality as No. 389.

Ref. Annual Report, ix, page 97. (See remarks under No. 389.)

Meg. A gray rock, consisting of small (about one twenty-fifth of an inch across), white, crowded feldspar crystals in a sparse, very fine-grained, darker groundmass.

Mic. In section the crowded *feldspar* crystals are not as distinct as in the hand specimen, for they are much altered and clouded and are composed largely of almost the same materials as found in the groundmass. The species of the feldspar cannot be determined. Nearly all the grains show no twinning, but a few show traces of twinning striæ, and one is a simple twin, apparently according to the Carlsbad law. In shape, these feldspars are rounded or subangular, and others are partly idiomorphic. In reflected light they appear gray and semi-opaque, and this character is also found irregularly in the groundmass. The groundmass is composed of flakes of *sericite* and *chlorite*, and small grains of quartz with probably feldspar also. The sericite is developed especially often in cracks of the feldspars and between the different grains, and the flakes sometimes have their long axes perpendicular to the surfaces of the feldspar grains. Crossing the section is a small vein-like form composed mainly of small grains of quartz, and similar quartz occurs elsewhere in the slide.

One small section.

Age. Archean (Keewatin).

Remarks. The exact nature of this rock is not evident. The feldspars may have been crystals in an acid eruptive, now much altered, or it is quite possible that they are elastic in their origin, being either true waterworn grains or else of a tuffaceous origin. That these feldspars have developed *in situ*, seems rather improbable when we consider their highly altered characters; at least, if they did develop *in situ*, they have been much decayed since.

U. S. G.

No. 394. SERICITE SCHIST.

Same locality as No. 389.

Ref. Annual Report, ix, page 97. (See remarks under No. 389.)

Meg. A siliceous, very fine-grained sericite schist, greenish gray in color.

Mic. The section is very fine grained. It consists of scales of *sericite*, and a little *chlorite*, and grains apparently of both *quartz* and *feldspar*. These grains make up a large portion of the section, but their exact nature cannot be determined. The section contains specks, gray and semi-opaque in reflected light, which under a high power are seen to be made of aggregates of very fine, rather highly refractive grains. The nature of these cannot be made out. They have elsewhere been referred to *epidote*, but may be siderite.

One section.

Age. Archean (Keewatin).

U. S. G.

No. 395. CLAY SLATE.

Vermilion lake; New York Mining Company's location; S. W. $\frac{1}{4}$ S. W. $\frac{1}{4}$ sec. 26, T. 62-16 W.

Ref. Annual Report, ix, page 98; Annual Report, xviii, page 20; Annual Report, xix, pages 125, 127. This locality is also described in the Fifteenth Annual Report, pages 280, 281.

Meg. A gray, very fine-grained clay slate.

Mic. The section is composed very largely of minute grains of *quartz* (with probably *feldspar* also); *chlorite* and a little *sericite* are also present. There are two particularly interesting features in this section. The first is the presence of much *siderite* in rough rhombs and irregular areas. Frequently a yellowish stain (*limonite*) accompanies the *siderite*. The second feature is the presence of numerous minute *rutile* crystals. These give bright polarization colors, and many heart-shaped twins are seen. One section.

Chemical analysis. Nos. 395, 396, 397, 398, 400, 423 and 428 represent some of the gold ores of the Vermilion lake gold excitement of 1866. These specimens were assayed together, as one sample, by Prof. C. F. Sidener and no gold nor silver was found.

Age. Archean (Keewatin).

U. S. G.

No. 396. QUARTZ. (*Vein.*)

"Gold' quartz, from the above mining location. This is white. It is scattered in the joints and irregular veinings in No. 395, similar to what may be seen in many places about Vermilion lake. (See report for 1878, page 23.)"

Ref. Annual Report, ix, page 98; Annual Report, xviii, page 20; Annual Report, xix, pages 125, 127.

Meg. Specimen missing.

No section.

Age. Vein in Archean (Keewatin) rocks.

Remark. See chemical analysis under No. 395.

U. S. G.

slate. Quartz. Schist.]

NO. 297. SLATE. (*Chloritic.*)

Vermilion lake. Locality uncertain. Minnesota Company's mining location. Perhaps on Birch point.
Ref. Annual Report, ix, page 98; Annual Report, xviii, pages 20, 21; Annual Report, xix, pages 125, 127.

Meg. Specimen missing (used for assay).

Mic. The section shows a distinct parallel structure, evinced by the prevailing direction of the *chlorite* shreds. It embraces much decayed feldspars, with minute *mica* scales, a little *quartz* in the form of independent, yet sub-rounded, sizable grains, and a noticeable amount of *siderite*, which is easily diagnosed by its high refractive power. It is usually clear and unoxidized, yet occasionally some dark accumulations are enclosed in it. It has an evident, fine and regular cleavage in two directions. This structure again distinguishes it from calcite, which generally shows only a coarse and rather distant cleavage in rigid heavy lines, or is destitute of evident cleavage.

Remark. This existence of *siderite* in the rocks of the region, sheared "quartz-porphyrines," graywackes, clay slates and chlorite slates, as well as in the jaspilytes, is worthy of special note, as it is the source, as supposed by some geologists, of the iron ore lodes of the Vermilion range. (See chemical analysis under No. 395).

One section.

Age. Archean (Keewatin).

N. H. W.

NO. 398. QUARTZ. (*Vein.*)

"The quartz from this mining location occurs in the joints of the rock, in irregular deposits, but generally coincident with the slatiness. It carries considerable pyrite, which is also scattered through the slates." Same locality as No. 397.

Ref. Annual Report, ix, page 98; Annual Report, xviii, pages 20, 21; Annual Report, xix, pages 125, 127.

Meg. Specimen missing (used for assay).

Age. Vein in Archean (Keewatin) rocks.

Remark. See chemical analysis under No. 395.

U. S. G.

NO. 399. CHLORITE SCHIST.

"Talcose (?) slate, from Simonds' location. This is farthest northwest (or west), and about four miles from the outlet of the lake; and between this and the Minnesota Company's location was that of Nobles, numerous islands occurring all along. This number represents the country rock. It is siliceous, and contains scattered nests or broken layers of white quartz, both coincident with the slates and in the diagonal jointage. Pyrite is scattered through the quartz, and through the slates, and particularly in a line of contact where they unite, the quartz becoming gray." Vermilion lake. The exact location is uncertain, but it may be on Silver (Shonea) island (southwest corner of sec. 31, T. 63-16 W.), where mining for gold was carried on. (See map in vol. iv, page 523.)

Ref. Annual Report, ix, page 98; Annual Report, xviii, pages 20, 21.

Meg. Specimen missing (used for assay).

Mic. The section is composed of *calcite*, *chlorite*, minute scales of *sericite*, and very fine grains of *quartz* and probably also *feldspar*. Considerable opaque material which is almost black in transmitted light and gray in reflected light, is present in small patches and also in minute specks. The characteristic feature of the rock is

the presence of large amounts of calcite, or more probably both calcite and *siderite*, as some of this material shows a very slight absorption.

One section.

Age. Archean (Keewatin).

U. S. G.

NO. 400. QUARTZ. (*Vein.*)

Same locality as No. 399.

Ref. Annual Report, ix, page 98; Annual Report, xviii, pages 20, 21; Annual Report, xix, pages 125, 127.

Meg. Specimen missing (used in assay).

Mic. The section shows coarsely crystallized *quartz* which has been fissured and in places evidently crushed into a mass of finer grains. The quartz shows very pronounced undulatory extinction and is cloudy, the cloudiness being due to the presence of numerous minute dust-like particles and cavities containing liquid; occasionally a cavity with a bubble is seen. Besides the quartz there are present small amounts of a gray opaque substance, reddish and yellowish stains, *chlorite*, *pyrite* and a metallic glistening mineral, perhaps *chalcocite*.

One section.

Age. Vein in Archean (Keewatin) rocks.

Remark. See chemical analysis under No. 395.

U. S. G.

NO. 401. HORNBLLENDE SCHIST.

Vermilion lake; probably from Menan island, or a little island just to the east of it; S. E. $\frac{1}{4}$ sec. 36, T. 63-17 W.

Ref. Annual Report, ix, pages 98, 99.

Meg. A gray, compact, fine-grained schist, with a distinct fibrous elongation. The rock is arranged in laminations that run S. 55° W., sloping south and embraces laminations and wide belts, also conformable with the rest (except where large areas come in) of No. 402.

Mic. The colored, shining mineral which gives the rock a micaceous aspect, proves not to be of mica, but of *hornblende* with a little *chlorite*, probably of the species *pennine*. The rock also contains *feldspar*, but much decayed, and much *quartz*, the latter probably of secondary date. Some *biotite*, and also *epidote*, the latter in large grains, appear in the slide, with some altered *garnet*, the alteration product being *chlorite*. There is also a little *sphene*, and of *ilmenite*, having a border of *leucoxene*. There are a few crystals of *apatite* and others of *zoisite*.

Two sections.

Age. Archean (near Couthiching).

N. H. W.

NO. 402. GRANITE.

Same place as No. 401.

Ref. Annual Report, ix, pages 98, 99.

Meg. Light colored, slightly chloritic granite.

Mic. The section shows quartz abundant, and a feldspar which is in part *microcline*, and in part perhaps *orthoclase* or *oligoclase*, but which is rather too much kaolinized to warrant an attempt at specific determination. One section.

Age. Archean (near transition to Coutchiching).

Remark. Where No. 402 occurs in large masses its boundary is not always parallel with the schists, but jogs across a foot or two of them and then runs again parallel, sometimes also crowding them confusedly. This is on the island nearest the point at the narrow passage for canoes bound west. The extremity of the point is of the same character of rock, but the change from the finer grained chloritic to mica slate or schist, is very gradual and imperceptible, the colors and characters blending and mixing apparently in the same rock.

N. H. W.

NO. 403. DIORYTE.

Vermilion lake; same place as No. 401.

Ref. Annual Report, ix, pages 99, 101; Bulletin ii, pages 120, 121.

Meg. A dark-gray, rather fine-grained, apparently micaceous and hornblendic rock.

Mic. The most conspicuous mineral, and perhaps the most abundant, is a pleochroic *hornblende*, which has elongated sections, but rarely shows good cleavages. Next to this is *epidote*, scattered irregularly throughout. Feldspar is both original and secondary, the former filled with micaceous microliths and having ill-defined boundaries, and the latter being clear and quartz-like in extinctions, frequently without cleavages or twinning. This feldspar is not common in this slide. When albite twinning appears it has the aspect of the species *albite*, as described in the rock No. 872. *Chlorite* is hardly distinguishable from some of the hornblende. When fortunately a grain is destitute of cleavage, remains dark or nearly dark on rotation, and has a rounded or perhaps a somewhat angular-hexagonal outline, it may be tested in convergent light. If it give a dark cross, or a very low angle 2 E, it is plainly chlorite. *Apatite* is present in a few stout, highly refractive crystals, evidently from the original crystallization from a molten magma. *Sphene* is scarce, and *biotite* common. *Pyrite* shows a few cubic sections. Two sections.

Age. Archean.

Remark. As remarked by Wadsworth this rock is probably an old eruptive. The glassy feldspar has much the appearance of quartz, which latter we do not find in the slide. It may be compared with rock Nos. 380, 875 and 872.

N. H. W.

NO. 404. GRANITE (*with biotite*).

Vermilion lake, on the north shore; perhaps in sec. 26, T. 63-17 W.

Ref. Annual Report, ix, pages 99, 100.

Meg. A fine-grained gray granite, composed of gray to pinkish feldspar, quartz and biotite.

Mic. The sections are too thick for careful study. They however show that the rock is a granite composed of *feldspar*, *quartz*, *biotite* and *chlorite*. The feldspar is frequently much clouded. It seems to be *orthoclase*, *microcline* and a plagioclase near *anorthoclase*. The biotite and chlorite are quite dark and filled with inclusions and are frequently opaque.

Two sections.

Age. Archean (igneous).

U. S. G.

NO. 405. BIOTITE SCHIST.

"A few rods further a ridge of this rock appears. This is a firm mica schist, with reticulations and inter-laminations of gray quartzite and quartz, and also cross layers and interlaminations of syenite. In the main the syenite is coincident with the schistose structure." Near the same locality as No. 404.

Ref. Annual Report, ix, pages 99, 100.

Meg. A fine-grained, dark-gray schistose rock composed of biotite, quartz and feldspar.

Mic. The section is composed of flakes of dirty brown *biotite*, *chlorite*, *feldspar* and *quartz*. The arrangement of the biotite and chlorite scales causes the schistosity of the rock. The chlorite is charged with minute black particles and appears to be an alteration product from the biotite. The feldspar is very largely altered to kaolin and chlorite; its species was not determined.

One section.

Age. Archean (Coutchiching).

U. S. G.

NO. 406. BIOTITE SCHIST AND GNEISS.

Near the same locality as No. 405.

Ref. Annual Report, ix, page 99; Annual Report, x, page 95.

Meg. A fine-grained, gray biotite schist, with laminations of a light-gray granitic rock which is composed of white feldspar, quartz and a little biotite.

No section.

Age. Archean (Coutchiching).

U. S. G.

NO. 407. HORNBLLENDE SCHIST.

Near the same locality as No. 406.

Ref. Annual Report, ix, page 99.

Meg. A fine-grained, gray, somewhat schistose rock, composed of hornblende and quartz and feldspar.

Mic. The section is composed essentially of a granular aggregate of green *hornblende*, *quartz* and *feldspar*. A little *epidote*, *pyrite*, *magnetite* and *apatite* are also present. The feldspar is quite largely altered to kaolin and a gray opaque substance, although much of this feldspar is rather fresh. Most of it shows no twinning lamellæ. One grain, which gave a positive bisectrix perpendicular, showed an extinction angle

of about 3° , and another grain, which was twinned, gave a negative bisectrix and an extinction of 74° . These results correspond closely with *andesine-oligoclase*.

One section.

Age. Archean (Coutchiching)

U. S. G.

NO. 408. DIORYTE.

Near the same place as No. 404.

Ref. Annual Report, ix, page 100; Annual Report, x, page 95.

Meg. A bold and rocky shore, running northeast, with the general character and structure seen at the last locality, is fairly represented by this rock, which is confused and granitoid, but largely of a dioritic aspect.

Mic. The section shows a semi-regenerated rock, in which a kaolinized feldspar is associated with a fresh and glass-clear feldspar. The latter is twinned on the albite plan, but the former has lost its structure and it cannot be determined whether it was ever striated. With these feldspars is *quartz* of secondary origin, and a *chlorite* which frequently polarizes with the peculiar bluish tint characteristic of *pennine*. A few grains with high refractive index are probably *sphene*.

One section.

Age. Archean (Coutchiching).

N. H. W.

NO. 409. GRANITE (*with biotite*).

Vermilion lake, near the outlet. Perhaps S. E. $\frac{1}{4}$ sec. 23, T. 63-17 W.

Ref. Annual Report, ix, page 100.

Meg. Light colored and granitic.

Mic. With much feldspar and quartz is a little biotite.

One (poor) section.

Age. Archean (igneous).

N. H. W.

NO. 410. GRANITE.

Same place as No. 409.

Ref. Annual Report, ix, page 100.

Meg. A coarsely granular aggregate of quartz and flesh-colored feldspar which embraces apparently two species, an orthoclase and a finely striated plagioclase, and a very little mica.

Mic. The small slide shows *microcline*, an unstriated feldspar and *quartz*. It happens not to cut the feldspar which shows evident albite striations under the hand-glass, which probably is *oligoclase*. It shows no mica.

One section.

Age. Archean (igneous).

N. H. W.

NO. 411. GRANITE.

Same locality as No. 409.

Ref. Annual Report, ix, page 100.

Meg. Medium-grained, pinkish granite, composed of a flesh-colored feldspar and quartz. There are also a few darker areas now mostly occupied by iron oxide from the decay of some dark mineral.

Mic. The section shows a granitic aggregate of quartz and feldspar. The feldspar is much clouded. A considerable part of it shows *microcline* grating, while much is finely twinned by the albite law. The twinning lamellæ are often discontinuous and bent, and there is a fine-grained aggregate between some of the grains, the whole suggesting that the rock has been subjected to pressure. These effects, however, cannot be carefully studied owing to the extreme thickness of the section. There are brownish stains throughout the section, and a few small, opaque, black areas, on the borders of which can sometimes be seen a very little *chlorite*. One of these areas is made up partly of *biotite*.

One section.

Age. Archean (igneous).

U. S. G.

NO. 412. BIOTITE SCHIST.

Same locality as No. 409.

Ref. Annual Report, ix, page 100.

Meg. A roughly schistose, gray rock, rather fine grained. It is composed of biotite, sometimes in scales of considerable size, and a granular aggregate of apparently quartz and feldspar.

Mic. The section is quite thick. It shows much feldspar, a considerable part of which is much clouded, usually not twinned. Two grains, each of which gave a positive bisectrix, had extinction angles of 4° and 6°. This result would place the the feldspar near *oligoclase* or *orthoclase*. *Biotite* and *chlorite* are both present in considerable amount, and *quartz* is not uncommon, although not nearly as abundant as the feldspar.

One section.

Age. Archean (Coutchiching).

U. S. G.

Remark. At the place where were obtained Nos. 409-412 there is an exposure of gneiss which passes confusedly to granite and to mica schist, but has no general schistose structure. There are small patches of mica schist surrounded by granite and bands of coarse granite running through the whole, varying to a fine granite.

N. H. W.

NO. 413. BIOTITE SCHIST.

From the Vermilion rapids, at the outlet of Vermilion lake northward; N. E. $\frac{1}{4}$ N. W. $\frac{1}{4}$ sec. 11, T. 63-17 W.

Ref. Annual Report, ix, page 100.

Meg. Rock similar to No. 912.

Mic. The section shows *biotite*, *hornblende*, *quartz* and *andesine*, with a little *garnet*, *magnetite*, *sphene* and *pennine*.

Two sections.

Age. Archean (Coutchiching).

N. H. W.

NO. 414. GRANITE.

Near the outlet of Vermilion lake, eastward from Outlet bay.

Ref. Annual Report, ix, page 100; Annual Report, x, page 95.

Meg. Light-colored, or flesh-red, coarse, biotitic.

Mic. *Microcline*, *quartz* and *orthoclase* (?), the last being entirely kaolinized. The microcline is fresh and bright, presenting a perfect exemplification of the characteristic structure. It affords a suggestive contrast with the much decayed other feldspar, and may be of secondary date. There is a little *biotite*.

One section.

Age. Archean (igneous).

N. H. W.

NO. 415. BIOTITE SCHIST.

Embraced in No. 414. This rock is entirely like Nos. 412 and 413.

One section.

Age. Archean (Coutchiching).

N. H. W.

NO. 416. BIOTITE SCHIST.

Location uncertain; in the vicinity of Outlet bay and Avis island.

Ref. Annual Report, ix, page 100.

Meg. Glistening mica schist.

Mic. The *mica* is less abundant in the slide than would be supposed from the color and general aspect of the rock, but a fresh feldspar is abundant. The mica has been partly changed, apparently to *chlorite*. The feldspar is, in part, at least, striated, but in the absence of crystallographic characters in those sections giving bisectrices, it is not possible to determine the species by the microscope alone.

One section.

Age. Archean (Coutchiching).

N. H. W.

NO. 417. BIOTITE SCHIST. (*Garnetiferous.*)

Location uncertain, but at some point on the east side of Outlet bay of Vermilion lake.

Ref. Annual Report, ix, page 100; Annual Report, x, page 95.

Meg. Dark, fine-grained, firm mica schist.

Mic. Much resembles rock No. 412, in having much-clouded feldspar, but in that respect differs from No. 416. It also contains considerable quartz. *Garnet*,

with many microscopic crystals, appears in conspicuous grains. It has coarse irregular cleavages, and a faint rose tint.

One section.

Age. Archean (Coutchiching).

N. H. W.

NO. 418. GRANITE.

Location not exactly known, but somewhere on Outlet bay, east side, on Vermilion lake.

Ref. Annual Report, ix, page 101; Annual Report, x, page 17.

Meg. Gray or flesh-red, medium-grained.

Mic. *Orthoclase* (kaolinized), *microcline*, *quartz*, *biotite*, compose this rock.

One thick section.

Age. Archean (igneous).

N. H. W.

NO. 419. BIOTITE SCHIST.

Exact location unknown. At some point in the schist area of Outlet bay of Vermilion lake.

Ref. Annual Report, ix, page 101.

Meg. Compact, fine-grained, gray schistose.

Mic. The thick section only warrants the statement that this rock consists of a dense, markedly schistose aggregate of clouded *feldspar*, *biotite*, *quartz* and *chlorite*.

One section.

Age. Archean (Coutchiching).

N. H. W.

NO. 420. BIOTITE SCHIST.

Location not exactly known, but near the southern limits of Outlet bay.

Ref. Annual Report, ix, page 101.

Meg. Softer mica schist, fine and glistening.

Mic. With much fresh and quartz-like *feldspar* appears *biotite*. After considerable search amongst these translucent grains, not one could be found that could be said unqualifiedly to be quartz, but the greater part of them gave, in convergent light, characteristic figures showing a biaxial mineral. These feldspars, differing remarkably from those in some of these schists, are believed to be of secondary origin, dating probably from the pressure and shearing of the original material. The much-clouded feldspars, which sometimes prevail, but are often seen in the same slide with the glassy forms, are therefore to be classed with the original elements of the rock. A striated, original grain, cut perpendicular to n_p , shows an angle of 10° between the optic plane and the albite macles, indicating *oligoclase*, the grain being in the reverse position from that required by Fouqué's tables.

