

Diabase.]

minerals shall be made we prefer to keep it distinct both from prehnite and from thomsonite. With the latter it is allied in the position of its axial plane, but this fact alone is not sufficient to destroy its distinctness from thomsonite, for it is found also in other zeolites, such as mesolite and sometimes in laumontite. One section.

*Age.* Manitou.

N. H. W.

NO. 567. DIABASE (*with olivine*).

From Lucky bay, south side of Isle Royale. (Lucky bay is represented on plate III, Tenth Annual Report.)  
*Ref.* Annual Report, x, page 53.

*Meg.* A porphyritic trap-rock, specked with a green radiated mineral and with brown, and apparently with epidote.

*Mic.* The *feldspar* is triclinic, but permeated with decay. *Zoisite* particles are scattered through it, and a little *calcite*. The *zoisite* has low birefringence; indeed, shows only gray and white colors. It is thus distinguished from *epidote*, which is abundant in the slide, and sometimes is embraced in the *feldspar*. A little *chlorite* is also embraced in these decayed *feldspars*.

*Quartz* appears as a product of alteration.

*Epidote* is abundant, both fibrous and regularly cleaved, in independent crystals, the former being the more refractive. It does not show the "intense polychroism" which is characteristic of the Sulzbach crystals, but rather a steady straw-yellow color, which rarely disappears, although it fades on rotation. The spheruliths are irregular, and are rather more like patches of curved or distorted crystals, showing between crossed nicols a transition from light yellow upward to orange yellow, red, blue, green, as the point of observation passes from the periphery of a spherulitic mass to the centre, thus changing from parallelism to perpendicularity with the fibration. This also indicates that the axial plane is transverse to the fibration.

*Olivine* has almost entirely given place to a finely fibrous "serpentine," or thalite which is almost isotropic.

*Apatite* remains in its original crystals, and is abundant. It is in the *titanite*, the *epidote* and the *plagioclase*. The crystals are sharp and perfect, frequently showing hexagonal sections. They are surrounded by a coating of *hematite*, or of *limonite*.

*Chlorastrolite* is closely associated with some of the *epidote*, forming radiated nests similar to the description given under the last number, surrounded generally by *epidote*.

An occasional brightly polarizing needle, seen in the *epidote* grains, remains undetermined.

*Rutile*, more or less altered by stains of *hematite*, and apparently changed to *leucoxene*, forms some conspicuous masses. Some of these grains are so large that

they occupy the whole field of the microscope. In one grain the intersecting twinning is rectangular, and the form revealed is quite like the quadrillage of microcline. This section is parallel to the base. In another grain the section is oblique, and the interpenetrating twinning is not so close. Three cleavages are brought into view conspicuously, which intersect so as to form isosceles triangles throughout the section. These grains are, in general, brown, but they have areas between the cleavages that are sub-translucent. This rutile is no doubt an alteration product after ilmenite.

*Augite* is abundant. It shows the anomaly of being comparatively fresh, while all the other original minerals (excepting apatite) are much changed. It crystallized early, in part at least, for some of the grains are perfect crystals, and, cut perpendicular to the vertical axis, show their characteristic cleavages and peripheral faces and angles. Other grains formed after the feldspars, and these are more altered.

Three sections.

*Age.* Manitou.

N. H. W.

NO. 568. DIABASE (*with olivine*).

Saginaw mine, near Conglomerate bay, Isle Royale.  
*Ref.* Annual Report, x, page 53.

*Meg.* A rather fine-grained, dark-greenish, gray rock, apparently considerably decayed. The only minerals noticeable are a greenish gray one (feldspar) and a black to reddish glistening one.

*Mic.* The section shows a rather fine-grained olivine diabase, somewhat decayed. The *augite* is violet to straw colored, is sometimes very slightly pleochroic, and frequently occurs in plates of considerable size holding many of the small *feldspar* laths. The *olivine* is now completely altered to *chlorite*. Filling in what were apparently cracks in the original olivine grains is a reddish-brown material. The whole section is more or less altered and now contains alteration products, chief among which is *chlorite*. Iron ore (*ilmenite* or *magnetite*) is quite common.

One section.

*Age.* Cabotian(?)

U. S. G.

NO. 569. EPIDOTE. (*Rock*).

Saginaw mine, near Conglomerate bay, Isle Royale. This rock is the ore of the vein and was mined for copper.  
*Ref.* Annual Report, x, page 53.

*Meg.* A mass of epidote, with some quartz and considerable copper.

*Mic.* The section is in large part composed of *epidote*. In many places are small areas which appear like a fine-grained diabase or similar rock composed of small *feldspar* laths in a sparse groundmass of altered *augite* or *glassy* material.

Amygdaloid. Chlorastrolite.]

These areas are not very sharply separated from the epidote, and it seems possible that the epidote has replaced the mass of the rock. However, what at first glance appears like altered augite or glass is in reality largely *native copper*, and the apparent feldspars are composed of fibres of *thomsonite*. A little *quartz* is present in the section.

One section.

*Age.* Cabotian(?)

*Remarks.* The section apparently shows a basic rock replaced by epidote, copper and thomsonite, although the evidence from this one section is not sufficient to demonstrate this fact.

U. S. G.

NO. 570. AMYGDALOID.

From the rock at the light-house at the entrance to Rock harbor.

*Ref.* Annual Report, x, page 53.

*Meg.* A brown amygdaloidal trap showing calcite, laumontite, chlorastrolite and chlorite; also apparently a little thomsonite.

*Mic.* The *augite* and *feldspar* microliths are ophitic. The olivine is almost wholly converted to *bowlingite* which is partly brown and partly almost isotropic, in the latter case approaching *thalite*, of which there is a considerable quantity, some of it being in spherulitic masses.

Two sections.

*Age.* Cabotian(?)

N. H. W.

NO. 570A. CHLORASTROLITE.

From the beach at Rock harbor, Isle Royale. These are weathered from the trap of the region and accumulate with the gravel on the beach. Compare No. 566.

*Ref.* Annual Report, x, page 53; American Geologist, vol. xxiii, page 116.

*Mac.* When this zeolite has its perfect development, without impurities and without inclusions, the exterior surface of the isolated pebbles presents a stellated and radiated coloration in green of two shades. Blocks of dark green, having a polygonal or irregular periphery, are separated from each other and surrounded by narrow bands or lines of a light green, the two shades blending rapidly at the contacts. Thus the pebbles, which have a sufficient hardness, possess a rich, flecked network of green, and a beauty which has caused their adoption as an ornamental gem. They vary in size from about half an inch downward to mere specks.

The specimens, however, which have this character in perfection, are not abundant. Many of the pebbles are not beautifully marked, but have a dull green color in general, and doubtless should not be allowed the name of chlorastrolite. This general greenness is sometimes quite dark, and in other cases it seems to fade into a very light green, resembling lintonite, in the same way that mesolite fades into lintonite. Outwardly this light green substance is structureless, quite hard and

polishes well. In a similar manner it fades out into a white structureless substance whose hardness is less, but also sometimes into a pinkish zeolitic substance which resembles mesolite. The idea is suggested by the examination of a large number of such transitions, that the green structureless substance is a transition stage between chlorastrolite and mesolite or thomsonite, the iron element prevailing on one side, and not on the other. It seems likely that this green structureless mineral may be that which has been analyzed and named zonochlorite, by A. E. Foote (American Association for the Advancement of Science, 1873). Probably no definite mineral composition or structure can be detected in this green substance, the extremes only being identifiable, viz.: mesolite on one side and chlorastrolite on the other. That the two minerals are closely allied in origin, structure and composition, differing principally in the content of iron, is evident not only from the chemical composition and optic characters, but also from their intimate association often in the same amygdule. Such association sometimes illustrates a sudden transition from one to the other, and sometimes a gradual one, with a considerable amount of the amorphous green mineral. The re-examination of zonochlorite by Hawes (American Journal of Science, x, 24, 1875) shows that it is not a homogeneous mineral. He describes it as having green earthy particles as impurities disseminated in a white mineral. It is evident also that the material examined by Hawes, under the name chlorastrolite, was not a fair sample of that mineral.