One section.

Age. Archean (Coutchiching).

N. H. W.

Quartz ore. Gold ore. Dioryte.]

NO. 421. QUARTZ ORE.

Vermilion lake; perhaps N. W. $\frac{1}{4}$ sec. 6, T. 62-16 W. This rock is missing, having been used in making assay of the Vermilion Lake gold ores. (See Annual Report, xviii, page 19.)

Ref. Annual Report, ix, page 101.

N. H. W.

NO. 422. MICA SCHIST.

Same place as No. 421.

Ref. Annual Report, ix, page 101.

Meg. A very fine-grained, micaceous, schistose rock, of a glistening, somewhat silky lustre, but which, notwithstanding its fineness, is probably of the same nature as the biotite schists of the region.

Mic. Consists of *quartz*, *biotite*, *muscovite*, *calcite*; the biotite is frequently occupied by a web of *sagenite* needles which form the characteristic angles of 60° with each other.

One section.

Age. Archean (Coutchiching).

N. H. W.

NO. 423. GOLD ORE.

Nobles' mining location, Vermilion lake; apparently on the south shore of Black Duck point; N. W. $\frac{1}{4}$ sec. 9, T. 62-16 W.

Ref. Annual Report, ix, page 101; Annual Report, xv, page 282; Annual Report, xviii, page 20; Annual Report, xix, pages 125, 127.

Meg. The samples consist of two rocks, evidently the country rock and some vein material. The former is green, fine, calcareous, pyritiferous, apparently sericitic. The latter is largely of calcite, with quartz and a little pyrite.

Mic. The slide was made evidently from the green portion of the rock, and while *chlorite* gives it color, it consists, still, largely of *calcite*. There is also a notable amount of a fresh secondary *feldspar*, and of some *mica*, less refractive than calcite, apparently *muscovite*. The calcite is not in large crystalline individuals, but in aggregates of many small crystals that interlock.

One section.

Age. Archean (Keewatin).

Remark. See chemical analysis under No. 395.

N. H. W.

NO. 424. DIORYTE.

Vermilion lake; perhaps on Birch point, a little west of the Minnesota Company's mining location; represents a local variation, apparently, in the slates of the region.

Ref. Annual Report, ix, page 102.

Meg. A hornblendic, barely schistose, green rock of rather fine grain.

Mic. The *hornblende* is the most conspicuous mineral, making the rock resemble the rocks already described from the east side of Vermilion lake (No. 380). Some of it is nearly colorless, and most of it is light green. It does not show any idiomorphic

relation to the feldspar, indeed feldspar is not an abundant ingredient. Yet there is a small amount of glassy secondary *feldspar*. *Calcite* is an important constituent.

One section.

Age. Archean (probably dike in the Keewatin).

N. H. W.

NO. 425. GRANITE.

Vermilion lake; probably from the island just south of Birch point and crossed by the west line of sec. 15, T. 62-16 W. Forms a low island in a large bay west of the government's station near the head of the bay.
Ref. Annual Report, ix, page 102.

Meg. The rock is jointed and somewhat schistose coarsely, in about the same direction as the slates. It is light-colored, consisting of quartz and a clouded, or slightly flesh-red crushed feldspar resembling orthoclase. There is also a nearly white feldspar abundant in this rock, which is twinned on the albite plan, and which is probably of later origin. Its form is more evidently that of definite crystals and these lie in a matrix, of the other feldspar and quartz.

Mic. The feldspars are all much kaolinized. One prism of apatite is visible.

One section.

Age. Archean (Keewatin).

N. H. W.

NO. 426. QUARTZ-PORPHYRY. (*Macerated debris, sheared.*)

The rock of Ely island.

Ref. Annual Report, ix, page 102; Annual Report, x, page 94.

Meg. Resembles the rocks Nos. 311 and 375. It is of a light-gray color, often with a light-green tint, having free quartz in an amorphous siliceous matrix, with sparse pyrite crystals.

Mic. The section is very fine grained, but there are forms of much frayed and altered feldspars, of the *plagioclase* type, which are conspicuous although they are so permeated by the fine scales and other crystallites resulting from their alteration that they can only be seen in polarized light, otherwise they are lost in the fine matrix in which they lie, and which is composed of the same materials. Sometimes rounded, or sub-rounded *quartzes* of considerable size are visible, sprinkled sparingly through the hand sample. Crystalline cleavages appearing like those of calcite can occasionally be seen on a broken surface, but this mineral under the microscope in part proves to have the characters of *siderite* rather than calcite.

One section.

Age. Archean (Upper Keewatin).

N. H. W.

NO. 427. JASPILYTE. (*Fragment in No. 426.*)

"Rock of Ely island, containing jaspery pieces."

"In traveling over the island, where much of the rock is bare, occasionally may be noticed bright red pieces of jasper superficially embraced in the formation, some of them three or four inches across. The position and structure of these pieces is at variance with the schistose structure of the rock in which they are embraced.

Quartz-porphry. Hematite. Jaspilyte.]

* * * These jaspery pieces, generally smaller than a butternut, but sometimes as large as one's fist, are nearly always angular, or but little rounded, and are in some portions thickly sprinkled over the surface of the schists." *Ref.* Annual Report, ix, pages 102, 103. (The section described as No. 427, in Bulletin ii, page 113, is not of this rock.)

Meg. The hand samples show two red-banded jaspilyte pieces in a rock which is somewhat similar to No. 426, but is more decayed and roughly schistose. A few small feldspars and quartzes are present in this rock.

No section.

Age. Archean (Keewatin).

U. S. G.

NO. 428. QUARTZ-PORPHYRY. (*Altered.*)

Rison's place, Ely island, Vermilion lake.

Ref. Annual Report, ix, page 103; Annual Report, xviii, page 20; Annual Report, xix, pages 125, 127.

Meg. Specimen missing.

Mic. The section is too thick for careful study. It shows numerous highly altered *feldspar* crystals and a few small *quartz* grains in a groundmass which is composed largely of *sericite* with also probably *quartz* and *feldspar*. *Pyrite* and considerable *siderite* are present; also some specks of an opaque gray substance, and one piece of *muscovite* which contains some of this opaque substance. Other similar areas are also seen, but they are much decayed. One section.

Age. Archean (Keewatin).

Remark. See chemical analysis under No. 395.

U. S. G.

NO. 429. HEMATITE.

North ridge, near Tower; probably in N. $\frac{1}{2}$ sec. 27, T. 62-15 W.

Ref. Annual Report, ix, pages 103, 104. Compare No. 871, which is hematite from the Lee mine on the South ridge.

Meg. The specimens show the usual, hard, glistening, crystallized hematite of the Vermilion iron range at Tower. A little quartz is present, and there are small cavities into which project minute plates of hematite. In some of these cavities is a little limonite.

Mic. The section shows *hematite* and coarsely crystallized *quartz*. The hematite sends small fibres into the quartz where the two minerals are in contact; and in places there is a narrow band of these fibres a little removed from, but parallel to, the outline of the hematite. The quartz is much clouded, this feature being in part due to minute dark specks, most probably of hematite, and cavities filled with *liquid*, frequently also containing bubbles.

One section.

Age. Archean (Keewatin).

U. S. G.

NO. 430. JASPILYTE.

Same locality as No. 429.

Ref. Annual Report, ix, pages 103, 104. Compare No. 866, which is jaspilyte from the South ridge.

Meg. The usual jaspilyte of the Vermilion iron range. One of the specimens is gray, another brownish and another red. The last is finely banded with darker bands which contain small magnetite crystals.

No section.

Age. Archean (Keewatin).

U. S. G.

NO. 431. MICA SCHIST.

"Rock that forms the first rapids of Pike river; three feet of gray, firm, fine-grained, heavy, crystalline rock, similar to some of the beds of the jaspilyte and slate formation." S. W. $\frac{1}{4}$ N. W. $\frac{1}{4}$ sec. 3, T. 61-16 W.
Ref. Annual Report, ix, page 105; Annual Report, xv, page 277.

Meg. A hard, fine-grained rock, apparently containing much quartz. Numerous glistening, small cleavage faces of mica are seen throughout the rock.

Mic. The section shows a rock composed largely of *feldspar*. This is in grains of considerable size, which have irregular outlines and which are surrounded by a fine-grained mass of similar feldspar with perhaps some quartz. The large grains of feldspar are not very sharply marked off from the smaller ones, but many of intermediate sizes occur. The feldspar rarely shows cleavage or twinning and the species was not determined. Scattered through the rock, and lying with their long axes in all directions, are small flakes of *muscovite*. These cut through the feldspar. There are also a few minute brownish *biotite* scales *chlorite* scales and a little *epidote*. A peculiar feature of the rock is the presence of large amounts of black dust-like material.

One section.

Age. Archean (Keewatin).

U. S. G.

NO. 432. BIOTITE SCHIST.

"In general a gray quartzite, but varying to a syenitic rock, and to a siliceous slate, and to white quartz, as well as to a tremolitic (?) mica schist, which is dark gray. It exhibits small faults, in which the otherwise parallel and regular strata, or laminations, are jagged or twisted, the west end moving southward about five inches or less. This rock, except in its perpendicular arrangement, and the absence of trap, resembles the gray quartzite formation of Pigeon point. It is more highly tilted, and generally metamorphic. The beds are nearly perpendicular, but dip to the south." Falls of Pike river; N. W. $\frac{1}{4}$ S. W. $\frac{1}{4}$ sec. 3, T. 61-16 W.
Ref. Annual Report, ix, page 105.

Meg. The hand specimen shows alternations of layers of a hard, dark-gray, siliceous, almost slaty rock and of lighter colored, coarser grained rock, which contains small white feldspars. There are gradations between these two extremes and also very fine laminæ, the whole showing a fine example of sedimentary banding.

Mic. The section, which is small, shows a biotite schist. It is composed essentially of a fine-grained aggregate of *biotite*, *quartz* and *feldspar*. Most of the biotite is cut parallel to the cleavage. There is more quartz present than feldspar, but the two are not easily distinguished, the feldspar being clear and fresh and untwinned. The feldspar shows no cleavage and its species cannot be determined. The most

Gneiss. Granite.]

striking feature of the section is the presence of long needle-like crystals of *hornblende*. The terminal planes are not developed, but cross sections show in good development the prism and brachypinacoid. These hornblendes are quite pleochroic, a being light brownish or straw colored, b greenish brown, and c bottle green. They run at random through the section and at times enclose grains of the other minerals.

One section.

Age. Archean (Keewatin).

U. S. G.

NO. 433. GNEISS.

Pike river, above the crossing of the old Vermilion road; perhaps in sec. 26, T. 61-16 W.
Ref. Annual Report, ix, page 106.

Meg. Reddish, fine-grained, apparently an alteration from quartzite or graywacke.

Mic. Presents an aggregate of much altered *feldspar* and *quartz*. The feldspar is crowded with brightly polarizing scales, apparently of *muscovite*, and cannot be specifically determined. Some *hornblende* and a little *zircon* (?) also appear in the slide. A fine sprinkling of dark substances, perhaps of *hematite*, gives some color to the section in high powers. One section.

Age. Archean (Coutchiching).

N. H. W.

NO. 434. GRANITE (*with hornblende*).

Portage between Pike and Embarras rivers, about a mile from the north end of the portage; perhaps in sec. 31, T. 60-15 W.
Ref. Annual Report, ix, page 106.

Meg. A medium-grained, gray granite, composed of white to pinkish feldspar, quartz and hornblende.

Mic. The section is composed mostly of *feldspar* and *quartz*. The feldspar is often much clouded by alteration and sometimes indications of a zonal structure are seen. Some of it shows no twinning, but much has very minute twinning lamellæ, and a few grains show the *microcline* grating. No satisfactory determinations were made, but it seems that the feldspar is *orthoclase*, *microcline* and *anorthoclase* or *oligoclase*. A few areas of *chlorite*, *biotite* and *epidote* are seen; these evidently are the product of alteration of some dark mineral (the hand specimen seems to indicate hornblende). A little *apatite* and iron ore are also present.

One section.

Age. Archean.

U. S. G.

NO. 435. GRANITE (*with hornblende*).

Embarras river; perhaps S. W. $\frac{1}{4}$ sec. 7, T. 59-15 W.
Ref. Annual Report, ix, page 107.

Meg. Dark, hornblendic, with reddish feldspar.

Mic. The slide shows *microcline*, a cloudy feldspar which shows neither cleavage nor twinning and is presumed to be *orthoclase*, *quartz*, *hornblende*, *magnetite* and a single compound grain, not twinned, of a biaxial, light yellow, rather highly polarizing and refractive mineral which has the characters of *augite*, except that the light yellow color is more like that of *epidote*. Its extinction is at a position which bisects the angle between the principal cleavages, and when the cleavages are vertical to each other its extinction is parallel to the cleavages. This occurs when the section is cut perpendicular to the plane of symmetry (compare No. 133). This mineral is always in association with some of the hornblendes, and is sometimes seen in remnants in the centres of the larger hornblendes, indicating that it has been altered largely to hornblende. In some instances there is a light-colored periphery separating it from the hornblende which extinguishes with the hornblende, but has a low bi-refraction; indeed, as low as the white of the first order. The hornblende is light green and distinctly pleochroic; it often embraces *sphene*, which is also quite common elsewhere in the form of small isolated sub-angular yellowish grains.

Two sections.

Age. Archean.

Remark. This granite resembles the granite of Kekequabic lake in several respects. The clouded feldspars above mentioned are the central areas of feldspars which, about their borders and often running all through them, have fresh growths. This might be called a zoning, when casually examined, but it is not due to zonal accretions about a feldspar floating in a magma. It is due rather to the regeneration which has penetrated a granitic debris. This rock, therefore, is to be considered a recomposed and recrystallized granite.

N. H. W.

NO. 436. MAGNETITE.

Near east line of sec. 15, T. 59-14 W.

Ref. Annual Report, ix, page 108.

Meg. Fine-grained, glistening *magnetite*, probably containing some quartz or other siliceous mineral. No section.

Age. Animikie.

U. S. G.

NO. 437. GRÜNERITE-MAGNETITE ROCK.

Same locality as No. 436. The rock associated with the ore.

Ref. Annual Report, ix, page 108; Annual Report, xvi, page 72; Bulletin vi, pages 119, 123, 129, 420.

Meg. A fine-grained brownish-gray rock which becomes lighter or almost white on weathering. It is made up of a mass of small, short, rather fibrous grains and *magnetite* and effervesces with hydrochloric acid.

Mic. The section is composed of a light yellowish mineral, *magnetite* and *calcite*. The light yellowish mineral is a monolinic *amphibole*. It is light yellowish to almost

colorless, and is sometimes slightly pleochroic, *a* being almost colorless, *b* light yellowish and *c* nearly like *b* but sometimes showing a tinge of greenish. It has a strong double refraction and is repeatedly twinned, and is referred to *grünerite*. It is massed in small grains, hardly fibrous, which show the prismatic cleavage well developed. Cross sections sometimes show one or two prism faces partly developed, but the mineral is usually completely allotriomorphic. The magnetite is in small grains and in large, granular, porous masses. The *calcite* is quite common, although not nearly as abundant as the other minerals. It is in small grains, quite frequently in connection with the magnetite, being between it and the *grünerite* or enclosed in the magnetite. This seems to be calcite rather than siderite, which mineral might be expected in this rock. It does not show the high index of refraction, rough black cleavage lines and the pleochroism which are common to the siderite of the iron-bearing rocks of Minnesota. Moreover the hand sample effervesces very readily in acid. Three sections.

Age. Animikie.

Remarks. This rock is part of the iron-bearing series of the Animikie. It is supposed to owe its crystalline character to the influence of the great gabbro mass just to the south.

U. S. G.

NO. 438. MAGNETITE.

Sec. 15, T. 59-14 W.

Ref. Annual Report, viii, pages 150, 151; Annual Report, ix, page 108.

Meg. Magnetite similar to No. 436.

No section.

Age. Animikie.

U. S. G.

NO. 439. TACONYTE.

Same locality as No. 438. Rock associated with the ore.

Ref. Annual Report, ix, page 108.

Meg. A fine-grained, hard, siliceous rock, gray in color, but becoming brownish and porous on weathering. It is seen to contain rather indistinct crowded granules in an aphanitic groundmass.

Mic. The section is too thick for careful study. It, however, shows a taconyte with numerous rounded granules in an almost colorless groundmass. These granules are quite distinct in ordinary light, being stained yellowish. In polarized light the granules are hardly distinguishable, the whole section breaking up into a fine-grained aggregate of *quartz*. Usually the grains in the granules are a little larger than those of the groundmass. *Magnetite* and *siderite* are also present, and there are some tufts composed of very minute radiating fibres. These fibres are colorless alone, but when massed together are yellowish brown. They are perhaps of *actinolite*. One section.

Age. Animikie.

Remarks. For a full description and discussion of the taconyte and its granules see Bulletin x.

U. S. G.

NO. 440. IRON ORE.

Perhaps in sec. 11, T. 59-14 W.

Ref. Annual Report, ix, page 108; Annual Report, xi, pages 156-159.

Meg. A dark reddish-brown, massive iron ore. Some is black and magnetic, other parts are apparently hematite, and much of it gives off water in heating, thus indicating limonite.

No section.

Age. Animikie.

U. S. G.

NO. 441. IRON ORE AND TACONYTE.

Same place as No. 440. Near the top of the shaft.

Ref. Annual Report, viii, pages 150, 151; Annual Report, ix, page 109.

Meg. The ore is banded and irregularly spotted with gray, the latter being siliceous and somewhat globular, characteristic of taconyte.

Mic. The section shows the characteristic round silica grains stained with magnetite, and in other parts is wholly occupied by iron ore.

The following sketch shows the manner of distribution of the ore in a section of this rock which is more siliceous than the average. There are several characters to be noted:

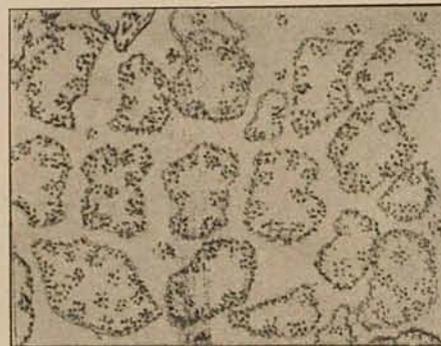


FIG. 20. DISTRIBUTION OF CLUSTERS OF MAGNETITE GRAINS IN THE PERIPHERIES OF SILICEOUS BALLS.



FIG. 21. SHAPES OF THE MAGNETITE CLUSTERS SEEN IN FIGURE 20.

These are chosen from a great number that generally show no grouping into cellular arrangement.

1. The ore consists of a very fine powder or dust, which is black in the section examined as if it were magnetite, and, except for the manner of grouping, which seems to have depended on some earlier or perhaps cotemporary cause, this fine powder is the idiomorphic or first element that shows independent or original characters. These dust-like particles are prevailing in clusters, somewhat as roughly shown in the figure (figure 20), except that each little cluster comprises many times as many of the particles as are shown in the figure.

2. These clusters are again grouped, in a larger way, into balls or siliceous grains, and in these larger grains they are most numerous at the peripheries. There is, besides, a thread of dust-like opaque particles at the very periphery of each of these balls, making thus a dark thread which quite distinctly outlines each section of a ball.

3. The only other observable element is silica, of a form that is so fine grained that it is comparable to the so-called chalcedonic silica of the jaspilite of the Vermilion Iron range. It might be supposed that each of these balls consists of a single mass of silica, having one orientation; but each ball is composed of many fine grains, and similar fine grains also fill the interstices between the balls.

4. In a high power, and the nicols crossed, these fine silica grains show their separate boundaries, and it is observable that in many cases they have the clusters of dark particles as nuclei. Each silica grain embraces one, rarely two, of these clusters where the clusters are numerous, but where they are wanting the silica grains have no central dark cluster. Occasionally a dark cluster is separated from the rest and occupies the centre of a grain in the midst of silica grains that have no nuclei. There is occasionally some confusion, and a cluster seems to be divided between two silica grains. But in the main it is plain that the silica grains grew up in some way under the influence of the dark clusters whenever the material of the clusters was present.

The dust particles are so fine that in the thickness of the slide, cut less than .03 millimeters in thickness, many particles overlap and interfere with each other so as to produce, in the otherwise clear quartz, a grayish obscurity. By lowering the objective, after the first particles come into view (in natural light), others are seen, but, owing to the effect of those that lie above the focal point, as well as to others that still lie below, they cannot be clearly differentiated from the obscurity; yet it is possible in many cases to discern the shapes of the dust clusters; hence, as seen in figure 21,

5. These clusters are rarely or never angular, though frequently they have one part sharper than the general rotundity. They are so constructed, sometimes, as to show that the particles are arranged in a manner of a cylinder or tube. This is evident by a proper manipulation of the fine adjustment screw, viz.: After the objective is lowered so as to focus on the upper side of the section, the particles that are distinctly in focus form perhaps a circular enclosure, or an oblong figure. By lowering the objective by a very small turn, the ring disappears, but its form reappears at the lower focal point, with greater or less distinctness. If the cylinder be crooked so that one side or end protrudes to the right or left from the focal point, the lowering of the objective brings into view distinctly the whole length of the tube on one side as different parts come into focus, until it is cut off by the lower surface of the section.

In other cases, indeed, in most of the clusters, there is no semblance of any structure, but frequently the clusters themselves are grouped, separated by transparent boundaries of siliceous matter in a manner that simulates the cells of foraminifers cut at hazard by the section. Indeed, they suggest strongly the cellular structures represented by Messrs. Woodward and Thomas on plates C and D of volume i of this report. It seems as if the clusters may have been the cells in which gathered the greensand element, and that on conversion from the protoxide to the sesquioxide the iron particles were forced to take such distribution as the walls of the apartments allowed, the walls themselves being replaced by silica. The general aspect of the magnetite, in its distribution in the thin section, suggests the debris of foraminiferal cells, with only occasionally a form preserved that exhibits a probable organic arrangement.

The illustrations that are given by Clark (Geol. Survey of New Jersey, 1892) showing the manner of accumulation of glauconite in the cells of foraminifers, might be supposed to show the original forms of the glauconite grains from which these clusters of magnetite powder were derived, but these are much finer than those.

The first suggestion of the glauconitic origin of the iron ores of the Mesabi range was made by Mr. J. E. Spurr, in Bulletin x, of the Minnesota Survey, and he likewise first conjecturally referred the greensand to the agency of foraminiferal organisms. His material was from the western end of the range where the ore is hematite, and where much of the glauconite is yet in the amorphous protoxide state. He found no structural evidence of organic agency in the microscopic slides which he examined. A re-examination of the same slides, while revealing much amorphous, though globular, greensand, yet does not give any suggestion of composite cellular arrangement. It seems that all the slides examined by him were made from rock in which the glauconite grains are isolated, each from the other, or are so broken and recompacted into a formless mass that no organic order is preserved. In the eastern end of the range the strata have been affected by the nearness of the gabbro range, and at the same time, fortunately, the separate cells are not so completely isolated

from their fellows. The result seems to be a partial preservation of the original cellular arrangement, as well as a more perfect crystallization of the iron into magnetite. The calcareous surroundings have been entirely replaced by silica, the exact outlines of each cell are more or less revealed by the positions of the opaque magnetite-dust clusters, and by the transparent lines that surround and separate them. When the greensand was broken and disseminated loosely, it seems to have been gathered, under the same dynamic force, into larger magnetite crystals and spicules, some of which appear in the same slide from which the foregoing drawings are taken. A photograph of this slide is represented by figure 8 of plate I.*

Two sections.

Age. Animikie.

N. H. W.

NO. 442. JASPILYTE.

From the shallow pit dug for silver by the Chester expedition of 1875. About half a mile south from the from the last; S. E. $\frac{1}{4}$ sec. 11, T. 59-14

Ref. Annual Report, ix, page 109; Annual Report, xi, page 159. This is the same rock as No. 1642, Bulletin vi, page 203.

Meg. A fine-grained, somewhat gray or greenish quartzite which in the field is somewhat banded with iron ore, and is associated with greenish graywackes and schist similar to the schists at Tower.

Mic. The section shows a characteristically fine siliceous rock which consists wholly of quartz.

One section.

Age. Archean (Keewatin).

Remark. This locality is discussed and illustrated by a diagram in Bulletin vi, pages 203, 204. The nature of this jaspilyte is greatly in contrast with that of No. 441. The two are found here in close proximity, yet they maintain their own characters. This rock is also illustrated by No. 1642.

N. H. W.

NO. 443. SANDROCK.

Near Fond du Lac, near the centre of sec. 2, T. 48-15 W.

Ref. Annual Report, x, pages 9, 30; Final Report, vol. i, pages 200-203.

Meg. Light-colored, coarse, approaching a conglomerate, with lenticular thin, interpositions of green shale which are sometimes an inch in greatest extension.

Mic. Along with many angular quartzes and microcline fragments is a large ingredient of aporhyolyte, or devitrified glass, the glass being more evident in the gray portion and the aporhyolyte in the red. Hematite is the coloring element, but is more abundant in connection with the aporhyolyte. Occasional grains of biotite, chlorite and amorphous leucoxene (?) are also present.

* Compare W. D. MATTHEW. On phosphate nodules from the Cambrian of Southern New Brunswick. *Transactions of the New York Academy of Science*, vol. xii, April 10, 1893.

Mic. The principal ingredient is quartz, in rounded grains which have iron rust about their borders. But *microcline*, *orthoclase*, *muscovite* and micro-granulitic quartzite are common. Some of the pebbles are cloudy, being an imperfectly devitrified *glass*. The quartzes are to some extent enlarged by secondary quartz, and in some of the interspaces is a fresh interlocking fine-grained quartz of secondary origin.

Age. Cambrian (in other places associated with the Manitou trap sheets).

N. H. W.

NO. 446. SLATE. (*Black.*)

Near the centre of the south side of S. E. $\frac{1}{4}$ sec. 30, T. 49-15 W. The exposure is in the bottom of a branch of Mission creek. Slaty cleavage strikes east and west.

Ref. Annual Report, x, pages 11, 30.

Meg. A very dark gray or black slate. It cleaves rather roughly and apparently is not so fine grained as most slates, but its constituent grains cannot be distinguished. Crossing the slaty cleavage, at an angle of about 20° , is a rough, schistose structure.

No section.

Age. Archean (Keewatin).

U. S. G.

NO. 447. SHALE. (*Gray.*)

Near centre of south side of S. E. $\frac{1}{4}$ S. E. $\frac{1}{4}$ sec. 31, T. 49-15 W. In Mission creek. Slaty cleavage strikes in the same direction as in No. 446.

Ref. Annual Report, x, pages 11, 30.

Meg. A very fine-grained, light greenish-gray, soft slate or perhaps more probably a shale.

No section.

Age. Archean (Keewatin).

U. S. G.

NO. 448. CONGLOMERATE. (*Red.*)

Near same place as No. 445.

Ref. Annual Report, x, page 11.

Meg. Specimen missing.

No section.

Age. Cambrian (*i. e.*, "Upper" Cambrian.)

U. S. G.

NO. 449. CONGLOMERATE. (*Pyritiferous.*)

S. W. $\frac{1}{4}$ N. E. $\frac{1}{4}$ sec. 1, T. 48-16 W.; St. Louis valley.

Ref. Annual Report, x, pages 11, 12, 17, 30. (Compare No. 1975.)

Meg. Hard, pebbly with vein quartz, with much pyrite, and having in general a light-gray color. Dips with the red beds about 10° E. of S. Some of the pebbles are two or three inches across. In some places nearly one-half of the pebbles are of the underlying slate formation. Nothing of a Keweenawan origin can be found in

this conglomerate. The finest part of the cement is apparently a consolidated kaolinic mud. The entire thickness is probably about 100 feet.

No section.

Age. Basal conglomerate of the fragmental Keweenawan (Puckwunge).

Remark. This conglomerate was struck in the deep well at Short Line Park, where it lies below a considerable thickness of "gabbro," and is interbedded with eruptive rock, some of which is apparently amygdaloidal. The age of this conglomerate is considered in vol. iv, page 567, also in this volume at page 54. N. H. W.

No. 450. SHALE. (*Greenish.*)

S. E. $\frac{1}{4}$ S. E. $\frac{1}{4}$ sec. 2, T. 48-16 W. North bank of St. Louis river. Underlies conformably No. 449.
Ref. Annual Report, x, page 12. Same as No. 1974.

Meg. A soft, very fine-grained greenish gray shale, quite similar to No. 447. When scratched with a knife blade a buff-color streak is left. There are a few brownish rusty areas, probably from the decay of pyrite, as a small pyrite grain is seen in the center of one of these areas.

No section.

Age. Archean (Keewatin).

U. S. G.

No. 451. SHALE.

Same place as No. 450. The bedding dips southwest about 4°.
Ref. Annual Report, x, page 12.

Meg. A soft, purplish-gray shale or slate having a rough, imperfect slaty cleavage which crosses the bedding of the rock at an angle of about 70°. The bedding of the rock is well exhibited by bands and laminae of different color. This rock is in general the same as Nos. 447 and 450. It has some greenish-gray blotches and streaks.

No section.

Age. Archean (Keewatin).

U. S. G.

No. 452. SLATE. ("*Pencils.*")

Same place as No. 450.
Ref. Annual Report, x, page 12.

Meg. Rock essentially the same as Nos. 447, 450 and 451. It breaks into long, rough prisms having a rhomboidal cross section. The two specimens preserved are about five inches long and usually less than a half inch in width.

No section.

Age. Archean (Keewatin).

U. S. G.

No. 453. SLATE. (*Black.*)

Lower falls of the St. Louis river; S. E. $\frac{1}{4}$ sec. 10, T. 48-16 W.
Ref. Annual Report, x, page 12.

Meg. A dark-gray, almost black, rock, having a rough cleavage. It is considerably coarser grained than most slates, but the constituent minerals are not to be determined macroscopically. It has a much rougher texture than the usual black slates of the region.

Mic. The section is composed essentially of dolomite and a black finely disseminated material which may be carbonaceous. There are also a few minute grains of quartz, and possibly some feldspar, and some flakes of chlorite. The dolomite is the main constituent of the rock. It appears like calcite, but is called dolomite, because the rock effervesces very slowly in cold acid, but rapidly when warm. In seams in the hand specimen the same mineral is developed.

One section.

Age. Animikie(?)

U. S. G.

No. 454. QUARTZ. (*Vein.*)

Same locality as No. 453.

Ref. Annual Report, x, pages 12, 21.

Meg. A mass of coarsely crystallized milk-white quartz. There are also pieces of what might be the wall rock of the vein. These are quite soft, and green or greenish gray in color. A little dolomite is also scattered through the specimen.

No section.

Age. Vein in Animikie(?) rocks.

U. S. G.

No. 455. ARGILLYTE.

Lower falls of the St. Louis river. Embraced between and contiguous to white quartz veins and laminae.
Ref. Annual Report, x, page 12.

Meg. This is a fine, nearly black clay state, with numerous joints and plications formed by pressure and slight shearing, apparently sparsely garnetiferous.

No section.

Age. Animikie(?)

N. H. W.

No. 456. GRAYWACKE.

Embraced in the slate at the lower falls of the St. Louis river.
Ref. Annual Report, x, page 12.

Meg. This is a typical graywacke. The grains of quartz are abundant, their larger diameters sometimes reaching one half a millimeter. The feldspars are somewhat kaolinized and rarely of a flesh-red color, and would average perhaps a little larger than the quartzes. These are embraced in a fine matrix of greenish, perhaps chloritic and siliceous matter, which gives color to the rock, which is dense, fresh and firm. It has a coarse, oblique structure, hardly susceptible of being called schistosity, which is coincident with the slatiness of the contiguous argillyte and

which was produced probably at the same time and by the same pressure that gave the argillyte its slaty cleavage.

Mic. The *quartzes* are sub-rounded and angular, and have a conspicuous undulatory extinction, indicative of incipient crushing. The *feldspars* are usually crowded with microliths and clouds of impurities which render them unidentifiable. These are probably of *orthoclase*, since others, which are plainly striated, and which must have undergone the same general history, are well preserved, though not of secondary origin. The fine matrix is composed of a gray or greenish-gray chloritic, ill-defined substance which probably represents simply the finer debris from the same source as the coarser grains. There is in it more or less of opaque dust.

One section.

Age. Animikie(?)

N. H. W.

No. 457. SLATE. (*Graywackenitic.*)

"Slate; average sample for the rock of the lower falls." Same locality as No. 453.

Ref. Annual Report, x, pages 12, 21.

Meg. A black, rough, slaty rock. The mass of the rock is dark, apparently siliceous and very fine grained. In it can be seen small scattered grains of quartz and some of feldspar.

Mic. The section shows grains of *quartz* and *feldspar* embedded in a dirty greenish groundmass. These grains vary from those which are rounded to those which are sharply angular. The feldspar is usually somewhat kaolinized. Many of the grains show no twinning, while a few show fine twin lamellæ. As a rule cleavage is not noticed, and the species of none of the feldspar grains was determined. The groundmass, under a high power, is seen to be made up of minute flakes of *chlorite* and *sericite*, among which are fine grains of probably both quartz and feldspar. There are also many opaque black to grayish specks throughout the groundmass. One small fragment thought to be *rutile* was seen, also apparently a fragment of brown *hornblende*. A few small *epidote* grains were seen also.

One section.

Age. Animikie(?)

U. S. G.

No. 458. GRAYWACKE.

From the clastic beds adjoining a dike at the lower falls of the St. Louis river, S. E. $\frac{1}{4}$ sec. 10, T. 48-16 W. The clastic rocks here have a coarsely basaltic structure along the east side of the dike, which is at least twenty feet wide (No. 459). The columns run east-southeast and dip about 30° from the horizon, while the dike runs north-northeast.

Ref. Annual Report, x, pages 12, 13; Annual Report, xxiii, page 239.

Mac. There are two hand specimens. One is a gray, hard, compact rock with an almost aphanitic background in which are numerous small quartz grains and gray and pink feldspar grains. This specimen is perhaps a fair representative of what

Kloos terms *horn-slate* (Annual Report, xix, pages 109-113). The other specimen is a fine-grained reddish-brown rock which much resembles the metamorphosed quartzites occurring at Wausaugoning bay and Pigeon point. It is composed of quartz and red feldspar mainly. It contains three blotches of bright red feldspar, two of which blotches have centres of calcite.

Mic. A slide from the gray specimen shows one of the usual graywackes of the region. Numerous angular and subangular, with few rounded, *quartz* and *feldspar* grains are embedded in a background which is of quite fine grain. The quartzes and feldspars are of all sizes up to those half a millimeter or more in diameter. The fewness of rounded grains may perhaps be accounted for by secondary enlargements but no grains which showed such enlargements distinctly were seen. The feldspar is apparently *orthoclase*, *anorthoclase* and *oligoclase*, although no grains were definitely determined, and the rock seems to represent granitic debris. The feldspar is in places altering to *sericite* and some of the grains are reddened. The background of the section is a very fine-grained aggregate of quartz and feldspar with numerous *chlorite* flakes, a few *sericite* (or *muscovite*) flakes and some opaque gray material. The chlorite flakes have their long axes usually parallel and they often bend around the larger quartz and feldspar grains. Much of the quartz shows distinct undulatory extinction and sometimes fracturing.

The section cut from the brown hand specimen shows a different rock. This slide is composed of quartz, feldspar and chlorite. It is very similar to sections of metamorphosed quartzite from the Pigeon point region. The feldspar is abundant and presents the characteristic reddened appearance so common in the Pigeon point rocks; it is probably both orthoclase and anorthoclase. No quartz grains showing distinct enlargements were noticed. The quartz shows undulatory extinction, but the chlorite scales are not in parallel arrangement as in the other slide. This rock is part of the graywacke of the region altered by a dike of basic rock, but at present the rock is holocrystalline and shows no distinctly clastic structures.

Two sections.

Age. Animikie(?)

U. S. G.

NO. 459. DIABASE (*with quartz and hornblende*).

Lower falls of the St. Louis river; a dike cutting the slates of the Animikie(?) in a direction north-northeast at least twenty feet wide. This has so hardened the slates that they are more durable under the action of the river than the dike itself.

Ref. Annual Report, x, page 13; Bulletin ii, pages 108, 109; Final Report, vol. iv, plate A.

Meg. A heavy, coarse, nearly black, or gray-black diabase, with hematitic spots.

Mic. The *feldspar* is *labradorite*, as shown by an extinction angle of 61° in a section nearly perpendicular to the bisectrix n_p . It is fresh and twinned on the albite, pericline and apparently on the Bavono plans. No other feldspar is present.

Diabase.]

Olivine is not abundant, but preceded the feldspar. It is much darkened by *magnetite*, and somewhat by *chlorite* and also by *bowlingite*.

Augite preceded the feldspars in large part—indeed, but little or no augite can be seen that followed the feldspars—but it is much altered, some of it having given place to a cloudy, brown and confused mass which cannot be differentiated, but apparently consisting of chlorite and hematite principally. This alteration of the old augite seems to have been cotemporary with the formation of several other minerals, viz.:

Quartz, *hornblende* and *biotite*, which appear as secondary minerals, but not in sufficient amount to seriously interfere with the classification of the rock.

Apatite is abundant, cutting the feldspar and the quartz.

There is a small amount also of what may be considered a devitrified *glassy residuum* from the magma, although these areas are so similar to the decomposition products from the augite that they can hardly be distinguished. One section.

Age. (Cabotian?) dike in the Animikie(?)

Remark. It is the most reasonable to refer this rock to the age of the great eruptive which forms the hills adjacent, which has been called a part of the gabbro. It has also certain petrographic alliances with the great dikes of the Grand Portage region, especially in the fact that the augite preceded the feldspars, a character which has not, as yet, been known to be prominent except in the Grand Portage region.

As to the date of the alteration of the augite, and its cause, see special discussion of petrographic peculiarities in Part III.

N. H. W.

NO. 460. DIABASE (*with olivine*).

Diabase from dike above the lower falls of the St. Louis river, nearly opposite Island No. 6; N. E. $\frac{1}{4}$ S. W. $\frac{1}{4}$ sec. 10, T. 48-16 W. From a smaller dike—probably a dike ten feet in width.

Ref. Annual Report, x, page 13; Final Report, vol. iv, plate A, and pages 17, 571.

Meg. A rather fine-grained, heavy, black diabase with a resinous luster.

Mic. The section shows a diabase composed essentially of lath-shaped *plagioclases*, *augite* and *magnetite*. The plagioclase shows equal extinction angles on either side of the twinning plane running up as high as 30° ; a grain which gave a positive bisectrix had an extinction angle of 23° ; both of these determinations indicate labradorite. The augite is mostly later than the labradorite, though some grains seem to be as early or earlier than some of the labradorite. The rock, especially the augite, has been altered considerably in places, and as secondary minerals there are *hornblende*, *chlorite*, *biotite*, *magnetite* and *quartz*. There are also some yellow areas (*bowlingite*?) which perhaps represent original olivine, and a few grains of *olivine* altering to a green product are present. One section.

Age. (Cabotian?) dike in Animikie(?) rocks.

U. S. G.

NO. 461. DIABASE.

Same locality as No. 460. From a dike eight feet wide.
Ref. Annual Report, x, page 13.

Meg. A fine-grained, dark-gray, diabasic rock with a few small porphyritic crystals of plagioclase.

Mic. The section, which is rather thick, shows small *plagioclases*, mostly lath-shaped, in a confused, dirty, greenish groundmass of alteration products. The *plagioclase* and part of the *magnetite* are the only original minerals present. What the original nature of the groundmass was is uncertain, but it seems probable that it was largely *augite* and the rock a diabase.

One section.

Age. (Cabotian?) dike in Animikie(?) rocks. U. S. G.

NO. 462. DIABASE.

From a dike crossing the river at the mouth of the creek* coming from the north on S. W. $\frac{1}{4}$ sec. 10, T. 48-16. It is about 30 feet wide, and is less durable than the hardened slate.
Ref. Annual Report, x, pages 14, 19.

Meg. Dense, black and fine grained, but sparsely porphyritic, with feldspars of the earlier consolidation.

Mic. The thick section only shows that the rock is composed essentially of *plagioclase*, *augite*, *magnetite*, and that the *augite* was earlier than the feldspar.

One section.

Age. (Cabotian?) dike in the Animikie(?) N. H. W.

NO. 463. DIABASE.

From a dike eight feet wide running north about 15° E. on the N. E. $\frac{1}{4}$ S. E. $\frac{1}{4}$ sec. 9, T. 48-16, crossing the river.
Ref. Annual Report, x, page 14.

Meg. The rock is medium grained, dark (nearly black), and has small, metalloid reflections, appearing like pyrite.

Mic. The much decayed section shows the *augites* were principally earlier than the feldspars, and that long *magnetite* rods have been generated.

One section.

Age. (Cabotian?) dike in the Animikie(?) N. H. W.

NO. 464. DIABASE (*with olivine*).

"From a dike crossing the river a short distance above the last [No. 463], in the same direction, but thirty feet wide."
Ref. Annual Report, x, page 14.

Meg. A rather fine-grained, dark-gray diabase.

Graywacke. Clay slate. Diabase.]

Mic. The section is very similar to that of No. 460, and has the same secondary minerals, except the yellow bowlingite (?). The rock contains considerable *olivine*, and *apatite*, both in short stout prisms and in long needle-like forms, is common.

One section.

Age. (Cabotian?) dike in Animikie(?) rocks.

U. S. G.

NO. 465. GRAYWACKE. (*Fine.*)

From the railroad cut, N. W. $\frac{1}{4}$ S. W. $\frac{1}{4}$ sec. 9, T. 48-16, St. Louis valley.
Ref. Annual Report, x, page 15.

Meg. Tough, gray, firm rock, hardly showing any tendency to slaty cleavage, finely arenaceous.

Mic. The section appears much like that of rock No. 456. The only variation from that description necessary to apply it to this rock is to reduce the size of the quartz and feldspar grains about two-thirds, or even nine-tenths; the former seems to be the correct statement in examining the slide, and the latter in megascopic aspect.

One section.

Age. Animikie(?)