As has been remarked under No. 566, this mineral has a well-marked individuality, structurally, while its chemical composition is quite different from that of thomsonite, viz.:

Thomsonite (Table mountain, Colorado, Hillebrand).		Chlorastrolite (Isle Royale, Whitney).*	
SiO <sub>2</sub>	40.52	SiO <sub>2</sub>	36.99
Al <sub>2</sub> O <sub>3</sub>	29.22	Al <sub>2</sub> O <sub>3</sub>	25.49
Fe <sub>2</sub> O <sub>3</sub>	0.79	Fe <sub>2</sub> O <sub>3</sub>	6.48
CaO	12.43	CaO	19.90
Na <sub>2</sub> O	4.31	Na <sub>2</sub> O	3.70
H <sub>2</sub> O	12.79	K <sub>2</sub> O	0.40
		H <sub>2</sub> O	7.22
	100.06		100.18

*Mic.* The marked superficial characteristics are expressed on the interior by a finely radiated fracture, the fibres of which start from points and run unequally to the right or left, so that the spherules are eccentric and the fibres of one spherule abut transversely or obliquely on those of another.

Extinction takes place parallel and perpendicular to the fibres.

The fibres are parallel with the mean axis of elasticity ( $n_m$ ) and hence sometimes where they have their elongated sections, they show a positive and sometimes a negative sign, the axial plane being transverse to the fibration.

\* *Geology of the Lake Superior Land District*, part ii, p. 97, 1851. *Journal Boston Society of Natural History*, vol. v, p. 488, 1847.

Diabase.]

In a section whose thickness is less than 0.03 millimeter the double refraction shows a coloration only when the fibres are cut perpendicularly, and then a straw yellow color. The actual double refraction is therefore somewhat less than 0.015.

Five sections.

*Age.* Cabotian(?)

*Remark.* In the trap rock at Rock Harbor every transition can be seen between the amorphous green mineral ("lintonite"?) to thomsonite and to chlorastrolite. A variety of pebbles gathered on the beach (No. 570B) illustrates this. In some of the amygdaloidal cavities prehnite also seems to have been formed, and it is associated with metallic copper, as noted at French river (rock No. 80). N. H. W.

NO. 571. DIABASE (*with olivine*).

From the Siskiwit mine, Isle Royale, near Rock harbor.  
*Ref.* Annual Report, x, page 53.

The *feldspar* is specked and even crowded with *zoisite*, but its albite twinning is very well preserved. Extinction on  $n_p$  is  $43^\circ$ , indicating labrador-bytownite.

*Augite* is almost lost by decay which has entered along the cleavages, leaving a grouping of isolated grains which extinguish in unison, having an ophitic relation to the feldspars.

*Olivine* has changed into two products which occupy the places of the original grains, viz.:

1. A brown opaque substance which resembles *bowlingite*.
2. A translucent but nearly isotropic substance.

In natural light the former often forms ferruginous veins which penetrate the latter, and by encroaching on it in greater and greater amount either occupies the whole of the space of the original olivine, or leaves only a nucleus which remains translucent. The translucent mineral, in natural light, has sometimes about the color and forms of the original olivine.

This nearly isotropic product of alteration of olivine has been met with frequently in the traps of the state, in the course of this examination, and it has frequently been called serpentine. But, as Prof. Lacroix shows (*Minéralogie de France et de ses Colonies*, page 417), it is a name without definite mineral significance, and had better be reserved for *the rock* in which these products constitute the mass, and the products can be assigned to more definite mineral substances. In this case the substance is hardly isotropic but seems in some cases to have a vague, coarsely felted extinction which approaches to a parallel fibrous extinction, and in others its fibrous structure is more evident, and it then resembles thalite.

*Quartz* as a secondary product is in grains of considerable size, embracing other minerals poikilitically. It is not common.

*Thomsonite* in small amounts in one section.

*Titanite* has resulted from alteration of ilmenite, but it is very rare in the section examined.

*Delessite* forms spherulitic clusters liable to be mistaken for chlorastrolite, from which it is distinguishable by its pleochroism (light green and white).

There is also a finely fibrous, translucent, colorless mineral, whose appearance and structure in general is like that described in No. 140, which may also be thalite.

Three sections.

Age. Cabotian(?)

N. H. W.

No. 572. DIABASE. (*Gabbroidal.*)

The rock of Scovill's point, Isle Royale.  
Ref. Annual Report, x, page 53.

*Meg.* Diabase considerably decayed, amygdaloidal with a flesh-red zeolite resembling laumontite, medium-grained brownish.

*Mic.* The *feldspars* are thickly charged with kaolinic substances, and they have sometimes lost their triclinic characters.

*Olivine* is altered as usual, and consists now of the substance which is usually seen as the product of such alteration, surrounded by brown borders and crossed by brown cleavage cracks or fissures in which the ferruginous oxide has gathered.

*Delessite*, a green, finely radiated mineral is gathered in other places, remote from the olivines, which between crossed nicols shows a parallel extinction and a bluish color.

*Augite* is in fine grains that antedated the feldspar. There is a much ferruginated mineral which shows an ophitic relation to the feldspar, which if not a later generation of augite is probably a glassy remnant of the magma, now entirely devitrified. The original augites are well preserved.

One section.

Age. Cabotian(?)

N. H. W.

No. 573. THOMSONITE AND PREHNITE.

From the trap at Scovill's point, Isle Royale; picked up on the beach.  
Ref. Annual Report, x, page 53.

*Meg.* Mostly radiated, nearly white, pebbles, averaging nearly an inch in diameter, occasionally tinted with gray (when fresh).

*Mic.* The fibration consists apparently of two (or three) minerals, one much coarser than the other. The coarse fibres are visible in natural light, but the fine ones are not. Between crossed nicols their double refraction when viewed perpendicular to their elongation is low—the section being less than .03 millimeter in

Thomsonite and prehnite.]

thickness—and the colors do not rise above the first order. But in sections that are transverse to the elongation the double refraction is higher, giving blue of the first order. In certain parts of the slide the long, coarse fibres show their rectangular, almost square, cross sections. These become inclined in other places and their sections are elongated, running to points at each end, and in others the elongation is almost, or quite, parallel to the direction of the section. This association is illustrated by figure 10, plate I. The mineral being biaxial, these rectangular basal sections indicate an orthorhombic crystalline structure, and the higher basal double refraction also indicates that the axial plane is perpendicular to the fibrillation. This position of the axial plane is shown also by the appearance of both optic axes and bisectrices in sections cut parallel with the elongation, as well as by the direction of retreat of the hyperbolæ in sections perpendicular to the bisectrices. This is shown by figure 24.

This mineral has parallel extinction. It occurs not only as coarse fibres but shares in the finer, fresher network which occupies the space between the radiating coarse fibres. The more decayed older fibres show high relief (or absorption) in convergent light on lowering the lower nicol in contrast with that of the fine network. Micro-chemical test gave lime and soda, indicating *thomsonite*.

Figure 26 shows the manner of grouping of the minute fibres of *prehnite* in the network between the coarser fibres.