N. H. W.

NO. 466. CLAY SLATE. (*Siliceous.*)

St. Louis river; from the falls; centre of sec. 8, T. 48-16.
Ref. Annual Report, x, page 15; Annual Report, xviii, page 47.

Meg. The beds here dip $33\frac{1}{2}^{\circ}$ toward the south-southwest, swinging round to the south-southeast, and being then in a dip of 39° to 43° . At these falls the rock is less slaty, and more siliceous. Yet it breaks in the direction of the prevailing cleavage easier than against it.

Mic. The rock might be called a fine siliceous graywacke.

One section.

Age. Animikie(?)

N. H. W.

NO. 467. DIABASE (*with olivine.*)

Rock of the dike at Thomson bridge. The river at the bridge is running in the course of this dike, which is about twenty-five feet wide. It is not so durable as the hardened slates on either side. Its direction is north-northeast.

Ref. Annual Report, x, page 16.

Meg. This rock resembles the rock of the great dikes at Grand Portage and Pigeon point, which there cut the slates, forming the principal hill ranges. (Nos. 293, 297, 298, etc.; compare, also, dike rocks Nos. 459, 460, etc.)

Mic. It has the composition and structure of a beautifully ophitic diabase, with older olivines.

In the feldspar extinction on 010 is $25\frac{1}{2}^{\circ}$, showing the usual result for these dikes, viz., *labradorite-bytownite*. It is pierced by long and large microscopic needles of *apatite*.

Chlorite, *biotite* and *bowlingite*, as alteration products, are dispersed scantily in the section, while *magnetite* plays its customary rôle.

Two sections.

Age. (Cabotian?) dike in the Animikie(?)

N. H. W.

NO. 468. ARGILLYTE (?) (*Metamorphic.*)

Rock adjoining the dike at the Thomson bridge; a part of the argillyte hardened.

Ref. Annual Report, x, page 16; Annual Report, xxiii, page 239.

Meg. Dense, black, apparently a fine-grained basalt.

Mic. The thick section shows between the nicols that an incipient crystallization has been started. This is evinced by the existence of roundish and oblong areas which thickly stud the slide, which are much lighter than the rest. These areas occupy more than one-half of the whole space. They are specked with scales of *muscovite* (?), which lie in all positions, and which cause the areas to remain light continually on rotation, although separately each scale has its extinctions.

One section.

Age. Animikie(?)

Remark. This may be from the selvedge of the dike itself.

N. H. W.

NO. 469. GRAYWACKE.

Near Miller's mill, a quarter of a mile north of Thomson; probably in N. E. $\frac{1}{4}$ S. W. $\frac{1}{4}$ sec. 5, T. 48-16 W. This bed is eleven feet thick, and in places it is conglomeratic; it has slaty layers on each side of it.

Ref. Annual Report, ix, page 82; Annual Report, x, pages 16-18, 20, 21, 23, 29; Annual Report, xxiii, page 239.

Meg. A light-gray rock, hard and siliceous. Small quartz and feldspar grains occur in a fine-grained matrix.

Mic. The section shows numerous rounded to angular *quartz* and *feldspar* grains in a dirty greenish groundmass. The section is too thick to enable this groundmass to be carefully studied, but it is evidently composed essentially of *chlorite*, iron ore, and a fine-grained aggregate of *quartz* and *feldspar*.

One section.

Age. Keewatin(?)

U. S. G.

NO. 470. SLATE. (*Black.*)

Near the same locality as No. 469. Quarried for roofing slate.

Ref. Annual Report, x, page 17.

Mic. A very fine-grained, black, clay slate, with a rather rough cleavage.

No section.

Age. Keewatin(?)

U. S. G.

NO. 471. SLATE. (*Black.*)

Near the same place as No. 469. From another quarry.
Ref. Annual Report, x, page 17.

Meg. Almost exactly the same as No. 470, except that it is not quite so black and cleaves a little better.

No section.

Age. Keewatin(?)

U. S. G.

NO. 472. QUARTZ. (*Vein.*)

Forty rods above the railroad (St. Paul & Duluth) bridge; S. W. $\frac{1}{4}$ S. W. $\frac{1}{4}$ sec. 5, T. 48-16 W. The vein coincides with the slaty cleavage of the enclosing slates, but it is irregular and soon pinches out.

Ref. Annual Report, x, pages 17, 18; Annual Report, xviii, page 47; Final Report, vol. iv, page 9 and plate A.

Meg. A mass of coarsely crystallized, milk-white quartz.

No section.

Age. Vein in Keewatin(?) rocks.

U. S. G.

NO. 473. GRAYWACKE. (*Pyritiferous.*)

From the ridge in which No. 472 occurs. Some of the pyrite cubes are three-fourths of an inch across, and occasionally an inch.

Ref. Annual Report, x, page 18.

Meg. A fine-grained, hard, siliceous, grayish rock, containing cubes of pyrite which are usually about a quarter of an inch across. The rock is so fine grained that its constituents cannot be determined macroscopically, but it appears like a fine quartzite. The weathered surface is almost white, but on a fracture just below this surface the rock is brownish, evidently due to the decay of some iron-bearing mineral.

Mic. The section shows *quartz*, *feldspar*, *siderite* (and also *calcite*), *chlorite*, *sericite* and opaque earthy specks. The quartz and feldspar are in grains of various sizes. In places larger grains of these minerals are embedded in a finer grained groundmass which is composed of all the minerals of the rock. There are, however, gradations in size from these larger grains to the smaller ones of the groundmass. In shape these larger grains are roughly rounded to angular, but even the rounded ones do not have sharp boundaries, but interlock with the surrounding grains. These grains appear to be fragmental, but a careful search failed to show any of them which show distinct outlines which had been added to by secondary growths, although there seems to be no doubt but what this process has occurred widely in this slide. The feldspar is often clouded; no careful determinations were made, but it appears to be orthoclase and oligoclase. The siderite is quite common and is frequently accompanied by a brownish stain. Two small prismatic crystals were seen which show a decided absorption of the ray vibrating parallel to the short axis of the crystal and also parallel extinction. These crystals are probably *tourmaline*. Two sections.

Age. Keewatin(?)

Remark. In general the rock has the same composition as other graywackes from this region. It seems to represent debris from a granitic rock mixed with some finer material most of which has crystallized as chlorite and sericite. U. S. G.

NO. 474. DIABASE (*with olivine*).

Dike rock near Carlton. There are several similar dikes in the near vicinity. This one is thirty feet wide. The slates dip 57° to the S. 5° E. (compass). The dikes all run about N. 5° E., with a slight variation either to the east or west of that, which is about the direction of the main gabbro mass northward from Rice's point.

Ref. Annual Report, x, page 18.

Meg. The rock is not distinguishable from that of the dike, already mentioned, running north and south under the railroad bridge near Thomson.

Mic. The *feldspar* shows extinction on 010 at 24° , indicating *labradorite-bytownite*. The *olivine* is sometimes changed to *bowlingite*. *Biotite* is shown by its pleochroism and *chlorite* by its green color. These with *augite* and *magnetite* constitute the rock.

Two sections.

Age. (Cabotian?) dike in the Animikie(?)

N. H. W.

NO. 475. DIABASE (*with olivine*).

From the most westerly of several dikes at Carlton. This dike passes west of Paine's sawmill.

Ref. Annual Report, x, pages 18, 27, 29.

Meg. This dike differs from the foregoing in having conspicuous porphyritic feldspars. One of these cut perpendicular to n_g has extinction at 23° , which is indicative of *labradorite*. Another parallel to 010 has extinction at 19° .

There are small *augites* which preceded the feldspars, but in the main the *augite* is later than the feldspar and embraces it ophitically. *Apatite* and *magnetite* are common, but *olivine* is not evident, as it is obscured by accumulations of magnetite.

One section.

Age. Cabotian dike in Animikie(?)

N. H. W.

NO. 476. GRAYWACKE.

From the south bank of St. Louis river, about a mile above Knife falls.

Ref. Annual Report, x, pages 20, 21.

Meg. Rather fine and granular, gray, coarsely schistose.

Mic. This rock appears like Nos. 469 and 465.

One section.

Age. Keewatin(?)

N. H. W.

NO. 477. GRAYWACKE.

Same locality as No. 20.

Ref. Annual Report, x, pages 20, 21.

Meg. A gray rock composed of small quartz and feldspar grains in a finer grained background.

Graywacke.]

Mic. The section shows *quartz* and *feldspar* grains in the usual dirty greenish groundmass. Both macroscopically and microscopically this rock is very similar to No. 469. (Compare also description of No. 473.)

One section.

Age. Keewatin(?)

U. S. G.

NO. 478. GRAYWACKE.

"Represents the last rock on the right [south] bank of the St. Louis above Knife falls."
Ref. Annual Report, x, pages 21, 23, 29.

Meg. Rock of the same general character as No. 477. Running through it is a band of decidedly coarser grain, but of the same composition.

Mic. The section was evidently made from the coarser band. It shows the usual *quartz* and *feldspar* grains in a greenish groundmass. The rock is very similar to No. 477. Compare also the description of No. 469, which is a similar, but finer-grained, rock. Nos. 477 and 478 differ from No. 469 in only one essential particular, *i. e.*, in lacking, or almost lacking, siderite and pyrite.

One section.

Age. Keewatin(?)

U. S. G.

NO. 479. GRAYWACKE.

From the brink of Knife falls, St. Louis river.
Ref. Annual Report, x, pages 21, 22.

Meg. Similar to No. 477, a gray, hard, arenaceous fragmental rock.

Mic. The section shows no essential variation from the characters already mentioned for several graywackes.

One section.

Age. Keewatin(?)

N. H. W.

NO. 480. GRAYWACKE.

"From the brink of Knife falls."
Ref. Annual Report, x, page 21.

Meg. A greenish-gray rock, much finer grained than most of the graywackes already described. A few small quartz and feldspar grains can be seen in a greenish background.

Mic. The section shows a few scattered *quartz* and *feldspar* grains, much smaller and fewer in number than usual in these rocks, in a greenish groundmass. The section is too thick for a careful study, but it is evident that this groundmass is composed, as usual, of *chlorite* (and probably *sericite*), and fine grains of *quartz* and *feldspar*. The rock is thus like the other graywackes of this vicinity except that it is mostly composed of the material which makes only the groundmass of the other specimens.

One section.

Age. Keewatin(?)

U. S. G.

NO. 481. ARGILLYTE. (*Siliceous.*)

From the brink of Knife falls, St. Louis river.

Meg. The piece has lines of shearing structure intersected by the slaty cleavage.
No section.

Age. Keewatin(?)

Remark. The structure lines in this rock might easily be mistaken for sedimentary banding. They seem to indicate planes of movement under a shearing stress. On the parting surfaces they are characterized by straight, parallel ridges and depressions, which by the natural shadows give the surface a fine banding of light and dark, but there is no apparent variation in the composition of the rock. Across the edges of the slates produced by the prevalent slaty cleavage, are other bands and ridges which do not have a close correspondence with those which mark the flat surfaces of the slates. Compare a similar structure seen in the rock of the railroad cut southeast from Carlton (Nos. 1978, 1979).

N. H. W.

NO. 482. GRAYWACKE.

At Knife falls, in the channel on the north side of the island.

Ref. Annual Report, x, pages 22, 23.

Meg. Slaty graywacke, alternating with graywacke.

Mic. This slide, which is too thick for microscopic use, only shows the usual composition of these fine graywackes, as already mentioned. It is crossed by alternating fine and coarser bands due to sedimentation.

One section.

Age. Keewatin(?)

N. H. W.

NO. 483. GRAYWACKE.

Knife falls, in the channel on the north side of the island.

Ref. Annual Report, x, pages 22, 23.

Meg. Coarse and arenaceous graywacke.

Mic. This rock is like No. 482, except in being coarser.

One section.

Age. Keewatin(?)

N. H. W.

NO. 484. GRAYWACKE.

Knife falls, in the channel on the north of the island.

Ref. Annual Report, x, pages 22, 23.

Meg. This sample is intermediate in coarseness between Nos. 482 and 483 and presents no new features.

One section.

Age. Keewatin(?)

N. H. W.

No. 485. GRAYWACKE. (*Fine.*)

Knife falls, in the St. Louis river. This rock is jointed, hard, and dike-like in appearance.
Ref. Annual Report, x, page 23.

Meg. A fine-grained rock very similar to No. 480.

Mic. The section shows a fine-grained graywacke of the same general characters as others from this vicinity. It is similar to, but finer grained, than No. 480, which see.

One section.

Age. Keewatin(?)

U. S. G.

No. 486. GRAYWACKE.

From the quartzite spit below Knife falls, St. Louis river.
Ref. Annual Report, x, page 23.

Meg. A greenish-gray, medium-grained graywacke, similar to No. 479.

Mic. The section shows the same general characters as already described,—quartz and feldspar grains in a dirty greenish groundmass.

One section.

Age. Keewatin(?)

U. S. G.

No. 487. ARGILLYTE. (*Slaty.*)

Knife falls, from slaty alternations in the spit below the falls.
Ref. Annual Report, x, page 23.

Meg. The specimen is a fine-grained argillyte, showing the curious banding described in the remark under No. 481, which might be mistaken for a sedimentary structure. There is simply a zigzag grain or fibosity which by its oblique intersection on the face of the cleavage planes produces a series of straight minute elevations, in the form of ridges, alternating with depressions. When the light strikes these favorably they cannot be seen at all, but when the ridges cast shadows over the little troughs the banding is conspicuous. There is no variation in the size of the grain, nor in its composition. The structure must be attributed to successive slippings, accompanied by crushing pressure, the resulting motion being minute and permeating the whole rock, so as to displace the original structure, and affecting the rock in a sort of undulatory fracture along parallel planes.

Mic. It is only when the section is very thin that the ultimate composition of this rock can be seen. It is then found to embrace only the usual minerals of the graywackes, but in a finer condition.

One section.

Age. Keewatin(?)

N. H. W.

No. 488. GRAYWACKE. (*Coarser.*)

Near the lower end of a small island north of Homestead island, St. Louis river, above Knife falls.
Ref. Annual Report, x, pages 23, 24, 29.

Meg. A coarser graywacke similar to Nos. 469, 477, 478.

Mic. The section shows the usual grains of *quartz* and *feldspar* in a rather sparse groundmass of *chlorite*, *calcite*, *sericite* and finer *quartz* and *feldspar*. A few small grains of a yellowish mineral with a high index of refraction and strong double refraction are present; this seems to be *epidote*. There is also a rock fragment similar to the finest-grained of these graywackes. This rock shows more rounded and sub-angular grains than, and not so many sharply angular ones as, most of the rocks from this vicinity. Moreover, the outlines of the rounded grains are distinct and they do not interlock with the adjacent grains as in No. 473.

Two sections.

Age. Keewatin(?)

U. S. G.

NO. 489. GRAYWACKE.

From a large boulder near the same locality as No. 488.
Ref. Annual Report, x, page 24.

Meg. Finer grained than the last, and intermediate between it and the more slaty portions. Similar to No. 486.

Mic. One of the usual graywackes of medium grain.

One section.

Age. Keewatin(?)

U. S. G.

NO. 490. GRAYWACKE.

From the rapids in the middle channel, north of Island No. 5, near Knife falls.
Ref. Annual Report, x, pages 24, 29.

Meg. The hand specimen and the section are closely similar to No. 489.

One section.

Age. Keewatin(?)

U. S. G.

NO. 491. GRAYWACKE.

From the same place as No. 490.
Ref. Annual Report, x, page 24.

Meg. An arenaceous, somewhat slaty, hard gray rock.

Mic. The section shows the same composition.

One section.

Age. Keewatin(?)

N. H. W.

NO. 492. DIABASE (*with olivine*).

From large boulders at the rapids at the head of Island No. 4, apparently from a large dike in place near, but which cannot be seen.
Ref. Annual Report, x, pages 24, 29; Bulletin ii, page 108.

Meg. Gray, rather coarse-grained and fresh, heavy rock.

Mic. The *feldspar* is optically embraced by the *augite*. *Olivine* is not abundant. *Magnetite* and a small quantity of alteration products, these constitute

the rock, which is similar to many other dike rocks already noted, in the same region.

One section.

Age. Cabotian dike in the Keewatin(?)

N. H. W.

NO. 493. GRAYWACKE.

At the rapids at the head of Island No. 4. From boulders, but evidently from the formation in place at this point.

Ref. Annual Report, x, pages 24, 26.

Meg. A coarse, gray, harsh, graywacke.

Mic. The description of No. 473 or of No. 488, will apply to this rock, but it is rather more coarse than they.

One section.

Age. Keewatin(?)

N. H. W.

NO. 494. GRAYWACKE.

About half a mile below Knife falls at the river bank. From one of the firmer beds of the formation.

Ref. Annual Report, x, pages 24, 26.

Meg. Schistose, gray, ordinary graywacke.

Mic. The section shows the usual ingredients, also some large areas of *calcite* or of *siderite*.

One section.

Age. Keewatin(?)

N. H. W.

NO. 495. DIABASE.

From a dike 200 feet wide. Fall in the St. Louis river near southwest corner of sec. 18, T. 49-16 W.

Ref. Annual Report, x, pages 25, 26.

Meg. A medium-grained, gray, heavy diabase.

Mic. The section is quite thick. It shows an ordinary diabase with considerable of a green alteration product.

One section.

Age. Cabotian dike in Keewatin(?) rocks.

U. S. G.

NO. 496. GRAYWACKE.

At the head of the uppermost of the Chain islands above Knife falls. Same as No. 493.

Ref. Annual Report, x, page 26.

Meg. Gray, medium grained.

Mic. The *quartz* and *feldspar* grains show the same sub-angular shapes. They lie in a gray matrix of chloritic substance in which are finer grains of the same minerals, with some *calcite*.

One section.

Age. Keewatin(?)

N. H. W.

NO. 497. GRAYWACKE.

"From near the middle of the central channel a short distance above the head of the uppermost Chain island."

Ref. Annual Report, x, pages 26, 29.

Meg. A rather light gray graywacke of medium grain. It is quite similar to Nos. 496 and 493, but finer grained than the latter.

Mic. The section shows, as usual, quartz and feldspar grains in a greenish groundmass.

One section.

Age. Keewatin(?)

U. S. G.

NO. 498. ARGILLYTE.

The rock of the country 150 yards above the fall where No. 495 was obtained.

Ref. Annual Report, x, page 26.

Meg. Gray, fine-grained, firm, cleaved argillyte.

Mic. This rock has no representing section. It is of a lighter gray color on the edges of the laminae than on the sides. It is plainly too siliceous to make a roofing slate.

Age. Keewatin(?)

N. H. W.

NO. 499. GRAYWACKE.

"Rock immediately overlying No. 498."

Ref. Annual Report, x, page 26.

Meg. A rather fine-grained graywacke. A few small pieces of a black argillyte are seen in the hand sample.

Mic. The section shows the usual graywacke described more fully under Nos. 473 and 488.

One section.

Age. Keewatin(?)

U. S. G.

NO. 500. GRAYWACKE. (*Slaty.*)

From near the southwest corner sec. 18, T. 49-16. From just below the falls which here occur in the St. Louis river.

Ref. Annual Report, x, page 26.

Meg. Fine grained, gray.

Mic. Besides the usual minerals this section shows a few grains that are much oxidized and stained with *limonite*, which were probably *siderite*. There is also one large oblong area which is filled with finely granular *quartz* grains, and appears to be of the well-known jaspilyte, or at least like that rock.

One section.

Age. Archean (Keewatin).

Remark. This grain of jaspilyte shows that as a rock it must have pre-existed. It could not, therefore, have been as late as those granites which are supposed to

have been eruptive since the Keewatin, *i. e.* unless those granites be themselves derived from fusion of Keewatin rocks, and such a material escaped fusion. (Compare H. V. Winchell, Geological Age of the Saganaga Syenyte, American Journal of Science [3], xli, 386.)

N. H. W.

NO. 501. DIABASE.

Right bank of the St. Louis river; centre of sec. 19, T. 49-16 W.
Ref. Annual Report, x, pages 26, 28, 29.

Meg. A black, heavy, rather fine-grained diabase.

Mic. The section shows *feldspar* laths, *augite*, *magnetite* and alteration products. The *feldspar* is abundantly twinned according to the albite law, and a few grains are seen which show this twinning and also that according to the pericline law. Equal extinction angles on either side of the composition faces of the albite twins run up as high as 29°, and a grain which gave a negative bisectrix very nearly perpendicular had an extinction of 63°; both of these results indicate *labradorite*. The *labradorite* is altering in places to a cloudy brownish material. The *augite*, instead of being in small plates, as would seem to be the case when viewed in ordinary light, in polarized light is seen to be in grains, which, however, are usually later than the *labradorite*. Some of the *augite* appears to be earlier than, or about the same date as, the *feldspar*. The *augite* is altering to a greenish material,—mostly *chlorite*. Much *magnetite* is present in small grains and crystals, probably original, and in rough rods, probably secondary.

One section.

Age. Cabotian; dike in Keewatin(?) rocks.

U. S. G.

NO. 502. DIABASE (*with olivine*).

Near Knife falls, at a cut by the railroad; width and direction not easily seen.
Ref. Annual Report, x, page 28; Bulletin ii, page 112.

Meg. Rather coarse-grained and dark-gray rock.

Mic. The *feldspar* is embraced optically by the larger *augites*, but there are many *augites*, of smaller size, that preceded the *feldspar*. A little *hornblende* has been formed by alteration of the *augite*, also a little *epidote* from the same source. The *olivine* is considerably altered also, becoming a brownish or yellowish brown *bowlingite*. *Magnetite* is common as rods and shapeless aggregations.

Two sections.

Age. Cabotian; dike in Keewatin(?)

N. H. W.

NO. 503. DIABASE (*with olivine*).

From another dike near the same place as No. 502.
Ref. Annual Report, x, page 28; Bulletin ii, pages 105, 106.

Meg. Rather coarse-grained and dark-gray rock.

Mic. All the characters mentioned under No. 502 appear in this rock except hornblende and epidote, and in addition one good sized and two smaller microscopic crystals of *rutile* are present. In the larger crystal the plane of the larger section happens to be so nearly perpendicular to the optic axis as to show unmistakably the uniaxial interference figure in convergent light; the grain also exhibits the four intersecting cleavages in two systems standing at 45° with each other, each system having its own intersection at 90° . *Biotite* is also scantily generated in this rock and abundance of *apatite*. *Chlorite* stains some of the feldspars.

One section.

Age. Cabotian dike in the Keewatin(?)

Remark. The above rutile grains are undoubtedly original. They are not in association with any possible alteration products from ilmenite. The largest grains are themselves somewhat altered about their margins, and while they are idiomorphic their outlines still are blunted.

N. H. W.

NO. 504. GRAYWACKE.

At two miles and a half north of Carlton, on the railroad.

Ref. Annual Report, x, pages 28, 29; Annual Report, xviii, page 47.

Meg. Contains black pebbly masses of what appears to be argillyte. These are somewhat rounded, often half an inch in larger dimension, and occasionally two inches long. They are covered with a black, shining and slippery coating, apparently slickensided.

Mic. Quartz, feldspar (*microcline*, *orthoclase*, *plagioclase*) *muscovite*, *chlorite*, *calcite*, *zircon*(?), with more or less coloring matter in the form of *hematite*; these constitute this elastic rock, which is not much, if any, metamorphosed beyond compact consolidation.

Two sections.

Age. Upper Keewatin(?)

N. H. W.

NO. 505. GRAYWACKE.

Two miles north of Carlton, on the railroad grade, at a long rock cut.

Ref. Annual Report, x, pages 17, 19, 29.

Meg. Hard, gritty graywacke.

Mic. Angular, frequent grains of *quartz*, *feldspar* of several kinds, and a few of *jaspilyte*, are embraced in the usual more or less clouded matrix, which consists of *chlorite*, *calcite* and fine *quartz* and *feldspar* debris.

One section.

Age. Keewatin(?)

N. H. W.

Argillyte. Graywacke. Slate.]

No. 506. ARGILLYTE. (*Slaty.*)

One mile north of Carlton, on the Knife Falls railroad.
Ref. Annual Report, x, page 29.

Meg. Large sample of slate, showing the slaty cleavage crossing the sedimentary structure.

No section.

N. H. W.

No. 507. GRAYWACKE.

Knife falls, just across the north channel, at the head of the second rapids, on Homestead island.
Ref. Annual Report, x, page 30.

Meg. Rather fine grained, with numerous seams and patches of vein quartz.

Mic. The comparative fineness of the grain, combined with the thickness of the section, renders it impossible to individualize the finer elements, though there is no reason to suppose this rock differs from others of the region. There are sparsely disseminated angular grains of quartz and of triclinic feldspar which are embraced in the much finer, gray, sub-opaque matrix.

One section.

Age. Keewatin(?)

N. H. W.

No. 508. GRAYWACKE.

"At the extreme upper end of Homestead island, at the very point, higher up than any rock along there before mentioned." St. Louis river above Knife falls.
Ref. Annual Report, x, page 30.

Meg. A rather light, greenish-gray graywacke of medium grain, very similar to others from this vicinity.

Mic. The section is quite thick, but shows that the rock is composed of grains of quartz and feldspar in the usual greenish groundmass.

One section.

Age. Keewatin(?)

U. S. G.

No. 509. GRAYWACKE.

"Some rods east of the head of Homestead island, on the north side [of the St. Louis river], about one hundred rods west of the head of the rapids that there run across to the other islands."
Ref. Annual Report, x, page 30.

Meg. Closely similar to No. 508.

Mic. A graywacke of the usual type, but the greenish groundmass is not as abundant as is common. Besides the usual minerals, *calcite* and small grains of *epidote* are seen, and there are a few small highly refractive, strongly double refractive grains which are probably *sphene*.

One section.

Age. Keewatin(?)

U. S. G.

No. 510. SLATE. (*Graywackenic.*)

"Slate from the very foot of Homestead island, below the rapids last mentioned [under No. 509]."
Ref. Annual Report, x, pages 12, 30, 38.

Meg. A very fine-grained, greenish-gray, slaty rock.

Mic. The section shows none of the large grains of *quartz* and *feldspar* common in the associated graywackes. It is composed of a greenish mass which under a high power is seen to be made up essentially of minute flakes of *chlorite* and a micaceous mineral (probably *sericite*), and minute grains of *quartz* and *feldspar*. A few grains of *epidote* are also seen, and there are specks which appear yellow in reflected light which are perhaps composed of very minutely granular *epidote*.

One section.

Age. Keewatin(?)

Remark. In composition this rock is essentially the same as the greenish "groundmass" of the graywackes of this locality. It simply represents the finer material of these rocks and it lacks the coarser grains of quartz and feldspar which are so characteristic a feature of the associated graywacke beds.

This rock is the last of the graywackes from the St. Louis river, and in this connection it is necessary to refer to the description of Dr. J. H. Kloos of rocks from the vicinity of Thomson (Annual Report, xix, pages 109-113). He described in detail two rocks, which he termed *horn-slate* and *roofing-slate*. The former evidently was a medium or fine-grained graywacke (compare Nos. 473, 508, 509, and others), while the latter seems to have been one of the black argillaceous slates which vary to graywacke slates like No. 510.

U. S. G.

The doubtful assignment of the rocks from Thomson northward to Cloquet to the Keewatin, is designed to express a slight preference for that rather than for Animikie. The more probably Animikie part of this series lies further south, appearing at the lower falls of the St. Louis, and at the cuts made by the Northern Pacific railroad. The question of the age of the Thomson rocks is considered in vol. iv, page 551.

N. H. W.

NO. 511. GABBRO AND GRANITE. (*Contact.*)

Duluth. At a point in the bed of Miller's creek, near the quarter section line of sec. 32, T. 50-14, 424 feet above lake Superior. This rock extends indefinitely up stream.

Ref. Annual Report, x, pages 34, 35; Bulletin ii, page 94.

Meg. The specimen consists of two rocks, a reddish granite and a gray gabbro.

Mic. The red rock has much *quartz*, both in isolated grains and in finer pegmatitic growths in the feldspars. The *feldspar* is stained with *hematite*, a fact which causes the general redness of the rock. It cannot be specifically determined, but is probably largely of *orthoclase*, yet occasionally along with some evident *plagioclase* a trace of very fine albite twinning can be seen, indicating, in this situation, that some of the feldspar is *anorthoclase*. No other mineral is abundant. There is some *hornblende*, a little *biotite* and *chlorite*, and an occasional *pyrite*.

Gabbro.]

The gray portion consists essentially of *augites* and *plagioclase*. The former are small, much altered and earlier than the latter. A little *magnetite* and a few grains of *biotite*, with a few isolated small areas of *quartz*, due to the proximity of the acid rock and much *apatite*, make up the category of minerals of this portion of the slide. The quartz does not appear in this portion in the form of micropegmatyte, but as isolated sizable grains. Rods and spicules, as well as irregular accumulations of magnetite seem to constitute the chief impurity in the augites. Still they are frequently simply clouded with alteration products in such a manner that their nature cannot be determined. One section.

Age. Cabotian.

N. H. W.

No. 512. GABBRO.

N. E. $\frac{1}{4}$ sec. 25, T. 50-15, on the "Herman Town road," northwest from Duluth. Land of Peter Benson. Occasional exposures of this rock rise above the rolling surface of gravelly red till. Elevation here is 500 feet, more or less, above lake Superior.

Ref. Annual Report, x, page 35; Bulletin ii, page 91.

Meg. Heavy, gray, trappean rock with so much magnetite that it sometimes disturbs the needle, rather coarse grained.

Mic. The *feldspar* is not wrapped about by the pyroxene, but was generated about cotemporary with it, presenting the structure of gabbro. It has an extinction angle on 010 of 21° which is about that of *labradorite*; another has extinction at 26° , at *labrador-bytownite*. Extinction on a section nearly perpendicular to n_x is $15\frac{1}{2}^\circ$ to $17\frac{1}{2}^\circ$, which is rather low for labradorite, but not conclusive, since the obliquity of the section may cause this deviation.

The *pyroxene* has a fine, clear, lamellar cleavage, like the cleavage seen in No. 133, but in the whole slide but two or three augite grains can be found whose extinction, like that of the augite of No. 133, is parallel to this cleavage. It occasionally shows twinning bands similar to those of albite in the plagioclase. Pyroxene forms rims about the olivine.

Olivine in subordinate amount occasionally surrounds the magnetite grains. In date it preceded the pyroxene. In some cases it has been replaced by ferruginous products of decay (bowlingite). A hematitic stain is a common feature in the vicinity of the olivines. The section studied is so thick (about .055 millimeters) that the olivine shows the light tints of the fourth order, whereas the augite is highly colored and about its edges all of the lower orders can be counted. In another section, made thin, the same fact in respect to the relative ages of the olivine and the feldspar is seen as in No. 258, viz.: it is in some cases later than the feldspars and than the augite. (Compare No. 703.)

Apatite is visible in sizable grains of the first consolidation. They are rounded at the extremities, and elongated, and present a marked shagreen on lowering the

polarizer and condenser. They are distinguishable from the olivine by reason of their clear white color in parallel light, their marked, single cleavage, which is parallel with one nicol at the instant of extinction, and by their very low double refraction, even in very thick section.

In order to be satisfied that this mineral is really olivine, further examination was made, viz.:

1. Another thin section was prepared, and about one-half of it was not covered by the glass lamella,

2. This uncovered portion was immersed in nitric acid for eighteen hours. There not being sufficient evidence of solution,

3. This uncovered portion was kept for five hours in a strong hydrochloric acid at 40° centigrade. In order to detect any gelatinous silica,

4. A part of the slide thus exposed to acids was covered with an aniline color, and then after thorough washing and even long soaking in clean water,

5. On examination there was a characteristic stain of the aniline in some of the border areas about the magnetite. But as there is very little of olivine in the portion thus treated, but little permanent coloration was produced. The other minerals were not visibly affected by these acids.

It seems plain, hence, that there is an olivine later than the feldspars. There is also an earlier olivine, which is now so changed that it takes the form of an isotrope, and must be considered to date from the first consolidation. The later olivine probably dates from the epoch of cooling, as already suggested for the rock No. 1.

Remark. Considering its exposed position this rock is little weathered. The relation of the olivine to the feldspar, as seen in No. 258, is illustrated by figure 18.

NO. 513. FORELLENSTEIN.

N. H. W.

From an outcrop near Duluth; N. W. $\frac{1}{4}$ N. E. $\frac{1}{4}$ sec. 27, T. 50-15; at about the same altitude as No. 512, and not far distant.

Ref. Annual Report, x, page 35; Bulletin ii, page 95.

This rock consists, as remarked by Wadsworth, essentially of *plagioclase* and *olivine*, making a forellenstein. The sections are too thick to be of use in making any further determinations. The rock is well preserved. It is probable that the lateness of the last glacial period has not allowed sufficient time for much decay on these summits, since the removal of the pre-glacial decay.

In another section of this rock appears a little *diallage*, surrounding, or at least embracing, the early *olivines*, accompanied by a little *magnetite* and still less of *biotite*.

Three sections.

Age. Cabotian.

Forellenstein.]

Remark. This rock might be styled anorthosite. By far its largest constituent is feldspar. It is similar to the "feldspar rock" of Carlton's peak, and to that of Little Saganaga lake.

N. H. W.

No. 514. FORELLENSTEIN. (*Gabbroid.*)

Near the centre of the S. W. $\frac{1}{4}$ sec. 22, T. 50-15 W., near Duluth.

Ref. Annual Report, x, page 35; Annual Report, xxiii, page 230; Bulletin ii, page 95, plate V, figures 1 and 2.

Meg. A dark gray rock of medium grain. Gray feldspar grains and crystals are seen enclosed in an almost black crystalline mass.

Mic. The section is composed of a granular mass of *feldspar*, *olivine* and *diallage*; *magnetite* and alteration products are also present, although the rock is comparatively fresh. The *diallage* is in small amount, the feldspar and olivine being the essential minerals. These two minerals mutually interfere in their outlines, having crystallized at about the same time. However, much of the olivine is earlier than the feldspar, though not idiomorphic, while occasionally a feldspar grain is seen which conditions the outline of the adjoining olivine. The *diallage* is in part later than the feldspars and in part of about the same date. It is seen enclosing olivine grains and in the interstices between the feldspars.

The *feldspar* is abundantly twinned according to the albite law and rarely a grain shows the pericline twinning. Equal extinction angles on either side of the twinning plane run up as high as 31° , and a grain which shows a positive bisectrix closely perpendicular gave an extinction of 20° , both of which results indicate *labradorite*.

The *olivine* is in roughly rounded grains and more commonly in aggregates in which the grains have polygonal outlines. It is altering to a yellowish and also to a green serpentine.

The *diallage* is only in small grains. It is much clouded by minute black (*magnetite*) inclusions which are usually arranged in lines parallel with the parting. In places the *pyroxene* extends in a narrow band between the olivine and the feldspar, and occasionally surrounds an olivine grain.

Magnetite is not very common and nearly all which is present is secondary, occurring in the altered olivines. Three sections.

Age. Cabotian.

Remark. The *diallage* is in such small quantities that it can be regarded as non-essential and the name forellenstein can be applied to the rock, which is essentially a granular aggregate of *labradorite* and *olivine*. It seems, however, that this forellenstein is only a facies of the usual gabbro very rich in olivine and very poor in *diallage*. Such a facies of the gabbro is not uncommon. It occurs in considerable amount about fifty miles northeast of this locality.*

U. S. G.

* A. H. ELFTMAN. *Annual Report*, xxiii, pp. 224-230.

NO. 515. DIABASE (*or fine-grained gabbro*).

At Sucker river; crosses the mouth of the river; runs northeast. Compare No. 89.
Ref. Annual Report, ix, page 24; Annual Report, x, page 36.

Meg. Brownish green, fine grained.

Mic. The great multitude of little *augites* antedated the microlitic *feldspars*, but occasionally a large augite is seen to be cut ophitically by the feldspars and also to include augite grains having different orientation, apparently of the older generation. *Magnetite* now largely replaces the olivines. There is a confusion of indeterminable secondary products, such as chloritic substance, bowlingite(?), biotite(?), hematite(?)

One section.

Age. Cabotian.

Remark. The date of the augites, with respect to the feldspars, in this fine-grained rock, is like that in some of the coarse-grained gabbros. N. H. W.

NO. 516. DIABASE.

Forms the bed of the stream at the mouth of Sucker river, and appears like a bed of lava. This disintegrates into globules and rots to a great depth before falling away.

Ref. Annual Report, ix, page 24; Annual Report, x, page 36.

Meg. Heavy, dark green and almost black when wet.

Mic. The section shows an ordinary diabase with ophitic structure.

One (poor) section.

Age. Cabotian.

N. H. W.

NO. 517. DIABASE. (*Gabbroid.*)

From the foot of the bluff, on the north side, at the mouth of Gooseberry river. Compare No. 108.

Ref. Annual Report, ix, page 28; Annual Report, x, pages 37, 38.

Meg. A fine-grained diabase, with some red mottling.

Mic. The section shows that in general the *augite* preceded the *feldspars*. The crystals of augite are small, but are independent of the feldspars, yet occasionally there is a larger augite which was of later date, as it is cut by the feldspars in an ophitic manner. Whether there is any chemical difference between the augites of different dates would be an interesting point to determine, but optically they appear much alike. The crystalline form in neither is perfect.

One section.

Age. Cabotian.

N. H. W.

NO. 518. DIABASE.

From the top of the low bluff at the south end of the beach at the mouth of Gooseberry river, containing amygdules of chalcedony. Furnishes some of the pebbles and all of the agates of Gooseberry beach. This rock slopes into the water, and, where it is constantly under the action of the waves, it is reddish, like the pebbles, but the pebbles mostly come from another bluff farther east, and are more acid. Compare No. 108.

Ref. Annual Report, ix, page 28; Annual Report, x, pages 37, 38.

Agates. Aporhyolyte.]

Meg. The rock is sparsely porphyritic with a striated feldspar. It is in general medium grained and brown.

Mic. The section shows an ophitic structure and a spottedness caused by the *augites*. The larger *augites* are less decayed and are less clouded by magnetite than the surrounding rock. The porphyritic *feldspar* has an extinction angle on the brachypinacoid of 28° , indicating *labrador-bytownite*. In a thinner section made by Marchand, of Paris, may be seen a brilliant orange red mineral in fine grains whose date seems to be earlier than the microlitic feldspars, whose extinction is parallel to a cleavage. It is taken to be *bowlingite*, an alteration from olivine. There is also a notable amount of a minutely crystalline mineral, so confusedly compact that it gives only an aggregate, yet granulated, polarization or simple darkening. This is probably what was called *saponite* by Owen, but which probably merits a specific designation of its own. (See No. 91B.)

Two sections.

Age. Cabotian.

N. H. W.

NO. 519. AGATES.

"Agates, taken from the rock at Gooseberry river."

Ref. Annual Report, x, page 37; Annual Report, xviii, pages 27, 61.

Meg. Agates, somewhat banded and usually white in color. In the interior of these the quartz is sometimes distinctly crystalline. A little calcite is also present.

No section.

Age. Cabotian.

U. S. G.

NO. 520. APORHYOLYTE.

At one mile west of Splitrock river. Rises from the water in a small bay, and continues eastwardly. This bluff is the source of the red pebbles which constitute the most of the beach at Gooseberry river. The rock does not crumble, but goes to pieces in a multitude of small fragments, which strew the beach and work westward under the action of storms. It belongs stratigraphically above the agatiferous trap at Gooseberry river, and is probably the same as the red granite at the west point of Beaver bay. Compare No. 110.

Ref. Annual Report, ix, pages 29, 30; Annual Report, x, pages 38, 39, 40.

Meg. The rock is finely porphyritic with a red feldspar and with quartz, but in the main it appears to be almost amorphous.

Mic. The great endurance of the pebbles derived from this rock is explained at once by an examination of the thin section, for it is permeated by poikilitic *quartz*.

In the section is seen an instance of a rather unusual unison of orientation of several small, clear *feldspars*. The individual crystals are sometimes idiomorphically formed, and show crystal faces and edges. They lie adjacent in the matrix of amorphous red substance, though are not in contact, but they all extinguish at the same instant. The drawing below was made by the use of the camera lucida in order to show this curious combination. In another place in the same section a much larger number of similar grains are grouped. These are, however, not perfect in

any instance in outward boundaries. The appearance is as if a rounded fragment, made up of many small fragments of feldspar, had been involved in the rock. That, however, is not a possible explanation, since they are oriented in common, and they must have originated in the rock. They seem to be an instance of *feldspar "globulaire,"* to use a term which has been applied by Fouqué to incipient quartz. The photographic reproduction of this structure is seen in figure 9, of plate I.

Two sections.

Age. Cabotian.

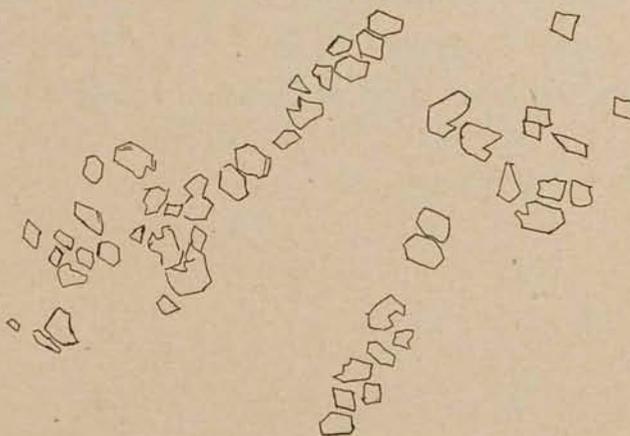


FIG. 22. FELDSPAR GRAINS HAVING SIMULTANEOUS EXTINCTION.

Remark. The identity of orientation in these small feldspar grains points to their being remnants of feldspar crystals which have suffered corrosion by the encroaching siliceous matrix. The poikilitic quartz of the rock appears to be a secondary element and the whole rock may be the result of an extreme alteration of a once more basic one; in which transformation the slow entrance of silica has been the chief feature. The general appearance of the rock itself is not noticeably different from the aporhyolytes of the region. These features, and other facts which are brought together in Part III, raise the question of the origin of all the poikilitic quartz of the aporhyolytes, as well as of the aporhyolytes themselves. (Compare No. 526.)

N. H. W.

No. 520A. LAUMONTITE, CALCITE, ETC. (*Vein matter.*)

From a vein in No. 520.

Ref. Annual Report, x, page 38.