Interlaced between these coarser fibres are fine radiating nests of a brightly polarizing mineral whose fibrous arrangement may be represented as stated by figure 26. So far as observable, these fibres are continually negative in elongation, but they frequently are cut perpendicular to  $n_m$ , giving for that reason their bright colors. They are, probably, in part, a finer condition of the mineral represented by figure 24. But as they never show, so far as observed, their highest coloration at the centres of the nests, but in the spreading rays (a), the axial plane is not perpendicular to the fibrillation. This mineral is markedly distinct from *thomsonite* (above) on lowering the lower nicol, owing to the partial decay of the *thomsonite* and not because of the difference of refractive index. The *thomsonite* appears to be the more refractive, but by the Becke process it is easily seen that the characteristic white band separating two grains adjacent, of the two minerals, moves, on raising the objective, toward the lighter colored mineral. Hence, the lighter colored mineral, lying between the coarse *thomsonite* needles, has all the necessary characters to show that it is *prehnite*, of which there is a notable amount in the rocks of this neighborhood.

There is, however, still another mineral in this slide. It is in long single fibres, and has no parallel extinction, but extinction occurs at a maximum of  $45^\circ$ . Such a



FIG. 26. MANNER OF GROUPING OF PREHNITE FIBRES.

section shows  $n_g$ , oblique, but these fibres exhibit an irregular and undulatory extinction, and their elongation is sometimes positive and sometimes negative. In the same fibre a small change (in the direction of elongation) in the point of observation will sometimes alter the interference figure from an optic axis to an axis of elasticity. These fibres are nearly always negative in elongation, but sometimes the same individual fibre changes from positive to negative at a cleavage or fissure which crosses it nearly at right angles, or quite obliquely. This indicates the optic plane is transverse to the fibrillation, as in thomsonite; yet a nearly square transverse section of one of the fibres shows an optic axis and is less doubly refractive than some of the fibres cut parallel to their length. This may be *scolescite*, although the maximum angle of extinction is much too large.

These anomalous fibres cannot be distinguished, in point of view of absorption, from the coarse fibres of thomsonite. They seem to be thomsonite in all points of view except in the wandering positions of the optic plane, which is sometimes even longitudinal.

One section.

*Age.* Cabotian(?)

*Remark.* This intimate mixture of two fibrous minerals shows how futile would be a chemical analysis for determination of the species. Many of these pebbles appear on the beach; the survey collection, already depleted by donation and exchange, still contains about seventy-five specimens.

A Boricky test gave, along with abundant crystals of fluosilicate of lime a few small rods of fluosilicate of soda. When powdered these minerals together do not gelatinize in HCl. It appears probable that thomsonite prevails over prehnite in these pebbles.

N. H. W.

NO. 574. DIABASE.

Extremity of Blake's point, east end of Isle Royale.

*Ref.* Annual Report, x, page 53.

*Meg.* A medium-grained diabase, apparently considerably decayed. What was evidently augite originally, now seems to be chlorite, and the feldspars are pinkish and greenish gray in color.

*Mic.* The section is too thick for careful study. It shows that the rock is a decayed diabase. The feldspars are cloudy and almost opaque, much radiating *chlorite* has been developed in the rock, and most of the augite has disappeared. Considerable iron ore (*ilmenite* or *magnetite*) is present, and there are stains of *hematite*. Possibly some olivine was originally present.

One section.

*Age.* Cabotian(?)

U. S. G.

Thomsonite. Prehnite and copper.]

No. 575. THOMSONITE.

From the beach on the north side of Isle Royale, about two miles southwest from Locke's point.

*Meg.* Pebbles of zeolitic minerals weathered from the trap-rocks of the region. They resemble those of No. 573, except that the majority of them have a tendency toward red, becoming pinkish and purplish, and in this respect they approach more nearly to the pebbles that have been distributed widely from Grand Marais under the name thomsonite. Still, they fall far short of being so brilliantly colored. Their structure is divergently fibrous.

*Mic.* The microscopic characters are the same as already noted for thomsonite under Nos. 161B, 535 and 573. So far as examined, these pebbles are without prehnite, but the slide shows some *delessite*. Two sections.

*Age.* Cabotian(?)

*Remark.* In this large collection some of the pebbles are white, or cream-white, and some are variously blotched with a green substance similar to lintonite. The white pebbles are probably thomsonite, perhaps sometimes mingled with prehnite. A thin section made from one of the sub-translucent green pebbles, without evident fibrous structure, proved to consist wholly of the same mineral, but massively and finely fibrous.

A few other pebbles in the same collection are evidently of prehnite.

*Analysis of No. 575.* This zeolite was analyzed by Prof. J. A. Dodge, with the following result. The material used seems to have been considerably altered by weathering:

Silica,	45.47 per cent.	45.47
Alumina,	21.01 "	21.01
Oxide of Iron,	3.60 "	3.60
Lime,	24.09 "	18.87
Magnesia,	.16 "	.16
Potash,	.21 "	.21
Soda,	.93 "	.93
Water,	.83 "	.83
Carbonic Acid,	4.10 " Carb. of Lime,	9.32
	100.40 per cent.	100.40

Regarding the carbonic acid as united with a portion of the lime, we have carbonate of lime 9.32 per cent, and we have left of the lime 18.87 per cent, which is to be considered as in combination with the silica, alumina, etc., as it stands in the right-hand column.

N. H. W.

No. 576. PREHNITE AND COPPER.

From a little bay at the eastern extremity of Fish island, north side of Isle Royale from the beach.

*Ref.* Annual Report, x, page 53.

*Meg.* The prehnite has served as a cement to angular fragments of amygdaloidal diabase, probably derived from a vein in the near vicinity, not seen. The color is light, grayish green, and the fracture is angular and vitreous.

*Mic.* The single section at hand serves only to indicate the high double refraction, which is sufficient to bring out colors of the fourth order, owing to its thickness. One section.

*Age.* Cabotian(?)

N. H. W.

## No. 577. MELACONITE.

Minong mine, Isle Royale.  
*Ref.* Annual Report, x, page 54.

*Meg.* With soda, on charcoal, this gave a bead of *metallic copper*. The ore is purplish black, in form of a powder, associated with some *malachite*.

*Age.* In Cabotian(?) rock.

N. H. W.

No. 578. COPPER. (*Stamp ore.*)

Minong mine, Isle Royale.  
*Ref.* Annual Report, x, page 54.

Metallic copper is spread through a brownish-red rock in a manner similar to that of the Calumet and Hecla mine, on Keweenaw point, though not plainly conglomeratic. It is more or less coated and accompanied by small deposits of cuprite. The rock appears to have been a somewhat open porphyryte, and the copper has entered its cavities, and at the same time a change has come upon the rock by reason of which a pseudamygdaloidal spottedness pervades it, *i. e.*, foreign minerals have been generated in nests at points in the mass of an originally non-amygdaloidal rock subsequent to consolidation. In these nests sometimes is a central core of metallic copper.

No section.

*Age.* Cabotian(?)

*Remark.* The existence of copper in the Cabotian (*i. e.*, in a dike in the Animikie) was first noted by A. C. Lawson in the Thunder Bay region. (*American Geologist*, vol. v, page 174, 1890.) The environments of the copper deposits at the old Minong mine, at the head of McCargo's cove, Isle Royale, are apparently not identical with those described by Lawson, but approach nearer those in Keweenaw point, and it may be discovered that this copper is, instead, in a conglomeratic outlier of the base of the Potsdam. The line of strike of the basal conglomerate at the west end of Isle Royale probably would carry the northern boundary of the Manitou and Potsdam to the vicinity of Conglomerate bay west of Rock Harbor.

N. H. W.

No. 579. SERPENTINE(?). (*Cupriferous.*)

Minong mine, Isle Royale. Nodules in No. 578.  
*Ref.* Annual Report, x, page 54.

*Meg.* This is a massive, green, fine-grained rock, carrying nests and spangles of metallic copper in a manner similar to No. 578, but less abundantly. Across the rock run veins consisting of a finely fibrous, silky mineral which stands vertical to the walls, apparently a form of asbestos. The source of this rock may have been from change of a basic pyroxenous mass included in No. 578. Indeed there is reason to

Amygdaloid. Copper and silver.]

believe that both Nos. 578 and 579 are parts of a general basal conglomerate into which the copper was introduced at some later date.

No section.

*Age.* Cabotian(?) (Perhaps in the basal, or Puckwunge, conglomerate of the Potsdam).

N. H. W.

NO. 580. AMYGDALOID.

Minong mine, Isle Royale. Adjoins the copper-bearing rock.

*Ref.* Annual Report, x, page 54.

*Meg.* Coarse, green amygdaloid, the cavities being filled with chlorite and geodic quartz, coated with green, sometimes also with calcite and laumontite. The amygdules make up more than one-half the bulk of the whole.

*Mic.* The rock is very fine grained, and was apparently originally in part glassy, the crystalline condition being due in part to devitrification. The chloritic rosettes give the black cross of spheruliths. Owing to the thickness of the only available sections no careful study is possible.

Three sections.

*Age.* Cabotian(?)

*Remark.* The fresh aspect of this loose amygdaloid resembles some of the Cabotian surface eruptives already described on the lake Superior shore in the vicinity of Duluth and eastward. So far as can be judged from the hand samples collected of Nos. 578, 579 and 580, they are from surface igneous rock, and appear to belong in the Cabotian red-rock and surface lavas. They would thus represent the southward flows from some great Cabotian dikes that occurred further north. The writer did not make sufficient examination to warrant him in holding a positive opinion as to the age of this copper-bearing rock.

N. H. W.

NO. 581. COPPER.

Minong mine, Isle Royale.

*Ref.* Annual Report, x, page 54.

Spreading, frond-like, crystalline, partially coated with malachite and cuprite, and bearing a little calcite.

N. H. W.

NO. 582. COPPER AND SILVER.

Minong mine, Isle Royale.

*Ref.* Annual Report, x, page 54.

A small slab, or scale, about an eighth of an inch in thickness, and about two inches in length by an inch in width, but of irregular shape, consists principally of copper, but there are eight separate masses of silver lying in the copper. These small masses vary from the size of a pin-head to that of a field-bean. They are roughened, like the copper, by reason of deposition on some rough surface. There

being small calcite grains still existing in some of the depressions, it appears that this metallic sheet was deposited on a calcite coating, or between two calcite surfaces, since both surfaces are roughened in the same manner, as if by fine calcite teeth, or rhombs.

*Remark.* The singular fact that in the lake Superior region copper and silver are thus associated without being alloyed, was first noted by Dr. C. T. Jackson,\* and has been confirmed by several other geologists since. When they are alloyed, as sometimes occurs in pieces extracted by the ancients, it is probably due to fusion at the time of extraction, since it is a matter of history that the Indians obtained copper in that region by applying heat to the rocks.†

N. H. W.

No. 583. COPPER (*with attached crystals of calcite and adularia*).

Minong mine, Isle Royale.

*Ref.* Annual Report, x, page 54; American Geologist, vol. xxiii, page 317.

Metallic copper is crystalline, in slender rods that are flanged and pointed like a spear-point, the alternating twins furnishing dull corners, slightly barb-like, which increases the resemblance to spear-heads. The calcite is in large masses, conspicuously cleaved and involved with the copper. It is not apparent which is the older. Upon these is an abundant deposition, as a coating, of fine crystals, which are flesh-red, which are so numerous that they constitute sometimes a massive mineral, whose free surfaces, as in the small cavities, are the only parts in which the crystalline facets appear. This mineral is insoluble and infusible, or difficultly fusible. In tube it gives no water.

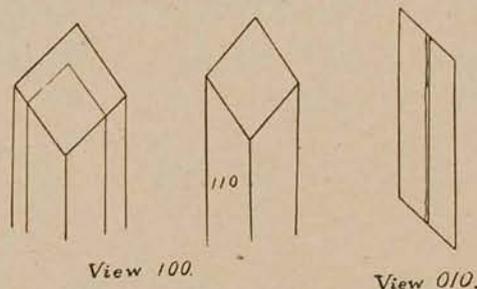


FIG. 27. CRYSTAL FACES OF ADULARIA IN NO. 385.

*Mic.* The mineral has a glassy transparency between crossed nicols, but contains numerous particles of non-translucent impurities. Its fracture is irregularly conchoidal, but is governed partially by the cleavage. The crystals, broken at random, give more numerous cleavages in which the axis  $n_m$  is vertical, indicating the basal cleavage, while fragments that show the axis  $n_g$  vertical are rare. The crystals are confusedly mingled, and sometimes twinned, or compound by parallel growths.

In the geodic cavities are innumerable compound faces, bounded by prismatic

\* Report on the geological and mineralogical survey of the mineral lands of the United States in the state of Michigan, 1849, pp. 386, 461. Compare, also, *Fourteenth Report of the Minnesota Survey*, for 1885, p. 819.

† *Voyage du Sieur de Champlain*, Paris, 1613, p. 246.

Copper.]

edges, showing a monoclinic form, in which the clinopinacoid is reduced to a very narrow surface, or is obsolete, as shown by figures 27 (page 436) and 28. It is seen occasionally as a narrow face running the whole length of the crystal. These crystals are about 1 or 1.5 millimeters in transverse section.

From a coarse powder, mounted in balsam, the double refraction is seen to be rather low. A bisectrix ( $n_p$ ) is in the acute optic angle, making the sign of the mineral *negative*. A fragment, represented herewith (figure 28), shows extinction at an angle of about  $9^\circ$  from the principal cleavage.

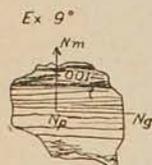


FIG. 28. FRAGMENT OF ADULARIA.

By means of a good thin section, the following characters were determined: The refraction and double refraction are low, about that of the feldspars. The acute bisectrix is  $n_p$ , and the optic angle is so small that the mineral appears almost uniaxial. The easy cleavage is perpendicular to  $n_m$ , and another is about perpendicular to  $n_p$ . The crystals are made up of a number of parallel columns, caused apparently, by the two cleavages, which allow them to be dislodged, and they do not all extinguish at the same moment, though essentially in their true positions. The optic plane is parallel with the diagonal of the transverse section. There is frequently a distinct division of the transverse section into four or more sectors, by planes of parting, running from the centre to the angles, and their somewhat irregular and striped manner of extinction seems to be due to a prevalent structure of that kind. There are also many subordinate divisions of the sectors into quadrilateral small areas which extinguish sooner along their edges than at their centres, or at one side sooner than at the opposite side. These conditions are probably peculiar to the multiple manner of development and interpenetration.

Micro-chemical test by the Boricky process gave evidence of much potash, and a trace of both soda and lime. A similar examination by the method of Behrens showed only potash and also the presence of alumina.\*

The specific gravity of these crystals is 2.544.

A goniometric measurement of the surface prism angles gave the following:

$$\overline{110} \wedge 110 = 61^\circ 30'.$$

These characters conspire to show that the mineral is near orthoclase, of the form *adularia*.

\*The micro-chemical search for alumina by the Behrens method is very direct and simple, viz.: a powdered portion of the pure crystals was dissolved in hydrofluoric acid and evaporated to dryness on a sand bath, in a small platinum crucible. The residue is dissolved in sulphuric acid, and again evaporated to dryness, bringing the mineral into the state of sulphate, soluble in water. After adding a few drops of water, and warming, a small portion of the solution may be placed on a glass slide, and a grain as large as half a pin's head of chloride of caesium, in powder, added to the solution on the slide, when immediately are formed crystals of sulphate of alumina and caesium which can be examined under the objective of the microscope. If the crystals form too rapidly they are simply crystallites in form of a cross (+) with ragged arms; but with further time they develop into octahedrons.

The test for potassium is equally direct: a small portion of the original solution is neutralized (*i. e.*, its excess of sulphuric acid) by a grain of acetate of soda. On a glass slide, by the addition of a drop of chloride of potassium, are formed immediately yellow octahedrons of chloride of potassium and platinum, which can be examined as they float in the liquid.