Meg. A mass of red laumontite and coarsely crystallized calcite. The specimen seems to represent the width of a vein—about three inches. The sides are of calcite and the interior of calcite and laumontite.

No section.

Age. Vein in Cabotian rock.

U. S. G.

NO. 521. APOTRACHYTE. (*Breccia.*)

"Is an irregular thrust-up rock, appearing in the beach near the west end of No. 520. Its bedding is distorted. It almost appears conglomeritic."

Ref. Annual Report, x, pages 38, 114.

Meg. The hand sample shows a breccia composed of rock which is somewhat similar to No. 520, but is more decayed and darker colored. Occasionally small spots, apparently amygdules, can be seen in the rock. It is seamed through and through by fine pinkish and gray veinlets, and the cementing material of the whole rock is a white, very finely crystallized silica, with some calcite.

Mic. The section was evidently made from one of the larger fragments of the hand specimen. It shows small porphyritic *feldspars*, considerably altered and clouded and frequently holding *chlorite* in irregular areas in a groundmass composed of small poikilitic areas of *quartz* holding minute, cloudy, feldspathic grains, and in all respects resembling the groundmass of many of the devitrified rocks already described. The species of the porphyritic feldspars was not determined. *Pyrite* and *calcite* also occur. The rock can be referred to an apotrachyte.

One section.

Age. Cabotian.

Remark. From the field description it seems possible, though not certain, that we have here a deposit of tuffaceous material. The hand specimen, however, would not warrant us in certainly referring this rock to a volcanic fragmental. U. S. G.

NO. 522. BASALT. (*Amygdaloidal.*)

Near the top of the bluff in the bay first north of Splitrock point.

Ref. Annual Report, ix, page 30; Annual Report, x, page 40.

Meg. A very fine-grained, dark brown rock, with amygdules of laumontite and calcite. The rock appears considerably decayed and contains many indistinct small areas of chlorite.

Mic. The section is made up of minute lath-shaped *feldspars* in a mass of alteration products, *hematite*, *magnetite* and *chlorite*. The feldspars are somewhat altered. A considerable number show albite twinning and equal extinction angles on either side of the composition face running up as high as 23° , indicating *labradorite*. What the original nature of the rock, aside from the feldspars, was, is uncertain, but it seems most probable that it was largely glassy.

Two sections.

Age. Cabotian.

U. S. G.

NO. 523. BASALT (?)

From the base of the bluff from which No. 522 was taken.

Ref. Annual Report, ix, page 30; Annual Report, x, page 40.

Meg. A very fine-grained, reddish-brown rock, holds a very few small porphyritic feldspars. Some small dark dots, probably magnetite, are visible.

Mic. The sections are much charged with *magnetite* and are highly stained by hematite, thus considerably obscuring the other minerals, which are *quartz* and *feldspar*. The feldspar is in small lath-shaped crystals and in larger grains, but the main mass of the rock, aside from the iron ores, seems to be composed of secondary quartz, often in small poikilitic areas. The exact nature of the rock is not clear, but as it seems to be similar to No. 522, it is thought to be a rather basic rock, largely glassy originally, but now much charged with secondary quartz. It is not, however, improbable that the rock was originally more of a trachyte than a basalt.

Two poor sections.

Age. Cabotian.

U. S. G.

NO. 524. DIABASE (*with olivine*).

Splitrock point. The great sheet of dark, basic rock that embraces the anorthosite pieces. This piece was obtained near the large anorthosite block that forms Splitrock point. This rock can be seen, at places along here, to be underlain by Nos. 522, 523, and the Two Harbor rock (No. 117) in the order named. At Splitrock point this sheet is seventy-five feet thick (see No. 112).

Ref. Annual Report, ix, pages 29, 30; Annual Report, x, page 40.

Meg. A massive, homogeneous, dark-green rock.

Mic. The *augite* has the ophitic relation to the *feldspars*. The *olivines* are small.

One section.

Age. Cabotian.

N. H. W.

NO. 525. SANDSTONE.

Associated with some of the amygdaloidal parts of Nos. 522 and 523.

Ref. Annual Report, x, pages 40, 114.

Meg. Apparently a grit composed of grains of devitrified glass similar to rocks Nos. 8A or 17, but mingled with masses of considerable size of amygdaloid. In the sand rock which also varies to a shale, and is light-colored as well as red, are flat, water-laid surfaces with an undulatory parting which has impressions resembling fucoids.

No section.

Age. Cabotian(?)

Remark. This rock is less firm and less siliceous than most of the grit rocks derived from apobsidian (as Nos. 17 and 30). Its shaly structure also is different from anything seen as yet in the Cabotian, and it might therefore be placed higher in the series. It is referred to the Cabotian rather than to the Manitou because of its association with the eruptives Nos. 522 and 523, which are immediately connected stratigraphically with No. 117 (the Two Harbor rock), and all of these have been referred to the Cabotian. Owing to the complexity of the structure, and the

occurrence of faults, such as that at Baptism river, and eastward from there, it is obviously impossible to speak at present with certainty of the stratigraphic sequence of the strata of the coast.

N. H. W.

NO. 526. GRANITE. (*Granophytic.*)

From the knob of red rock at the west side of Beaver bay (see No. 124).

Ref. Annual Report, ix, page 32; Annual Report, x, pages 40, 41; Final Report, vol. i, page 196.

Meg. An even-grained rock of a purplish gray color, not coarse.

Mic. The section shows a semi-crystalline rock, *i. e.*, one that retains still a trace of its original magmatic condition. While it shows much *quartz*, this quartz is not in definite and separate crystalline grains. Some of it is poikilitic, embracing a multitude of minute impurities, many of them opaque, and some of it is pegmatitic. The poikilitic parts are not clearly and fully oriented into separate areas, as is frequently seen in some of the aporhyolytes, but they seem to be more interlocked and blurred, as if there were still some glassy residuum. Other quartzes are evidently from the original magma, having taken their form while still the fluid condition remained, since they have embayments in which an isotropic glassy(?) substance is seen. This *glassy substance* is somewhat reddened by *hematite*, when viewed in natural light, and cannot be distinguished from the bulk of the apobsidian which constitutes a prominent feature of this part of the coast. From these embayments the same substance can be traced, with greater or less distinctness, throughout the slide, sometimes less isotropic and frequently embracing polarizing microliths.

There is another feature that allies this rock with No. 520, *viz.*: the existence of clear *globular feldspars* which are grouped sometimes to the number of half a dozen, surrounded by the same amorphous reddened substance, all extinguishing at the same instant. In this case the feldspar grains are plainly of some *plagioclase*, since occasional striation is apparent.

All the minerals, except the porphyritic quartzes, are much clouded by fine microliths and reddened by *hematite*, and the quartzes themselves are not free from dark particles—even those which might perhaps be considered to date from the quartz-porphyry stage of the rock.

The specific determination of the feldspar is impossible. While the larger part of it is probably of *orthoclase*, some is still *plagioclase*.

Some *magnetite* and a trace of some ferro-magnesian mineral can also be observed. Two sections.

Age. Cabotian.

Remark. This interesting rock affords another petrographic link between the extremes of the red rock of the region; *i. e.*, between the rhyolyte and the red granite. It has commonly been known as a granite, but it is more nearly a granophyre.

Aopobsidian.]

Meg. On a fresh fracture the rock is ashen gray in color. It is aphanitic, contains no porphyritic crystals and presents no variations in grain except a fine, indistinct mottling in lighter and darker shades of ashen gray. The specimen is crossed by several, narrow, distinct bands nearly parallel and about half an inch apart. These bands are from one to two millimeters wide and are of a gray to pinkish color. Frequently a narrow strip along the centre of a band is darker colored than the rest of the band and is seen to be composed largely of quartz. Sometimes these quartz bands are wavy. The material of these bands, except for the central strip of quartz, is as aphanitic and structureless as the rest of the rock.

Mic. The sections in ordinary light present a cloudy appearance, with small transparent areas and numerous black dots of *magnetite*, also some *hematite*, and a few larger irregular areas of magnetite. In a few places these grains of iron ore are surrounded by a narrow rim of a highly refracting substance, probably *sphene*, thus indicating that the iron ore is, in part at least, *ilmenite* rather than magnetite. Under crossed nicols and a high power the section breaks up into an irregular patchy aggregate of small poikilitic *quartz* areas. The quartz encloses the iron ore and minute, cloudy, semi-opaque, irregular grains which as a rule show no influence on polarized light, although occasionally one is seen which shows slight changes on rotating the stage. The nature of this material cannot be determined, but it is thought to be largely feldspathic, most probably *orthoclase*. The quartz frequently has a clouded appearance and thus resembles feldspar, but no cleavage is present and some of the grains which resembled feldspar the most gave uniaxial interference figures.

A section across one of the bands shows hardly anything different from the rest of the rock, as the band, except for the central strip of quartz, is hardly distinguishable under the microscope. If anything is to be noticed, it seems to be a greater abundance of the opaque feldspathic grains in the band. The central strip is more transparent and contains very little of the feldspathic material. Three sections.

Age. Cabotian.

Remarks. This rock is thought to have been originally a glassy rock like an obsidian, and its present condition is due to devitrification. No glass, as such, can be said to be present, although it cannot be said that part of the opaque so-called feldspathic substance is not still glassy. The bands which cross the rock do not furnish evidence as to their original nature, but it seems probable that they represent chains of spheruliths, although no trace of spheruliths is present. In the hand specimen these bands are quite similar to the spherulith layers in the rocks from South mountain.*

U. S. G.

*F. BASCOM. *Journal of Geology*, vol. 4, pp. 818, 819, 1893; *U. S. Geol. Survey, Bulletin cxxxvi*, plate X.

NO. 529. DIABASE (*or gabbro*).

Beaver bay. From the peninsula which forms the southern barrier to enclose Beaver Bay harbor.
Ref. Annual Report, x, page 41; Bulletin ii, page 117.

Meg. Dark, diabasic rock, apparently from the great sheet which carries the feldspar masses.

Mic. The *augite* was in part earlier than the *feldspar*, and is considerably altered, sometimes to a grayish mineral that resembles *leucoxene*, but more frequently to a greenish chloritic substance. When it is cut favorably and is sufficiently fresh it shows a diallagic lamination parallel with 100. There is considerable *quartz* in pegmatitic growth in the feldspars.

Two sections.

Age. Cabotian.

Remark. The samples collected represent a series of six numbers, designed to illustrate the progressive stages in the decay of this rock to a surface soil. It is evident that the freshest of the samples collected is yet considerably altered, though probably not by weathering, the chief change consisting in the entrance of quartz. This is more likely to have entered the mass while it was still hot. N. H. W.

NO. 530. DIABASE.

From the shallow bay half a mile west of the west point of Beaver bay. This rock contains patches of red rock like No. 526, and within two rods, after a short interval not exposed, the rock No. 526 is seen in full force, forming a bush-covered bank. The patches are as fragments or boulders, generally, but some patches do not appear like transported masses, but like dikes and veins. Forms a narrow dike-like belt two and a half feet wide, running east and west.

Ref. Annual Report, x, page 41.

Meg. Dark, rather fine-grained diabase.

Mic. The section shows an ordinary ophitic diabase, with some of the *augite* earlier than the plagioclase, and with a little *quartz* and *biotite*. The *augite* is the gathering place of much magnetite in fine grains, and the gray *leucoxene* mentioned in Nos. 529 and 531 as a result of alteration indicates that it is titaniferous.

One section.

Age. Cabotian.

Remark. The irregular inclusions of the "red rock" in this diabase, although they appear, in some instances, like veins and dikes, are not to be taken as evidence of the later date of the red rock. They illustrate the easy dissemination of the acid elements of the red rock in the basic, a fact which is exemplified in many places, and which has been noted by Bayley on Pigeon point.* On the other hand the isolated, scattered pieces of the red rock in the diabase, which in some places are nearly as abundant, but never so large, as the pieces of anorthosite, can be explained only by assuming the greater age of the red rock. N. H. W.

*Bulletin ciz, U. S. Geol. Survey.

Diabase. Aporhyolyte.]

NO. 531. DIABASE (*or gabbro, with quartz*).

From the narrow dike-like belt mentioned under No. 530.

Ref. Annual Report, x, page 41.

Meg. Rock of even grain and purplish-gray color, resembling rock No. 526, but of a darker tint.

Mic. The feldspar is (or was) a *plagioclase* in crystals of considerable size, but is now so penetrated by pegmatitic quartz and impurities that its optic properties are nearly destroyed.

There are grains of *diallage* which yet show the polarization and the characteristic lamination, but the most of the diallage is altered to other substances, or penetrated by other minerals so that it could not be recognized were it not for the visible steps of transition from one extreme to the other. In some cases it seems to form a gray semi-opaque substance resembling *leucoxene*; in others it is converted to a green mineral, and in others still it is brown with accumulated *hematite*. It is not ophitic, but is in small roundish grains which preceded the feldspars.

Apatite is not uncommon, and *biotite* is in some conspicuous grains. There was apparently no olivine in the rock, at least nothing can be seen of it in the slides.

Quartz is not abundant, but forms separate grains in angular spaces between the other grains; also frequently as pegmatitic growths in the plagioclases. Two sections.

Age. Cabotian.

Remark. The assignment of this rock to an alteration of a basic rock by contact with acid material is necessary not only by force of the field relations, but also of the petrographic characters. There is no independent space which seems to have been occupied originally and wholly by the acid elements, but these are simply insinuated amongst the basic elements after the practical formation of the basic minerals. The transformation must have taken place while the mass and the adjoining rocks were yet hot, and were easily penetrated by liquids and gases. The rock, therefore, is to be considered as a silicified selvedge of a basic intrusive or flow-sheet. This, of course, brings up the question: How much of this red-rock series can be attributed to the same origin? and may not rock No. 526 (the red "granite" of Beaver bay) be assigned to this origin, rather than to the consolidation of an acid magma? In this connection comparison may be made with the descriptions of rocks Nos. 263 and 265, Wausaugoning bay, and with much of the so-called "intermediate rock" of Bayley. (Bulletin cix, U. S. Geol. Survey.) N. H. W.

NO. 532. APORHYOLYTE. (*Breccia in diabase.*)

"Reddish, and sometimes greenish, trap-like rock, surrounding or embracing pieces of the feldspar at Beaver bay. This rock is similar to rock No. 526, at least in some of its parts. The feldspar masses have the appearance of having been carried in this rock, or to have been *in situ* when it was deposited as a sedimentary rock, and subsequently to have suffered the metamorphosing forces with it."

Ref. Annual Report, ix, page 33; Annual Report, x, page 41.

Meg. The rock is dark, brownish-gray in color, is aphanitic, and contains a few small porphyritic quartzes and feldspars. It appears macroscopically like a dark quartz-porphry or aporhyolyte. The peculiar feature of this rock is that it contains many pieces of a nearly similar but more quartzose and flesh-colored or reddish rock. These pieces are firmly welded to the main rock and in some places no very sharp line can be drawn between the two rocks as they blend together. The included pieces are quartz-porphry or aporhyolyte.

Mic. The section is a small one and is assumed to have been made from the main mass of the rock, although it may have been taken from one of the included masses. The section shows a groundmass composed of the usual devitrified material of the aporhyolytes—of semi-opaque, isotropic feldspathic grains and areas of poikilitic quartz. In a thinner section the feldspars are microlitic and frequently in spherulitic arrangement. The other half of the same slide has the feldspars in a diabasic or radiated arrangement, and lacks the quartzes. There are a few small quartz phenocrysts, not distinctly idiomorphic, and some confused areas composed of cloudy material, quartz, chlorite and iron ores, which seem to represent completely altered feldspars. Several of the quartz crystals are separated into several parts, similar to the corroded quartzes of many quartz-porphries. The section shows small dark rod-like bodies which are composed of chlorite and granules of iron ore. Hematite and magnetite in small granules and crystals are abundant throughout the rock, and there are also flakes of chlorite and a few flakes of biotite.

One section.

Age. From the Beaver Bay diabase.

U. S. G.

Remark. This rock has complicated and interesting relations. That it is more recent than the great anorthosite and than the red rock pieces that it carries, goes without saying, but it is not to be inferred that they were separated by important geologic events. They were, as supposed, involved in the same grand eruptive epoch. The abundance of genuine quartz-porphry pieces shows the near proximity of the great Cabotian quartz-porphry formation, and it is perhaps most reasonable to refer this rock to the fusion and incorporation in a basic flow, of Cabotian acid eruptives. Thus its abnormal features may be due to almost cotemporary eruptions of differing degrees of basicity. A casual glance might lead an observer to take it for a brown diabase. It is a phase of the Beaver Bay diabase, due to the inclusion but not complete digestion of numerous fine pieces of the red rock series. The great diabase of the region thus seems to have played a multiple rôle, as it acted now on anorthosite, now on Cabotian quartz-porphry, now on Cabotian diabases and amygdaloids* and now on clastic strata, all of which seem to have pre-existed in the

*MR. ELFTMAN is authority for the statement that in the midst of the great diabase sheet of the Beaver Bay region are detached pieces of fine diabase and of amygdaloid. These are doubtless from the old Cabotian surface flows.

Aporhyolyte. Conglomerate. Diabase.]

region. It certainly produced in a belt of varying width and volume an intermediate rock (No. 531) caused by the reaction of the acid element on the diabase itself. This diabase and its geognostic relations are more fully treated in Part I, of this volume.

NO. 533. APORHYOLYTE.

N. H. W.

"Rock of the Great Palisades. (Compare No. 139.)"

Ref. Annual Report, x, page 41.

Meg. A reddish-brown rock, hard, compact and aphanitic. It is thickly strewn with small phenocrysts of quartz and a gray to pinkish feldspar.

Mic. The section contains two quartz phenocrysts and one small *feldspar* in a groundmass which shows poikilitic *quartz* areas of considerable size. The section furnishes an excellent example of these poikilitic quartzes in a devitrified rhyolite. (Compare No. 68.) *Magnetite* and much *hematite* are present in minute particles throughout the rock, and also in larger grains. A feature of the section is a small quartz vein which crosses it and which cuts directly through one of the quartz phenocrysts. In this crystal the vein is cloudy, but the quartz deposited in the vein has the same orientation as the phenocryst. Another section, made later, shows essentially the same features.

Two sections.

Age. Cabotian.

U. S. G.

NO. 534. CONGLOMERATE. (*Red.*)

At one mile east of Manitou river. The same is seen at the mouth of Manitou river.

Ref. Annual Report, x, page 42.

Meg. Easily crumbling, the cement being principally of calcite. Some of the pebbles are about an inch in diameter, and from that size they grade downward to mere sand, yet the whole mass is composed of eruptive materials, of which the most of it was originally porous. It appears to have been produced entirely by waste from an amygdaloidal lava.

No section.

Age. Potsdam.

N. H. W.

NO. 535. DIABASE. (*Mesolite, scolescite* and thomsonite amygdaloid.*)

Terrace point. (See Nos. 163A and 193.)

Ref. Annual Report, ix, page 51; Annual Report, x, page 42; American Geologist, vol. xxii, page 347, December, 1898.

Meg. Amygdaloidal diabase, containing many zeolites which have been widely distributed as thomsonite.

Mic. A fine large section made by Marchand shows the nature of this rock in a beautiful manner. As a whole the rock is ophitic and amygdaloidal, but the small

*If, according to Dana, this name is derived from *σκαλιτζή*, the proper spelling is neither scolecite, preferred by him, nor scolesite, used by Lacroix, but scolescite, the letter ξ being derived from a Doric composition of σκ.

feldspars are much changed by a kaolinic alteration and apparently sometimes this promoted the formation of thomsonite in the immediate vicinity. In such a case the fibres of thomsonite are vertical to the elongation of the feldspars. In the augites are embraced sometimes ten or twenty of such altered microliths.

The olivines which are small are also changed largely to *bowlingite*, which sometimes is faintly greenish, but is usually of a dark red or orange red.

The zeolites constitute the most interesting element in the rock. They are of two kinds which optically are quite distinct, inasmuch as one is almost dark constantly between crossed nicols, and the other is translucent. They are both radiately fibrous, but the former is more fine and more regular in its structure. These are for the most part in separate amygdaloidal masses or areas, but occasionally they are seen in the same mass, where they are contrasted in the same manner, though intimately intergrown. The coarsely fibrous zeolite is easily identified as thomsonite. It is elongated both negatively and positively, and extinguishes parallel to the elongation. The finer zeolite is that which has usually been distributed under the name of thomsonite. It has a parallel extinction which may be observed by a faint increase of its darkness when in agreement with either nicol. Its section, viewed macroscopically, is white, in the slide. It is probably a soda zeolite, *i. e.*, a form of the natrolite group of Dana. These zeolites are discriminated under Nos. 535A and 535B.

Besides the foregoing, *scolescite* forms rounded amygdules in the same rock. Outwardly they resemble *thomsonite* except that so far as noticed this mineral does not grow into such large masses as thomsonite, but forms small round balls. It is not iron-stained in pinkish bands, like mesolite, but is clear and glassy white. When mesolite is white it is porcellanous. Under the microscope the section of *scolescite* shows negative elongation and low double refraction, characters that distinguish it from thomsonite.

Lintonite is green outwardly, very fine and hard, and seems to grow in small rosettes in the mesolite and in larger independent masses.

Two sections.

Age. Manitou.

N. H. W.

NOS. 535A AND 535B. MESOLITE AND THOMSONITE.