A test for soda was made as follows, without result, viz.: A drop of the original solution was evaporated to dryness on a glass plate, and to it was added first a drop of acetic acid and afterwards a drop of acetate of uranium. Had soda been present there would have formed tetrahedral crystals of acetate of uranium and sodium.

*Remark.* This mineral appears to be the same as that noted by J. D. Whitney\* at the Copper falls and Douglass Houghton mines on Keweenaw point, where it occurs implanted on quartz and copper, and which gave on analysis the following composition:

Silica,	-	-	-	-	-	-	-	-	65.88
Alumina,	-	-	-	-	-	-	-	-	17.35
Oxide of iron,	-	-	-	-	-	-	-	-	.57
Potash and soda.	-	-	-	-	-	-	-	-	16.20 (by loss)
									100.00

He made no direct determination of the alkalies, not having been able to obtain enough of the substance for such analysis.

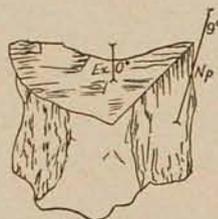


FIG. 29. ADULARIA,  
CUT PERPENDICU-  
LAR TO  $n_p$ .

In still another section it appears that in crystals cut perpendicular to  $n_p$ , there are four sectors which, while extinguishing approximately in unison have partial extinctions somewhat out of unison, and also exhibit an imperfect microcline structure. The mineral has too small an optic angle for microcline. The figure attached shows the grain cut perpendicular to  $n_p$ . There is no evidence of twinning on the Baveno plan, as the whole section has  $n_g$  in the same direction. These variations of extinction must be attributed to irregularities of development.

Samples in the General Museum are Museum Nos. 1900, 1389 and 1370, where it is implanted on epidote, lining irregular cavities.

N. H. W.

NO. 584. COPPER.

Minong mine, Isle Royale.

Ref. Annual Report, x, page 54.

Battered thin scales, from half an inch to two inches in greatest dimension. Found in the mines about the large masses worked by the ancients.

N. H. W.

NO. 585. DIABASE (*with olivine*).

Minong mine, Isle Royale.

Ref. Annual Report, x, page 54; Popular Science Monthly, vol. xix, page 601.

In the form of rounded beach-stones, used as hammers by the ancient miners. Probably transported from the north mainland, where they are common. They evidently got their form by the action of the waves on the beach. They are not withed. They are found in the debris about the old mines.

Three sections.

N. H. W.

\*Report on the Lake Superior Land District, part ii, p. 102, 1851.

Wood. Calcite and Galenite.  
Graphite. Diabase.]

## No. 586. WOOD.

Minong mine, Isle Royale.  
*Ref.* Annual Report, x, page 54.

Found in the ancient mines. For an account of these ancient miners, by N. H. Winchell, the reader may consult the Popular Science Monthly, September, 1881.

N. H. W.

## No. 587. CALCITE AND GALENITE.

Silver Islet.  
*Ref.* Annual Report, x, page 55.

*Meg.* A mass of crystals of *calcite* and *galenite*, with a very little pyrite. The crystals of galenite show combinations of the cube and octahedron, the latter usually being better developed.

*Age.* Vein in Animikie rocks.

U. S. G.

## No. 588. GALENITE.

Silver Islet.  
*Ref.* Annual Report, x, page 55.

*Meg.* A mass of octahedra of *galenite*. The largest of these crystals is over two inches across.

*Age.* Vein in Animikie rocks.

U. S. G.

## No. 589. GRAPHITE.

Silver Islet.  
*Ref.* Annual Report, x, page 55.

*Meg.* The hand sample is apparently a mass of much decayed rock which has been impregnated and partly replaced by *graphite*. The original nature of the rock is not clear; it now contains a little *calcite*. The hand sample resembles somewhat the graphitic quartzite from Pigeon point (No. 270). Probably a third, or possibly half, of the rock is graphite.

No section.

*Age.* In a vein in the Animikie. This is from the great vein at Silver Islet.

U. S. G.

## No. 590. DIABASE.

Silver Islet, Thunder bay. From the great dike at the bottom of the mine, 720 feet below the level of lake Superior.\*

*Ref.* Annual Report, x, page 55; Bulletin ii, page 116.

*Meg.* A medium-grained, gray, massive rock, crossed by several thin veins of calcite.

*Mic.* The minerals are all considerably changed, notwithstanding the great depth from which the specimen was obtained, a circumstance which may be attrib-

\*For an account of the discovery and working of the silver deposits of Silver Islet, the reader may consult MACFARLANE, *Transactions of the American Institute of Mining Engineers*, viii, p. 223.

uted to the nearness of the great vein on which the mine was operated, and which is also corroborated by the small calcite veins which cross the specimen.

*Quartz* forms micropegmatyte in the *feldspars*, and also isolated, independent grains. *Sericite*(?) and other gray substances are distributed through the feldspars, rendering them so obscure that their albite twinning is almost destroyed. *Biotite* is surrounded occasionally by *chlorite*, which also spreads more widely, especially in some of the feldspars. Olivine is not distinguishable, and the *augite*, which is detected by its ophitic relation to the feldspars, is changed to a dirty, fibrous, ferruginous substance that in some places may approach hornblende, but in general is greenish, and related to some *chlorite*. *Apatite*, *magnetite* and a small amount of *titanite* also appear, the last forming groups of tapering, lath-shaped crystals with high refraction and high double refraction, having much the color and irregularity of cleavage seen in ferruginous olivine.

One section.

*Age.* Cabotian dike in the Animikie.

*Remark.* The condition of this rock, at 720 feet below the surface, cannot be attributed to ordinary weathering. It is the most obvious inference that it is due in some way to the presence of the great dike which here is known to cross the vein and the country rock. Whether it can be attributed to the greater ease with which surface waters could enter along the walls of such a fissure, or to the heat imparted to the walls, resulting in an action and retroaction of the walls on the dike, is apparently the only question that need be considered. The mineral contents of the vein seem to show that the mineral solutions came from below rather than from above, and the presence of considerable amounts of graphite indicate a high temperature. It seems, therefore, that the condition of the igneous rock is due to a reaction from the country rock. In that respect this dike illustrates what has been inferred from an examination of several dikes on Pigeon point and elsewhere, viz., the entrance of quartz cotemporary with the alteration of all the minerals of the dike during the process of cooling.

N. H. W.

NO. 591. MARBLE.

Silver Islet. From the vein worked for silver.

*Ref.* Annual Report, x, page 55.

*Meg.* This is massive *calcite*, varying in color from gray-white to flesh-red-white. In the gray portion is visible some *galena*, and in the flesh-colored some *pyrite*.

*Mic.* There is a little *quartz*, in angular grains, isolated in the mass.

One (thick) section.

*Age.* Vein in the Animikie.

N. H. W.

Breccia. Diabase. Slate.]

No. 592. BRECCIA (*of slate*).

Silver Islet. From the vein of the Silver Islet mine.

*Ref.* Annual Report, x, page 55.*Meg.* Angular fragments of slate are cemented by the gangue rock No. 591.*Mic.* A section of the marble shows a confused massive growth of *calcite*, with a small amount of *quartz*, and a single grain that appears to be *titanite*, resembling the titanite of No 590.

One section.

*Age.* Vein in the Animikie.

N. H. W.

## No. 593. DIABASE.

From a breccia in the vein of the Silver Islet mine.

*Ref.* Annual Report, x, page 55; Bulletin ii, pages 118, 120.*Meg.* This rock appears identical with No. 590, from the bottom of the shaft.*Mic.* There appears to be an element of *leucoxene* in the changed *augites*, giving, along with a loss of polarizing power, a sub-transparency which is also specked with opaque particles which are probably *magnetite*; otherwise the section is comparable to that of No. 590.

One section.

*Age.* Vein in the Animikie.

N. H. W.

## No. 594. SLATE.

Silver Islet. The rock that encloses the vein.

*Ref.* Annual Report, x, page 55.*Meg.* Argillaceous slate, in which the laminae are due to the original sedimentation.*Mic.* One thick section only affords the determination of a narrow vein of granular quartz that crosses it. The rock is crowded with opaque substances.

One section.

*Age.* Animikie—Taconic.

N. H. W.

No. 595. DIABASE (*with hypersthene*).

Cores of the diamond drill at the bottom of the Silver Islet mine.

*Ref.* Annual Report, x, page 55; Bulletin ii, pages 59, 92; Wadsworth, Bulletin ii, page 59.*Meg.* A diabase of medium grain, firm and gray.*Mic.* This rock is more nearly in its original condition than No. 590, but has suffered some change similar to that seen in that rock. *Quartz* appears as a secondary product both as micropegmatyte in the feldspars and as isolated grains between the other minerals. *Apatite* is quite abundant piercing all the other minerals. The *feldspars* are somewhat zoned and are twinned on the albite and pericline types.

The olivine has quite disappeared, as such, and its spaces are filled with more or less indeterminate ferruginous substances, and by *biotite*.

The pyroxenic element is nearly intact, but ferruginous opaque substances have gathered about it, and in its basal fissures. It is orthorhombic, and hence is either enstatite or hypersthene. Its high double refraction seems to indicate hypersthene, but its very slight pleochroism is nearer to that of enstatite. At the same time the acute angle of the optic axes seems to embrace  $n_p$ , which stands perpendicular to the face 100. This mineral, in the same slide, having been determined as enstatite by Wadsworth, we prefer to accept his decision provisionally, until better material is at hand.

One section.

*Age.* Cabotian dike in the Animikie.

*Remark.* This rock shows to what extent, under favorable conditions of access of heated waters, the massive rocks may be affected by alteration, this being taken from about 730 feet below lake Superior.

On having made another section, thinner than that examined by Dr. Wadsworth, it is apparent that the pyroxene above is hypersthene. This is indicated by the high double refraction in a section perpendicular to  $n_m$ , which reaches red of the first order, in a section not over, but rather less than, 0.03 millimeter in thickness. This hypersthene is older than most of the feldspars, and it was frequently encased in augite, at least in a highly doubly refracting rim which is much altered and which has the fibration of a diallagic alteration of augite. This rim, as well as other isolated augites, was generated, for the most part, later than the feldspars, and approximately cotemporary with the zoning of the latter.

N. H. W.

NO. 596. BRECCIA (*cemented by calcite*).

"Stamp ore," Silver Islet.

*Ref.* Annual Report, x, page 55.

*Meg.* The fragments are partly from the slate and partly from the dike rock. There seems to be but little reason for using such rock as stamp ore.

*Mic.* The slide consists of the elements of the dike rock, and of the slate. But of the former the feldspars only remain identifiable. *Quartz*, *hematite* and chloritic substances have arisen as products of decay, while veinings of *calcite* also cross the slide.

One section.

*Age.* Vein in Animikie rocks.

N. H. W.

NO. 596A. HUNTILITE.

From the Silver Islet mine.

*Ref.* Annual Report, x, page 55; Engineering and Mining Journal, vol. xxvii, page 55, 1879.

Shale. Conglomerate. Sandrock.]

An arsenide of silver, dark gray to massive, dull, often porous and crumbly. Described by Dr. Wurtz, this mineral consists of two varieties. The two were analyzed together, and while essentially an arsenide of silver, contained some antimony, mercury, sulphur, cobalt, nickel, iron, zinc and water. The mineral is sub-sectile, sub-malleable, and has a hardness about 2.5.

N. H. W.

## NO. 597. SHALE.

Silver Islet landing.

Ref. Annual Report, x, page 56.

*Meg.* This red and buff fissile shale is conglomeratic below, and has a thickness of forty feet. No section.

*Age.* Upper Cambrian.

N. H. W.

NO. 597A. CONGLOMERATE. (*Cherty.*)

From the bottom of No. 597.

Ref. Annual Report, x, page 56.

*Meg.* The general aspect is fine-grained, both of the fragments and of the matrix. Siliceous, calcareous and gray, blotched with angular chert pebbles from the size of a pin-head to two inches in diameter, this rock represents apparently a non-conformable passage from some part of the Keweenaw to a later formation.

*Mic.* The section is very fine grained. The cement is partly of *calcite*, but siliceous spherules which give a black cross, and rhombic sections that are probably of *calcite*, are scattered through it. Except for these forms the section appears like a fine fragmental chert. Two sections.

*Age.* Upper Cambrian.

N. H. W.

## NO. 598. SANDROCK.

From a stratum thirty-five feet thick, underlying No. 597.

Ref. Annual Report, x, page 56; Bulletin vi, pages 123, 420.

*Meg.* Light-red dolomite, sandrock, mixed with red sandrock.

*Mic.* Fragmental *quartz* grains compose the bulk of this rock, the cement being colored by iron. One section.

*Age.* Upper Cambrian.

N. H. W.

NO. 599. CONGLOMERATE. (*Pebbly.*)

From a stratum lying below No. 598; five feet thick.

Ref. Annual Report, x, page 56.

*Meg.* The pebbles are well rounded by beach action. Many of them are red, appearing to be of taconyte. This rock resembles the Puckwunge conglomerate, and perhaps holds the same chronologic place.

*Age.* Potsdam(?)

N. H. W.

No. 599A. PEBBLES (*from No. 599*).

*Ref.* Annual Report, x, page 56.

*Meg.* The pebbles are red and hard.

*Mic.* Two sections made from different pebbles are alike in consisting essentially of fine-grained quartz, but they differ in microscopic aspect by reason of the distribution of the coloring matter. They are both originally composed of grains of sand, such sand being itself a fine-grained quartzite. About these grains grew secondary quartz in coarser grains, filling the interstices completely. In one of these sections that would conclude the description, but in the other there is a concentric banding of the coloring matter, making the secondary quartz bands appear oölitic, the coloring matter forming entire circuits about the original nuclei and passing independently through all the coarser secondary quartzes without deviation from the contours of the original nuclei, although the quartzes embraced in the encircling band have various orientation. In general the width of the band is less than the diameter of the contained grain, but in a few instances it is equal to it, thus increasing the apparent pebble 200 per cent in its shorter diameter. The belts of impurities that can be counted are sometimes six or even ten, depending on the minuteness with which they are differentiated. In a few instances the nuclei of these concentric bands are of other substances, calcite or magnetite, but the quartzite nuclei are always of the same character. They are themselves made up of secondary quartz growths, which took place at an earlier date, and may be referred to aporhyolyte, from which they cannot be distinguished, except that they are not known to show a fluidal structure, or to taconyte, which is also made up, in its last phase, of minute secondary quartz grains.

*Age.* Puckwunge(?) (Basal Potsdam).

N. H. W.

## No. 600. SLATE.

Silver Islet landing, a short distance north of the lake.

*Ref.* Annual Report, x, page 56.

*Meg.* Greenish or grayish, aluminous, but rather coarse and quartzose slate. From the lower portion of the beds exposed. The higher beds are softer.

*Mic.* The quartz grains are angular and the cementing material is opaque.

One section (too thick).

*Age.* Upper part of the Animikie (Grand Portage graywacke).

*Remark.* In the fall of 1896 a considerable thickness of this slate, or what is presumed to be at this horizon, was noted in the Puckwunge valley (compare Nos. 2070, 2071, 2073), and was named subsequently the Grand Portage graywacke. So far as could be learned from the exposures near Silver Islet landing there is a gradual transition from hard quartzite upward into this rather fragile and slaty graywacke.