There were made nine thin sections of the zeolites from the amygdaloid No. 535, intended to bring to light the characters of the beautiful mineral which has been widely distributed under the name thomsonite, and several sections of the species lintonite, all bearing this number. These minerals are also enumerated under other numbers (Nos. 163A, 193 625A, 625B) and by reference to those numbers further facts may be found. These sections and others made of the same zeolite from other

Mesolite and thomsonite.]

places on the north shore of lake Superior, from the same series of diabase sheets, show plainly the close intermixture of two zeolites, mesolite and thomsonite, the former being more abundant than the latter.

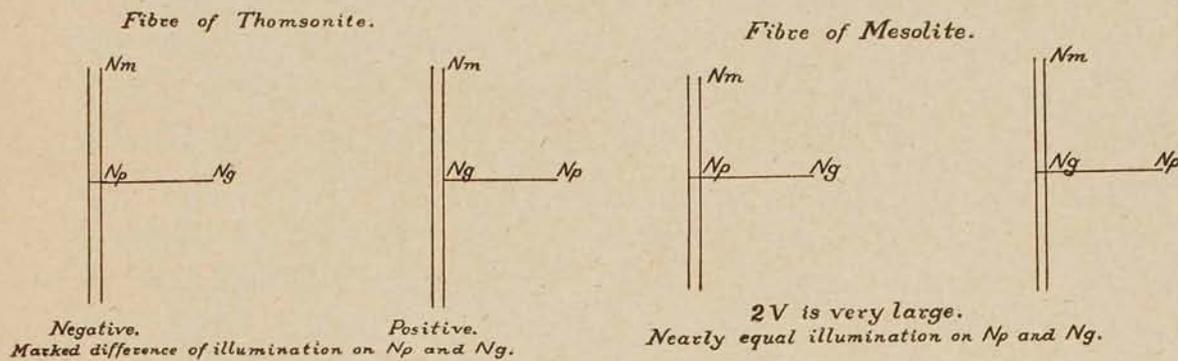


FIG. 23. DIAGNOSTIC OF THOMSONITE AND MESOLITE.

The concentric growth, shown by the eyelets seen on the exterior of the beach-worn pebbles, is evinced in the thin section by concentric bands of varying colors. These bands vary in composition as well as in fineness of fibre, sometimes fading gradually into each other, and sometimes changing rather abruptly.

Of the specimens chosen the following notes were taken prior to the making of the sections:

- (a) No. 535. Amygdaloidal rock, containing small zeolitic spherules supposed to be thomsonite.
- (b) No. 535A. Coarsely fibrous zeolite, possibly stilbite, from the rock.
- (c) No. 535A. Supposed thomsonite, two sections, from the rock.
- (d) No. 535A. Supposed thomsonite.
- (e) No. 535B. Supposed thomsonite, from the beach, with some of the rock, two sections.
- (f) No. 535B. Supposed lintonite, from the beach, with some of the rock.
- (g) No. 535B. Supposed thomsonite, from the beach, pyramidal form, very common.

Of these the following results were reached after petrographic and micro-chemical investigation, viz.:

- (a) The amygdaloidal rock (a) contains only thomsonite as zeolitic filling.
- (b) Composed of thomsonite.
- (c) Composed of mesolite banded with minute fibres of thomsonite; specimens are quite similar.
- (d) Composed of mesolite banded with minute fibres of thomsonite.
- (e) Mesolite, with spheruliths in the rock and in the mesolite surrounded by another undetermined mineral which seems to be gonnardite, as described by Lacroix (*Minéralogie de France*, vol. ii, page 279), and also to resemble lintonite.
- (f) Is not homogeneous, but consists largely of some amphibole, hardly dichroic, of zoisite, sphene and of some other undetermined fine-grained substances.
- (g) Proves to be mesolite.

Of these numbers c, d and g represent the variegated and banded pebbles which are credited, in recent publications, to Grand Marais, as thomsonite, particularly c and d; while the pebbles that are actually of thomsonite are usually not chosen for their beauty and are coarse-grained and non-banded.

Thomsonite and mesolite have not only similar chemical composition, but similar optical properties. Yet in two important particulars their characters are so different, under the microscope, that they are easily distinguished. In general also it can be said that the fibres of thomsonite are coarse and irregular compared to those of mesolite, which are fine, rigid and straight. The distinguishing difference, however, is in the low double refraction of mesolite (about 0.012) compared with the

rather high double refraction of thomsonite (about 0.028). Consequently in an ordinary section of the former the fibres are all uncolored in whatever position they are cut and in some very thin sections they are almost isotropic between the nicols, at least invisible. In thomsonite, however, the fibres show variations of color, and as they are cut more and more obliquely their colors rise until, in a section nearly or quite transverse to their length, the colors are red, blue or green. The color is green in such a section when it is 0.03 millimeter in thickness, and blue or red when slightly less than 0.03 millimeter.

The variations of light and darkness in a mesolite section or in a lot of fibres mounted in balsam by themselves, are quite small. This is owing to the fact that the optic angle being large and the optic plane perpendicular to the fibres (or sensibly perpendicular), the sides of the fibres always present n_p or n_e (or some intermediate pole) in the field of the microscope, and the amount of light capable of passing parallel to n_e is nearly the same as parallel to n_p . It is not so with thomsonite. The optic plane, situated transverse to the fibres as in mesolite, causes some of the fibres to show n_p and n_e in the same manner as in mesolite. But in thomsonite the optic angle is small, and the sections perpendicular to the acute bisectrix n_e are much darker than those perpendicular to the obtuse n_p . In a longitudinal section, in the midst of a lot of dark fibres (n_e) may run parallel a lot of brightly illuminated ones (n_p), the contrast being very striking. It is only necessary to apply the convergent lens when it is quickly seen that they only differ in being perpendicular to different axes of elasticity. Such light fibres are scattered, in some cases, amongst the dark ones, and, in finer and finer lines which also become shorter in the finer portions of the slide, they make a network of light and dark fibres, sometimes parallel the one to the other, and sometimes at right angles. These differences are visible in No. 535A(b) above enumerated.

It will be shown (No. 625B) that in the amygdaloids containing these two zeolites they are sometimes in the same vacuole, the thomsonite being pierced by the needles of mesolite, and somewhat later in date than the mesolite. It appears, by this series of sections that in many cases the two were generated simultaneously. This is shown by some of the bands of the handsome mesolite pebbles. In thin section some of these bands are wholly of white mesolite, and uniformly they are marked by the low tints of the gray of the first order, but, toward the exterior of the band, suddenly begin to appear bright spicules which pierce the darkness of the mesolite. These are thomsonite fibres cut so as to present the obtuse bisectrix n_p perpendicular in the microscope. Those which are cut so as to present n_e are so nearly dark that they cannot be distinguished from the surrounding fibres of mesolite. Nor indeed can it be stated that the next succeeding band consists wholly

Lintonite, mesolite, okenite. Diabase.]

or only partly of thomsonite. These very fine bright fibres are distributed through it. They are always negative in elongation. It has to be assumed that they are associated with about an equal number that are cut so as to present n_x perpendicular, but these cannot be distinguished. That the whole band is not of thomsonite is probable from the fact that, on tracing the fibres toward their converging point, while the bright fibres disappear, there are some fibres which are cut transverse to their elongation. Their sections are quadrilateral and their color of double refraction is low—even lower than that of the bright needles of thomsonite. They must be therefore of mesolite, for a similar section of thomsonite would show, as already stated, a color either red, blue or green.

It is hence allowable to infer that mesolite and thomsonite are closely intergrown throughout the band in which there are occasionally the bright needles which have always negative elongation.

In none of the sections is there a band made up wholly of thomsonite in the midst of mesolite bands.

That these bright needles are of thomsonite and not of mesolite is evinced by the fact that they occur sometimes in the midst of a coarser mesh of mesolite fibres which of themselves show slight difference of light, indicating that they lie sometimes in a position to show n_p and sometimes n_x perpendicular.

A green pebble having this number, collected as lintonite, proves to be not homogeneous, but consists largely of fragments or imperfect crystals of an *amphibole* mingled with *zoisite* and some *sphene*, with other indeterminate substances. N. H. W.

NO. 535B. LINTONITE, MESOLITE, OKENITE(?)

An unfavorably thick section shows the first two of these zeolites distinctly, but in the same mass as the mesolite the mesolite fibres which are negative in elongation are replaced in the direction toward the apex of the fibration by an entirely different mineral which, with much coarser fibres, parallel extinction and low double refraction, thus resembling scolescite, has a positive elongation, a combination of characters which would allow of its being *okenite*. Without chemical test, however, this is only a provisional determination.

One section.

N. H. W.

NO. 536. DIABASE. (*Gabbroid*.)

From the basaltic columns at Grand Marais (see No. 199).
Ref. Annual Report, x, page 43.

Meg. A brownish rock of medium grain, standing in vertical columns, in a manner similar to the rock at Little Marais, forming the barrier that encloses the harbor of Grand Marais.

Mic. The *feldspar* shows its *plagioclastic* character in many striations of albite twinning. The *augite* is both earlier and later than the feldspars. The earlier crystals, which are the most abundant, are small, and interfere with the outlines of the feldspars, but the later are fresher and embrace several of the feldspars ophitically. But two or three augites of this later date can be seen in the two sections examined. They are much larger than the earlier augites. The *olivine* is for the most part altered to a yellowish brown mineral which represents *bowlingite*, although most of it is not perfectly developed as bowlingite. Olivine was generated before the feldspar, but later than the augite. *Magnetite* in small amount and a small quantity of the magmatic residuum may be seen in the slide.

Two sections.

Age. Cabotian.

N. H. W.

NO. 537. DIABASE. (*Luster-mottled.*)

West side of Cow's Tongue point; S. W. $\frac{1}{4}$ sec. 10, T. 61-2 E.; same as No. 211.
Ref. Annual Report, x, page 43.

Meg. A fine-grained, brownish diabasic rock showing, especially on weathered surfaces, luster-mottling.

Mic. The section shows small feldspar laths embedded in augite plates and in a dark opaque mass which is almost entirely hematite and magnetite. The iron ores fill in the spaces between the augite plates.

One section.

Age. Cabotian.

U. S. G.

NO. 538. APORHYOLYTE.

The first rock in the bay east of Cow's Tongue point.
Ref. Annual Report, x, page 43.

Meg. This rock, both macroscopically and microscopically, is similar to No. 212, which is from the same locality.

One section.

Age. Cabotian.

U. S. G.

NO. 539. BASALT.

Short distance west of the mouth of Brulé river (see No. 220).
Ref. Annual Report, ix, page 56; Annual Report, x, page 43.

Meg. Brown, rather fine grained, with small irregular shaped mottlings of green.

Mic. The interstitial matter is a brown devitrified glass, which embraces now the feldspars and the augites, as well as certain altered ferruginous crystals that were probably olivine originally. It also contains many crystallites and opaque grains, the latter probably of magnetite. The green spots are formed by irregular

Basalt.]

aggregations of a chloritic mineral which between crossed nicols shows a fibro-lamellar structure without affording distinct polarization.

One section.

Age. An old Cabotian surface flow.

N. H. W.

NO. 540. BASALT. (*Coarse.*)

A mile and a half east of the mouth of Brulé river (see No. 221).

Ref. Annual Report, ix, pages 57, 61; Annual Report, x, pages 43, 44, 45, 47; Bulletin ii, page 103.

Meg. A rather coarse, brownish-gray rock, composed of feldspar, which is sometimes in long striated crystals, and a shining black material which is often in long streams.

Mic. The section is composed largely of *feldspar* in tabular, rarely lath-shaped crystals of considerable size, and of less *augite* in grains which appear to be a little earlier than, or of about the same date as the feldspars. The feldspars show a tendency to an idiomorphic development, and thus give the section a porphyritic aspect. Twinning, both by the albite and pericline laws, is common. A determination of the feldspar by equal extinction angles on either side of the twinning line was unsatisfactory, owing to a lack of sections with the proper orientation. However, five crystals furnishing bisectrices were found, and these gave very similar results. Two sections having a positive bisectrix exactly perpendicular gave extinction angles of 8° and 9° respectively; while three sections cut almost perpendicular to a negative bisectrix gave extinction angles of 66°, 67° and 69° respectively. In the last three the bisectrix was removed only a little from the centre of the field of vision, but was well within this field. These results all agree in indicating that the feldspar is *andesine*.

Scattered all through the section outside of the large feldspars and augites, and penetrating the cracks, is a dirty yellowish brown, sometimes greenish material, which contains small feldspar microliths and a few small augite grains. Considerable of this material seems to be an alteration product from a former unindividualized base, but much of it still appears to be glassy areas of considerable size remaining perfectly black when rotated under crossed nicols. With this glassy material is some secondary *quartz*, and *apatite* and *magnetite* are common.

One section.

Age. Cabotian.

Remarks. There are two peculiar features in this section. The first is that the feldspar is *andesine* rather than labradorite, the usual feldspar of the basic Cabotian and Manitou rocks thus far examined. The second is that considerable unindividualized material, which is still glassy, is present. This rock is perhaps a part of the same mass as that represented by Nos. 221 and 223.

U. S. G.

NO. 541. BASALT. (*Zirkelyte.*)

Grand Portage island. A dike ten feet wide cuts the quartzite and conglomerate, running E. 10° N. by needle, without displacing the bedding.

Ref. Annual Report, x, pages 45, 46.

Meg. Very fine-grained, nearly black.

Mic. The rock is fresh and undecayed. The *glassy residuum* is not abundant, but clear, although it embraces some *magnetite* rods and some polarizing crystalliths. The *augite* is in fine, isolated, roundish grains that antedate the feldspar for the most part, but which are occasionally broken by the feldspar, showing that these minerals were nearly cotemporaneous.

One section.

Age. Manitou.

N. H. W.

NO. 542. DIABASE (*with olivine.*)

Grand Portage island; on the east side of the island this is basaltic, rising about twelve feet. Stratigraphically it is the highest rock on the island, having a thickness of fourteen feet.

Ref. Annual Report, x, pages 45, 46, 47.

Meg. A gray, rather coarse-grained rock.

Mic. The *feldspars* are ophitically related to the *augite*. The *olivine* is rather fresh. There is a residuum of brownish substance, evidently non-differentiated base.

One section.

Age. Manitou.

N. H. W.

NO. 543. BASALT. (*Zirkelyte.*)

Grand Portage island. Immediately underlies the last, having a thickness that may be twenty feet.

Ref. Annual Report, x, pages 45, 46, 47.

Meg. The rock is amygdaloidal with light blue chalcedony (or with quartzine) and with calcite.

Mic. The *feldspar* is partly ophitic in the *augite* and partly later than the *augite*. It is also similarly surrounded by the *basaltic residuum*. Olivine is rather fresh, but not abundant. The basaltic residuum has changed partly to a brown substance in which some small feldspars and occasionally *apatite* are visible, and partly to minutely microlitic substance, in which the microliths are not spicular but round, and polarize like *mica*. They are densely packed. This kind of alteration is occasionally mingled with the brownish or greenish product already mentioned, but in several conspicuous areas it surrounds in narrow belts a greenish fibrous substance whose spicules are spherulitically placed, but which does not easily transmit light. The nature of this greenish fibrous substance is not determined, but it may be *thalite*, as its hardness is about the same as *saponite*, of which thalite is a form.

One section.

Age. Manitou.

N. H. W.

NO. 544. BASALT. (*Zirkelyte, globuliferous.*)

Grand Portage island. In a belt crossing the island east and west, but probably only a phase of rock No. 545. It is the last to run under the water at the west end, and at the east end it is the topmost rock in the bluff. Its thickness may be twenty feet.

Ref. Annual Report, x, page 45.

Meg. A curious, dark globuliferous trap-rock, disintegrating readily, the hard globules, which are of stony structure (not minerals), and nearly black, rolling out like shot, or bullets, and covering the ground after the rest of the rock is rotted to a greenish soil. The rock itself is chloritic and dark green.

Mic. The rock was consolidated before it crystallized. As a consequence there is a large amount of undifferentiated magma, which, however, is devitrified. It now embraces handsome spangles of *magnetite*, which is the only determinable mineral connected with the magma remnants. Other spaces of exceedingly irregular outline are filled with a pale yellowish, fibrous alteration mineral that resembles *thalite*. The most of the rock itself consists of small *augite* crystals or fragments of crystals, generally granular and sub-rounded, but not entirely so. Amongst these are a few fine *plagioclases*, and occasionally in the centre of a lot of alteration products is a little *quartz*. These, with considerable *calcite*, make up the rock.

Five sections.

Age. Manitou.

N. H. W.

NO. 545. BASALT.

"A bed of fibrous green trap, passing through the centre of the island [Grand Portage] and forming its highest parts, and also producing a long sloping beach on the southeast side running under the chalcidonic amygdaloid [No. 543]. In the centre of the island it appears like a burnt scoria or slag, due, perhaps, to the effect of Nos. 543 and 542, though these have been removed in the central part of the island, appearing now only along the south and southwest shores."

Ref. Annual Report, x, pages 45, 46.

Meg. A dark-gray, very fine-grained, heavy, compact diabasic rock.

Mic. The section is composed largely of small, thickly crowded *augite* prisms. With these are numerous small *magnetite* crystals. These two minerals are set in a sparse background of *feldspar*. This is in comparatively small areas of later date than the other minerals and enclosing them poikilitically. The different feldspar areas are not sharply separated from each other; they infrequently show twinning, and their species was not determined. Scattered through the section are many green to yellow areas composed of a mineral in minute scales (serpentine). Some of these areas possibly represent old *olivine* phenocrysts, but many of them seem to be rather an altered part of the rock,—possibly originally glassy.

Two sections.

Age. Manitou.

U. S. G.

NO. 546. SANDSTONE (*or arkose*).

Grand Portage island. Eight feet thick.

Ref. Annual Report, x, pages 46, 47. (Compare No. 256.)

Meg. A very fine-grained, purplish gray sandstone. Along one edge of the specimen is a band, about half an inch wide as far as shown, of an ashen gray color. This band seems to be of the same grain and composition as the rest of the rock.

Mic. The section is composed of small grains of *quartz* and *feldspar*, with a small amount of yellowish brown material between some of the grains. The grains are rounded or sub-angular and are closely crowded together. Some of the quartz grains show secondary enlargements and it seems probable that many more than show this feature distinctly have also been enlarged. The *feldspar* is largely cloudy and probably *orthoclase*, although a few *plagioclase* and less *microcline* grains are seen.

One section.

Age. Potsdam.

U. S. G.

NO. 547. BASALT. (*Zirkelyte.*)

Grand Portage Island. A bed of trap. This is sometimes brecciated or finely and irregularly jointed, with white nodules of saccharoidal calcite. Resembles rock No. 541. Probably an intrusive, thirty-six feet thick.

Ref. Annual Report, x, pages 46, 47.

Meg. Heavy, fine grained, nearly black.

Mic. The slide is characterized by porphyritically distributed small *augites*, lying in a *glassy* and microlitic base. The *augites* are somewhat radially grouped, as if twinned on one of the domes. There is but little of the non-crystallized magma. *Magnetite* in small cubes is frequent. Some microlitic *feldspar* and considerable *calcite*, with pale yellowish areas of a very finely fibrous alteration mineral, which is the same as mentioned in No. 544 as possibly *thalite*, are the only noteworthy features. The rock is similar to No. 544.

Two sections.

Age. Manitou.

N. H. W.

NO. 548. QUARTZYTE.

Grand Portage island. Five feet thick. (Compare No. 256.)

Ref. Annual Report, x, pages 46, 47, 48.

Meg. Sometimes with mica scales between the beds, of a dark color, but generally striped with brown-red, with thin laminations. In some parts it is gray.

Mic. The rock is composed of angular *quartzes* and *feldspars*, some of the latter being of *plagioclase*, and of devitrified *glass*, the last constituting about one-half. Other substances are present, but it is not possible to determine them, except *hematite* and *calcite*. There are some light-brown grains that may be of *augite*.

One section.

Age. Potsdam.

Conglomerate.]

Remark. This ingredient of volcanic glass in this rock, indicates that it is not probably at nor near the base of the Animikie, for no such rock could be obtained in such quantities from the Archean. That had been completely crystallized before the opening of the Animikie. This rock, therefore, and the formation to which it belongs, carrying with it the underlying basal conglomerate, seems to be later than some Cabotian eruptives, and hence is probably nearer the bottom of the Potsdam. The only explanation of a possibly Animikie age would be the presumption of cotemporary volcanic action in early Animikie time by which such materials could be incorporated; but that presumption again is just as reasonable at the time of the earlier part of the Potsdam, and is negatived by the red rock material found in the underlying conglomerate which is a product of the Cabotian disturbance. N. H. W.

NO. 549. CONGLOMERATE. (*Breccia?*)

Grand Portage island. The cementing rock is a quartzite or grit like No. 548, but coarser. Sixteen feet in thickness.

Ref. Annual Report, x, pages 46, 47.

Meg. The rock is a gray conglomerate, of rather coarse pebbles. The preponderating element is clear quartz, or gray quartzite. In the case of the gray quartzite the pieces are flat, slaty and firm, and can be referred directly to the quartzite slates of the Animikie, which rises in the adjacent hills of Grand Portage to the height of three or four hundred feet above the level of the lake. The rest of this conglomerate consists largely of finer debris of the same kind, but also contains numerous pebbles of red quartz-porphry, red felsyte and red granite. This can also all be referred to the hills at Grand Portage.