N. H. W.

Diabase.]

NO. 601. DIABASE. (*Porphyritic.*)

From a dike about a mile north of Silver Islet landing. This rock gradually passes into No. 602, the interval of transition being perhaps two feet, and the two run in the same direction as the Silver Islet dike. The whole width is about forty-five feet, evenly divided between Nos. 601 and 602.

*Ref.* Annual Report, x, page 56; A. E. Barlow, Ottawa Naturalist, vol. ix, pages 25-46, 1895 (Review in the American Geologist, xvi, 1895, page 119).

*Meg.* A medium-grained diabase, with coarse porphyritic crystals of a light-colored feldspar scatteringly disseminated through it, the crystals in some cases making about one-fourth of the entire rock.

*Mic.* The rock is holocrystalline. The section shows only the groundmass. The *feldspar* and the *augite* are ophitic in their relation to each other, the latter also being sometimes distorted by dynamic movements. The rock shows the usual characters of a somewhat weathered coarse diabase.

One section.

*Age.* Cabotian eruptive.

*Remark.* Rock similar to this is seen frequently about the western environs of Gunflint lake, in the form of sills and dikes in the Animikie of that region. Compare Nos. 1314 and 2051. These coarse feldspars were named huronite by Dr. J. J. Bigsby, but seem to be a saussuritized condition of the coarse labradorites of the rock, the secondary grains being of high single refraction and probably of *zoisite*. N. H. W.

## NO. 602. DIABASE.

About a mile north of the "Landing" at Silver Islet; a dike.

*Ref.* Annual Report, x, page 57; Bulletin vi, plate XV.

*Meg.* An ordinary diabase, of rather fine grain and quite heavy.

No section.

*Age.* Cabotian(?)

U. S. G.

## NO. 603. DIABASE.

Extremity of Pigeon point.

*Ref.* Annual Report, ix, page 69; Annual Report, x, page 56. Compare Nos. 287, 291, 1843.

*Meg.* A coarse-grained rock appearing more like a gabbro than a diabase. The minerals are plagioclase, augite and olivine. Sometimes a few subporphyritic feldspars are seen.

*Mic.* The section shows a diabase of coarse grain composed of *plagioclase*, *augite*, *olivine*, iron ore and alteration products. The rock is a good representative of the diabase (or gabbro) of Pigeon point described by Bayley (U. S. Geol. Survey, Bulletin six, pages 32-38), who gives analyses of the rock as a whole, of the feldspar and of the augite. The feldspar is *labradorite*. The olivine is generally altered to a brownish or greenish material (bowlingite?). The augite is in places also altered, the secondary products being *biotite*, *chlorite* and *quartz*. The augite is, as a rule, later than the

labradorite, and the olivine appears to be older than either. However, one compound olivine grain was seen which was later than some of the surrounding feldspar. This structure in rock No. 258 (Hat point) is illustrated on page 285.

*Age.* Cabotian.

U. S. G.

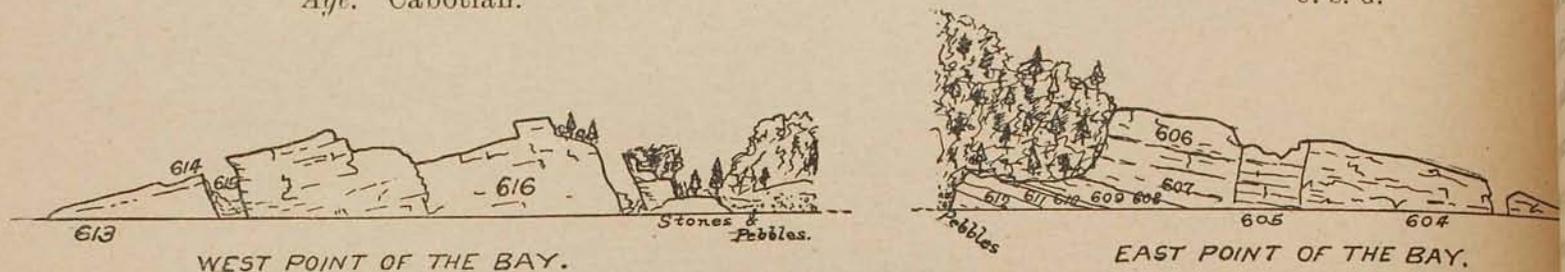


FIG. 30. LITTLE PORTAGE BAY, PIGEON POINT.

No. 604. SLATE.

Near the "little portage" on Pigeon point, south of the dike (No. 605) on the point next east of the little bay on the south shore whence the portage starts out. The portage trail is eighty-seven paces from shore to shore. *Ref.* Annual Report, ix, pages 69, 70; Annual Report, x, page 57.

*Meg.* Fine grained, black, with conchoidal fracture, a hardened fragmental.

*Mic.* The section shows angular *quartzes*, also sub-rounded, impacted in an ill-defined matrix, which is dark, and evidently holds some iron oxides and other opaque substances. One section.

*Age.* Animikie.

*Remark.* Figure 30 shows the structural relations of rocks Nos. 604 to 616.

N. H. W.

No. 605. DIABASE (*with olivine*).

Little portage of Pigeon point. A dike twenty-five feet wide, cutting the slates and quartzite; south end of the portage.

*Ref.* Annual Report, ix, pages 69, 70; Annual Report, x, page 57.

*Meg.* Medium-grained diabase.

*Mic.* The *augite* is, in part, distinctly and beautifully ophitic on the *feldspar*, but in part also was earlier than the feldspar. The rock is fresh. One thick section.

*Age.* Cabotian intrusive in the Animikie.

N. H. W.

No. 606. GNEISS (*with hypersthene*).

Rock extending next north of the dike No. 605, in contact with it, but forming the surface.

*Ref.* Annual Report, ix, pages 69, 70; Annual Report, x, page 57; Wadsworth, Bulletin ii, Minnesota Geological Survey, page 120.

*Meg.* The rock is medium-grained, uniform, "pepper and salt" color.

*Mic.* Consists largely of secondary *quartz* in form of micropegmatyte in the *feldspars* and of isolated grains of much altered feldspar, whose triclinic nature can hardly be established, owing to a cloudy and grayish diffusion of alteration products through it, of *hornblende*, which is greenish, fibrous, and somewhat dichroic, of *biotite*, *apatite*, *chlorite*, and perhaps other secondary minerals, the whole indicating a metamorphic condition of a clastic rock or a silicified selvage of a basic one. Two sections.

Quartzite.]

*Age.* Animikie (metamorphosed).

*Remark.* This is one of the "intermediate rocks" mentioned by Bayley. (Bulletin six, U. S. Geol. Survey.)

The section examined by Wadsworth, contains, in addition to the minerals mentioned above, *hypersthene*, which is of dark yellow color and characterized by parallel extinction and pleochroism. This mineral can hardly be recognized in the section made later and above described, but certain much altered, evidently pyroxenic, grains, now consist of *biotite* (showing sometimes a greenish or chloritic tendency), and of *hornblende*, may have resulted from that mineral. The mineral hypersthene was apparently among the earlier minerals of the rock. It does not hold an ophitic relation to the plagioclases, and therefore preceded them in generation. It seems, therefore, that the magma that cooled to form this rock was derived essentially from the clastics, probably with only partial fusion, and perhaps with basic intermixture from the gabbro, forming an intermediate magma in respect of acidity, before the generation of this hypersthene.

On the other hand, this rock, which in color and general appearance approximates the dark gabbro of Pigeon point, may be looked upon as an altered condition of that rock. Its environment is such that it must have been permeated, on that supposition, very readily by the acid elements of the adjoining country rocks. It is also a common observation, under such conditions, to see the basic rocks thus affected, as at Duluth, at Wausaugoning bay, and at Silver Islet.