Mic. The thin section not only confirms the megascopic appearance, but adds some interesting other facts, viz.: There is a considerable ingredient of originally volcanic material amongst the debris. This is in the form not only of devitrified glass grains, but of porphyry pebbles in which the feldspar crystals are still apparent by their forms, although their optical properties are lost by a profound change that has affected the conglomerate. In short, the conglomerate seems to have been formed subsequent to the origination, in that neighborhood, of acid lava flows and quartz-porphyrines.

Another fact which is vividly revealed by the thin section is the calcification of the rock, and of all the elements of which it is composed except the quartz. The pebbles of igneous rock, and the porphyritic feldspars contained in them, are so permeated by calcite and so changed to kaolinic particles that they cannot be identified except by their structure and relations to surrounding portions. The feldspars do not extinguish, but present ever a lightness which is flecked with light and dark particles which under rotation shift and disappear and return again, making a constantly varying fine mosaic. Two sections.

Age. Puckwunge (basal Potsdam).

Remark. The greatly altered condition of the silicates in this conglomerate can be attributed to hot waters that resulted from the immediately succeeding surface lavas which were cotemporary with the formation in which they occur, and which are entirely distinct structurally from the intrusives. N. H. W.

NO. 550. DIABASE.

Grand Portage island. From a dike, thirty-four feet wide, cutting the quartzite and conglomerate, near No. 541.

Ref. Annual Report, x, page 46.

Meg. A medium-grained, dark-gray diabasic rock. It contains some plagioclase crystals considerably larger than the most of the feldspars, thus giving a porphyritic aspect to the rock.

Mic. The section shows a much changed rock filled with confused dirty alteration products which are usually brownish. *Plagioclase* and *augite* are pretty well preserved, and it seem possible that *olivine*, as well as unindividualized matter, was originally present.

One section.

Age. Manitou(?)

U. S. G.

NO. 551. DIABASE (*or basalt*).

From a dike crossing the southeast corner of Grand Portage island.

Ref. Annual Report, x, pages 46, 94, 112.

Meg. Medium-grained, dark-gray, heavy diabase.

Mic. The section shows lath-shaped *feldspars*, *augite*, *magnetite* and a confused mass of dirty, greenish alteration products. The feldspar shows equal extinction angles on either side of the albite twinning line as high as 25°, indicating *labradorite*. The *augite* is in grains rather than in plates and some of it is earlier than, or of about the same date as, the feldspar, while some is later than the feldspar. *Magnetite*, especially in rough rod-like forms, is abundant. There are also some areas which seem to represent altered *olivines*. It seems probable that some of the areas of alteration products came from an unindividualized base.

One section.

Age. Manitou(?)

Remarks. This rock is said to constitute a dike which crosses the southeast corner of the island. It is thus later than and cuts the igneous beds of this part of the island. The conglomerate and quartzite do not occur on this part of the island.

Leaving out of consideration the actual age of the rocks of Grand Portage island and their relations to the rocks of the adjacent main land, it may be said that this island *appears* to hold three different rock masses, which may be arranged *provision-*

Quartzite.]

ally as follows: (1) The oldest of these is the conglomerate and quartzite (or sandstone) represented by Nos. 254, 256, 546, 548, 549, 1831, 1832 and 1833. It is stratigraphically the lowest rock on the island and occurs only on its north or north-east side. (2) Overlying the conglomerate and quartzite are certain igneous rocks which are in part, and probably in whole, surface flows. These are later than the underlying clastics, although it is possible that the lower part of these flows is interbedded with the clastics and thus cotemporary with them. These igneous rocks are represented by Nos. 255, 543, 544, 545, 547, 1834 and 1834A. (3) A later series of diabase dikes cutting both of the foregoing. These dikes are represented by Nos. 541, 542, 550 and 551.

U. S. G.

No. 552. QUARTZYTE. (*Plumbaginous.*)

Pigeon point, near the trail to Parkerville; sec. 32, T. 64-7 (see No. 270).

Ref. Annual Report, ix, page 65; Annual Report, x, pages 48, 58; Bulletin vi, pages 123, 420.

Meg. Quartz plainly constitutes the greater portion of this rock, but it is obscured by the colored elements. The graphite forms a metallic unctuous coating. The general aspect is black.

Mic. The *quartz* is secondary, separated areas extinguish simultaneously and the forms are angular.

Feldspar crystals are generally not observable, but in one case a striated feldspar of the first consolidation is well preserved, and some of the microliths can also be identified.

Sphene can be seen in numerous isolated highly polarizing grains and rods of irregular shape and strongly roughened surface on lowering the condenser. In reflected light it is opaque white.

Calcite also is not uncommon, the little roughness of the surface, visible on lowering the condenser, being sufficient to produce a minutely speckled polarization, the colors, even in a thin section (.02 millimeter), being red, blue, yellow, etc.

One or two grains of *zircon* are distinguishable by reason of bright green polarization in a very thin section, and rectangular outlines.

Several rods also highly doubly refracting and refractive, are probably *rutile*.

Pennine and *biotite* are abundant, and closely associated, the former showing its characteristic halos, and the latter varying to a translucent mica which polarizes in colors.

Graphite blackens the rock and the section, sharing this in a small degree, however, with *pyrite* and perhaps with magnetite. Two sections.

Age. Animikie(?)

Remark. This rock apparently is changed from the basic eruptives of the region by contact on the sedimentary rocks adjacent.

In another section, the rock, though bearing this number, is a granular quartzite, with but little else besides quartz. Scatteringly disseminated are a few nests of biotite scales, somewhat radiatedly arranged and associated with chlorite. There are also a few spicules of magnetite.

The rock represented by this section is very certainly a condition of the quartzite of the locality.

N. H. W.

NO. 553. QUARTZITE.

Near the portage trail to Parkerville, at the north shore of Pigeon point.

Ref. Annual Report, x, page 48.

Meg. Firm, gray quartzite.

Mic. The section consists essentially of angular and sub-rounded grains, lying in a matrix which consists of finer grains of the same, and of particles that are finely granular, as if from a composite rock. The latter are not so transparent, and often quite cloudy with a chloritic substance, and between crossed nicols remain nearly dark continually. They have a deceptive resemblance to devitrified glass.

One section.

Age. Animikie(?)

N. H. W.

NO. 554. DIABASE.

From the east end of the most easterly island separating Washington harbor from Grace harbor, Isle Royale. It has somewhat the appearance of an imperfectly basaltic dike, but as it develops a few rods further north it appears as an overflow; at least it lies on other trap and amygdaloid. It forms a little harbor where fishing shanties are erected.

Ref. Annual Report, x, page 48.

Meg. A dark-brownish, fine-grained diabase. Scattered through the rock are small greenish areas (chlorite) and also reddish ones. To the latter is due the brownish cast of the rock.

Mic. The section shows a diabase composed of *feldspar*, *augite* and *magnetite*. The whole rock is much changed and now contains abundant dirty greenish and reddish alteration products. Part of these products are due to the change of the feldspar and augite, but it seems as if some of the reddish material was from an original glassy base.

One section.

Age. Cabotian.

U. S. G.

NO. 555. SANDSTONE. (*Red.*)

Isle Royale. Overlies the conglomerate of the west end of Isle Royale. Resembles No. 548 of Grand Portage island. Has regular bedding, with strata sometimes thirty inches thick, extends for several miles, making islands and points. Specimen is from Siskiwit point; dip 10° to 20° S.; apparently has a thickness of 300 or 400 feet. A gritty shale separates the quartzite from the conglomerate.

Ref. Annual Report, x, page 49; Annual Report, xiii, pages 100 (No. 165) 103; Bulletin viii, page xxxiii.

Meg. Red, smoothly-weathering sandstone, which might be called a quartzite.

Sandstone. Conglomerate. Diabase.]

Mic. The section contains not only *quartz* but considerable devitrified *glass*. The grains are not well rounded. The *hematite* coloring is evident.

One section.

Age. Potsdam.

N. H. W.

NO. 556. SANDSTONE. (*Red, shaly.*)

South shore of Siskiwit bay, Isle Royale.

Ref. Annual Report, x, page 50.

Meg. A brick-red rock, fine grained, but holding small pebbles, all of which are reddened and many of which are hard and siliceous. The rock effervesces slightly in acid, showing the presence of some calcite.

No section.

Age. Potsdam.

U. S. G.

NO. 557. CONGLOMERATE (*with copper*).

"Cupriferous conglomerate, from the Island mine, Isle Royale, near the head of Siskiwit bay. This is also argentiferous."

Ref. Annual Report, x, page 50.

Meg. A coarse, red conglomerate. The pebbles are usually pretty well rounded and are of all sizes from very minute ones to those an inch or more in diameter; in fact the whole rock is largely composed of these pebbles, there being comparatively little siliceous cement. There is also calcite cement, and some native copper, although the hand specimen does not show the latter clearly. The pebbles are all red and in general can be said to be felsytes. Many of them are porphyritic with feldspars and resemble devitrified glassy rocks.

No section.

Age. Potsdam; probably the Puckwunge conglomerate.

Remarks. This rock is similar to the copper-bearing conglomerates on Keweenaw point, and also to No. 155.

U. S. G.

NO. 558. DIABASE (*with olivine*).

Near the stamping mill of the Island Mine, Isle Royale. Near the creek coming through the location [This mine is north from the head of Siskiwit bay, and perhaps 200 feet above the lake.]

Ref. Annual Report, x, pages 50, 51.

Meg. Gray, with lustre-mottled spots, medium grained; not a fresh rock.

Mic. The rock is ophitic, and the olivines are altered to a greenish substance, surrounded by much magnetite.

Two sections.

Age. Cabotian(?)

N. H. W.

NO. 558A. THOMSONITE.

From cavities in No. 558.
 Ref. Annual Report, x, page 50.

Meg. This mineral is light lilac gray, or a pinkish white or white, with a hardness 5 or 6. Its structure is massive, or fibrous and divergent, the rays becoming separated, acicular orthorhombic crystals. Some of the masses are two inches, or more, in diameter.

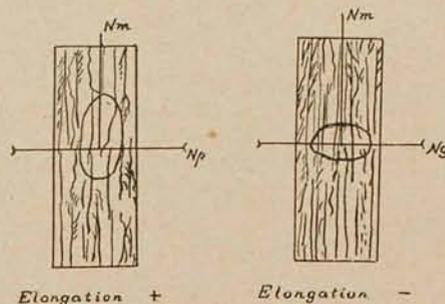


FIG. 24. ORIENTATION OF THE FIBRES OF THOMSONITE.

Mic. The structure is divergently fibrous, the fibres having both positive and negative elongation and a parallel extinction. The axial plane is perpendicular to the fibres. In a section of a lot of fibres showing n_g vertical, the axial angle is so small that the hyperbolas do not leave the field of the microscope. The double refraction is rather high, the fibres that are cut obliquely to n_m giving colors of blue and even green. The highest color (for the thickness of the section, which is about 0.03 millimeter) would be the second yellow, found in fibres cut perpendicular to their elongation. But few if any such appear in the slide. The fibres are coarse, compared to the zeolites which have passed as thomsonite for several years, derived from the vicinity of Grand Marais. They are not straight and rigid, but somewhat alternating and fluxuous, with a feathery structure often prevalent. Figures above show the position of the axes of elasticity and the cleavage.

One section.

Age. Cabotian(?)

N. H. W.

NO. 558B. EPIDOTE AND CALCITE.

Veins in No. 558.
 Ref. Annual Report, x, page 51.

In this green *epidote* is a little metallic *copper*. The *calcite* is in scattered nests.
 No section.

Age. Cabotian(?)

N. H. W.

NO. 559. DIABASE (with olivine).

Immediately overlies the cupriferous conglomerate of the Island mine.

Meg. A much-rotted, gray, medium-grained rock.

Diabase. Conglomerate.]

Mic. This rock has the same characters as No. 558, of which it is probably a portion. This, however, contains, in the hand specimen, no amygdaloidal structure, but it is permeated with a serpentinous, greenish mineral whose hardness is about 2 or 3. This is yellowish-green in small masses, but is dark when thick. It appears to be *thalite*, having its vermicular structure and positive elongation. One section.

Age. Manitou.

N. H. W.

No. 560. DIABASE (*with olivine*).

Forms a bed under the cupriferous conglomerate No. 557; known as the "greenstone range," where it rises to the surface further north.

Ref. Annual Report, x, page 51.

Meg. Gray, medium-grained, specked with small nests of calcite, hence on the weathered surfaces somewhat porous, made up of a plagioclase and a rusty brown mineral, the product of alteration of either olivine or augite. Other ingredients are indistinct.

Mic. The rock is ophitic, but the augite is nearly lost by alteration, its form only remaining as a rusty, indefinite substance, embracing the feldspars. The olivine (which was in part later than the feldspars) is altered to the brown substance mentioned, which is only brown by reason of accumulated oxide of iron, being transparent in the centre of the grain, and even almost isotropic. These parts are as shown by the accompanying sketch, in which *a* represents the usual and familiar isotropic product of olivine alteration when not rendered opaque by iron. Extinction in the grain, especially visible in the part *c*, and faintly in *d*, is parallel with the longitudinal cleavages. The transverse cleavage in the section sketched is not precisely perpendicular to the longitudinal. In another grain, however, these cleavages are perpendicular to each other. This is the substance which has been referred to as *bowlingite* in several rocks. It seems to be monoclinic.

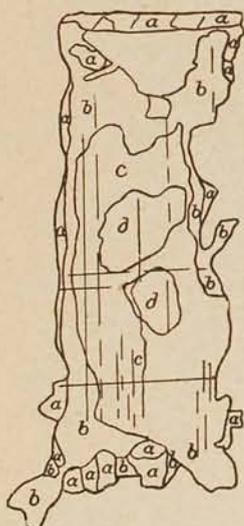


FIG. 25. CLEAVAGE OF BOWLINGITE IN ROCK NO. 560.

The *feldspar* is much altered and multitudes of highly refractive grains are crowded in it, some of which are *zoisite*, having a longitudinal extinction.

The *augite* is plainly preserved, but much destroyed.

Age. This is apparently from a Cabotian intrusive series rising in the form of grand dikes forming the most of the northern precipitous shore of Isle Royale. It is comparable to the dikes in the region of Grand Portage.

N. H. W.

No. 561. CONGLOMERATE. (*Finer debris.*)

From the cupriferous part of the conglomerate at the Island mine, Isle Royale.

Ref. Annual Report, x, page 51.

Meg. Resembles an altered volcanic debris. It is light-colored and crumbling.

Mic. There is a profusion of microscopic grains, some of which (zoisite?) are of very low birefringence, and others, though fewer, which are bright, and extinguish parallel to their length (mica? and thomsonite?), while large areas that were once occupied by some crystals (augite?) are now green with rings and rosettes of chlorite (delessite?).

Age. Puckwunge (basal Potsdam?).

N. H. W.

No. 562. BASALT (*with olivine*).

From a niche in the coast-line south of the east end of Siskiwit lake. This is under the sandstone that forms the peninsula south of Siskiwit bay, but above the conglomerate of the Island mine. Rises from the water with dip to the south. Associated with harder and also epidotic rock in patches.

Ref. Annual Report, x, pages 52, 53.

Meg. The specimen shows a homogeneous, somewhat decayed, medium-grained brownish rock, similar to numerous Keweenawan diabases.

Mic. An ophitic structure is apparent. There is not only fresh *augite*, but a ferruginous much altered mineral whose relation to the feldspar is ophitic, suggesting its derivation from augite or from glass; it resembles otherwise the brownish *bowlingite* which is derived from olivine. Careful inspection, however, shows that it has resulted from the alteration of both. When it occupies the areas of original olivines it has some translucency, and even birefringence, and its color is like that of hematite or it is replaced by an isotropic or faintly polarizing substance which between the nicols is sometimes blue (pennine?). When it is not derived from olivine it is formed of an irregularly disseminated magnetite powder, which is aggregated frequently in such quantities that the entire mass is opaque. When not abundantly massed it is seen to be in an isotropic or *glassy* matrix which is undoubtedly a residue from the magma. The *feldspar* is considerably penetrated with *epidote*.

Two sections.

Age. Manitou.

N. H. W.

No. 563. DIABASE. (*Altered.*)

From one of the trap layers alternating with sandstone and shale at the entrance of Chippewa harbor, Isle Royale.

Ref. Annual Report, x, pages 52, 53.

Meg. Much changed, brown, apparently amygdaloidal and pseudamygdaloidal, spotted white with calcite. Shows also a finely radiated green mineral, apparently some form of chlorite, like delessite. The rock is firm.

Mic. *Feldspar* is filled with gray and yellow *epidote* or with general saussuritization. *Augite* is entirely lost by the severe alteration to which the whole rock has been subjected. No olivine is distinguishable. In place of these primary minerals

Thomsonite. Calcite, quartz.
Chlorastrolite.]

are a lot of secondary minerals—*calcite, chlorite, hematite (?) quartz, epidote*. Two (poor) sections.

Age. Manitou.

N. H. W.

NO. 564. THOMSONITE.

Zeolitic white mineral from the trap at Chippewa harbor.

Ref. Annual Report, x, page 52.

Meg. The structure is radiated and lamello-fibrous, rather coarse.

Mic. The thickness of the only section made is too great to permit of positive determination of the optic characters, being colored, in general, between crossed nicols, in the tints of the third or fourth order. About the edges, however, can be seen small fringes and patches of the brighter tints of the second order, indicating a high double refraction. This, taken with the outward resemblance to No. 55SA, may be sufficient to indicate *thomsonite*.

One (poor) section.

Age. Manitou.

N. H. W.

NO. 565. CALCITE, QUARTZ, ETC.

From the beach, Chippewa harbor, Isle Royale.

Ref. Annual Report, x, page 52.

Meg. A piece from the trap composed chiefly of calcite and quartz, with a little of the rock matter attached, and embracing a radiated (coarse) green mineral whose hardness is about 3.

No section.

Age. Manitou(?)

N. H. W.

NO. 566. CHLORASTROLITE.

From an amygdaloidal bed of trap that disintegrates near the narrows of Chippewa harbor.

Ref. Annual Report, x, page 52; American Geologist, vol. xxiii, page 116.

Meg. The amygdules are, in size, up to half an inch in diameter, but the larger ones are composed of several radiating nests, appearing like chlorastrolite. The fibres are firm, and not easily broken, green in mass, but light-green in single. They are quite short, rigid and uniform, and also fine—finer than those of thomsonite, but about the same in coarseness as the fibres of mesolite. (Compare No. 570.)

Mic. The elongated fine fibres are not brilliantly polarized between crossed nicols. In the space of their elongation from the centre of a spherulith to its circumference, these fibres sometimes undergo variations of color. For instance, at the centre the tint is neutral (or bluish neutral); at a short distance from the centre the same rays, or others that have replaced them, are light yellow, still further the field is wholly of the neutral tint, same as at the centre; then a light-yellow supervenes, and at last the neutral tint returns,—making three recurrences of the same

neutral tint, separated by intervals of light, or light yellow. These changes shift from one to the other, not abruptly, but by the gradual oncoming of streaks or spots of the other tint. The transitions between the yellow and the neutral tints are always through a narrow interval of white which blends on one side with the neutral and on the other with the yellow.

If the convergent light lens be used it is at once apparent by the nature of the interference figure, that the fibres that undergo these changes of color are all situated uniformly in the same position with respect to the section, from the center to the circumference of the spherulith. They may all give the bisectrix n_g . Or, in another spherulith or in another part of the same spherulith, while these same variations are exhibited, the interference figure seen is that indicative of n_p , from one end of the fibres to the other. It is inferred therefore that these variations of color are not due to a shifting of the fibres with respect to the position of their axes, but to an overlapping succession of fibres cut obliquely, producing a section that might be compared to the layering of shingles on a roof.

It is also apparent that the fibres are parallel to n_m , and hence that the axial plane is perpendicular to the elongation, as in thomsonite.

The specific gravity of this mineral is found to be 3.155.

Lacroix has investigated chlorastrolite from an optical point of view* and reached the conclusion that it should be associated with thomsonite. Hawes considered it a variety of prehnite, but the optical properties distinctly show that it belongs with the group of thomsonite, in so far as its optical plane is transverse to the elongation. According to Dana,† who follows Hawes, it is not a homogeneous mineral, and he places it in an appendix to the zeolites, with doubtful species and synonyms. The specimens examined by us, however, are pure and optically uniform in all their characters. There are seen smaller spheruliths which are green and which between the nicols appear uniformly blue, embraced scatteringly in the fibres of the chlorastrolite, but, as they are probably a radiated chlorite (delessite?) their presence does not affect the purity of the surrounding fibres. Lacroix also mentions inclusions of quartz and oxide of iron, and an amorphous substance occupying the centre of the spheruliths. These, however, make no part of the mineral. They would, however, be very likely to be embraced in any chemical analysis which might be made; and this is the only plausible explanation which we can make of the analyses which vary, and of the view of Hawes that the mineral is not homogeneous. Such chemical analyses have no validity as a guide to the nature of the mineral. The mineral has a strong fibrous character, structurally, and a constancy of optical orientation which give it an individuality of its own, and until chemical analysis of some of the pure

* *Bulletin de la Société de Minéralogie de France*, x, p. 147.

† *System of Mineralogy*, p. 610 (sixth edition), 1892.