N. H. W.

NO. 607. QUARTZYTE. (*Altered.*)

Pigeon point. Next rock north of No. 606, and underlying it.

*Ref.* Annual Report, ix, pages 69, 70; Annual Report, x, pages 57, 58.

*Meg.* The hand sample shows one of the phases of the altered quartzite of Pigeon point. The sample varies some in grain and color, and is composed of *quartz*, red to gray feldspar, *hornblende* and *chlorite*.

*Mic.* The rock is composed of *quartz* and *feldspar*, which is clouded and more or less red; these two minerals are sometimes intergrown to form micropegmatite; yellowish-green *hornblende*, *chlorite* and *biotite* are also common, some *magnetite* and a few almost opaque rough rods, whose exact nature is not clear. Two sections.

*Age.* Animikie.

U. S. G.

NO. 608. QUARTZYTE. (*Metamorphosed.*)

Pigeon point. Apparently a modification of the quartzites. Lies below No. 606.

*Ref.* Annual Report, ix, pages 69, 70; Annual Report, x, pages 57, 58.

*Meg.* Fine grained, reddish, quartzose. (See figure 30.)

*Mic.* The abundant *quartz* grains are wholly the result of regeneration and rearrangement of the quartz of the original clastic rock. About one-third of the

rock is of other material, viz.: *feldspar*, containing many inclusions, seldom showing a polysynthetic striation, *biotite*, sometimes greenish, these two embracing the quartzes as in a pervading matrix, and accommodating themselves to their forms. The red color of the rock comes from the hematite which stains the feldspar.

*Age.* Altered Animikie.

N. H. W.

NO. 609. QUARTZYTE. (*Metamorphosed.*)

Pigeon point. Similar relation to the dike No. 605, but further from it than No. 608.  
*Ref.* Annual Report, ix, pages 69, 70; Annual Report, x, pages 57, 58.

*Meg.* The weathered surface is spotted irregularly with red and gray. The interior is spotted in the same way, but in some places, on fresh fracture, appears like a red granite.

*Mic.* The elements of the clastic rock seem to have been wholly recrystallized, in some parts of this rock. The *quartz* shows no remaining traces of evident clastic origin, but is angular and fresh, its form being imprinted in the surrounding feldspathic portion. The feldspathic portion is red and was later to take position than the quartz. It is so clouded with ferruginous matter that it can simply be said to be crystalline, darkening regularly, but its cleavage and striation of twinning (if it had it) are invisible. It is presumed to be orthoclastic. While these compose the most of this rock, it also contains *biotite* and *chlorite*, while *hematite* serves as pigment generally. One section.

*Age.* Animikie.

N. H. W.

NO. 610. QUARTZYTE. (*Metamorphosed.*)

Pigeon point. Near the same place as the last, but further from No. 605.  
*Ref.* Annual Report, ix, pages 69, 70; Annual Report, x, pages 57, 58.

*Meg.* This rock is very similar to the last, but has more of the red element.

*Mic.* The microscopic characters are not observably different from those of No. 609. One section.

*Age.* Animikie.

N. H. W.

NO. 611. QUARTZYTE. (*Metamorphosed.*)

Pigeon point. Near the same place as the last, but further from the dike No. 605.  
*Ref.* Annual Report, ix, pages 69, 70; Annual Report, x, pages 57, 58.

*Meg.* This is a more crystalline rock, appearing like an imperfect red syenite.

*Mic.* Along with the foregoing minerals mentioned in No. 609, can also be seen here a striated *feldspar*, much stained with the same ferruginous substances, and a single angular small grain that resembles *sphene*. One section. (See figure 30.)

*Age.* Animikie.

Quartzite.]

*Remark.* As the metamorphism increases in receding from No. 605, it is probable that it is not due, on the north side of the dike, wholly to that dike, but rather to the main dike or axis of Pigeon point, which, however, is not visible at this place. These rocks, from No. 606, succeed each other in a downward order of apparent stratification, receding northward from the dike No. 605. N. H. W.

No. 612. QUARTZYTE. (*Metamorphosed.*)

Pigeon point. Near the same place, at the little bay at the south end of the "Little portage."  
*Ref.* Annual Report, ix, pages 69, 70; Annual Report, x, pages 57, 58.

*Mag.* Appears like the last but perhaps is more uniformly crystalline and uniform in grain, and in color, though not so red as the last.

*Mic.* Reddened *feldspar*, occasionally striated, is the most abundant element. *Quartz* is also abundant. Next is mica, apparently *muscovite*. These three are mutually interlocked in a granitic fashion, one being occasionally isolated within a mass of the other. The mica sometimes is replaced by a greenish fibrous or plated mineral, probably chloritic, with low double refraction and strong pleochroism. In some considerable areas *pennine*, finely fibrous, with a dark-blue color of double refraction is closely mingled with the feldspar and with the muscovite. These, with a few grains of *sphene* and the coloring matter (*hematite*) constitute the rock.

*Age.* Modified and crystallized Animikie.

*Remark.* The relations of Nos. 607-612 to the dike and to the quartzite cannot be stated positively, for the whole situation is confused, yet the position of the beds from which they are derived is such that they would succeed each other in descending order northward. No. 604 seems to be the quartzite hardened. It forms a surface sloping to the lake. It is cut by No. 605, but as No. 605 rises five or six feet above the lake it comes in contact on the north side with No. 606, which while so situated as to be the apparent continuation of No. 604, has a very different lithology. It is more like the rock No. 603, in its color and outward general character, but differs microscopically. It is coarser grained than No. 604, but has free quartz and hornblende. No. 606 overlies the numbers following to No. 612. These last cannot be said unqualifiedly to come in the order numbered, but probably do approximately. The layers are in strata that dip south or southeast, weathering out thin-bedded. The samples did not come from successive beds, but rather at increasing distances along the beach, somewhat descending in the strata. The most fragile of these layers (Nos. 611 and 612) are at once followed by the pebbly beach where the portage trail passes over to the north side. It was doubtless owing to the occurrence of these soft beds, which rot and easily chip into pieces under the action of the water and ice of the lake, that the break-down in the peninsula occurs here. They are due therefore to the action of the main dike which forms the axis of Pigeon point, rather

than to the dike No. 605 in contact with which they are found at the south side of the point. This would imply the existence of a fault at the north side of the dike No. 605, running parallel with it. (Compare figure 100, vol. iv, report on the Pigeon Point plate; repeated above by figure 30.)

N. H. W.

NO. 613. QUARTZYTE. (*Metamorphosed.*)

Pigeon point. West side of the little bay at the south end of the "Little portage."  
*Ref.* Annual Report, ix, pages 69, 70; Annual Report, x, page 58.

*Meg.* Rock is gray, but otherwise appears much like some of the foregoing.

*Mic.* There is a trace of the clastic origin of some of the quartz grains in this slide. They have interior forms outlined by lines of impurities, on which later growth of quartz has taken place, both parts extinguishing at the same instant.

One section.

*Age.* Animikie.

N. H. W.

## NO. 614. DIABASE.

Pigeon point. At the extremity of the west point of the little bay from which the "Little portage" starts, south side of Pigeon point.

*Ref.* Annual Report, ix, page 69; Annual Report, x, page 58.

*Meg.* Fine grained, nearly black, resembling No. 604.

*Mic.* The rock consists of the elements of the diabases of the country, at least *augite*, microlitic *feldspars*, the former being cotemporary or earlier in date than the *feldspars*, and of *magnetite*.

One section.

*Age.* Sill(?) in the Animikie.

*Remark.* The outward resemblance of this rock to No. 604, and its similarity of position with respect to the little bay, one on either of the points that enclose the bay, would lead one to consider them of the same rock mass. But one is a hardened clastic, and the other is a finely crystalline irruptive. This idea would not be weakened by the fact that a coarser diabase dike cuts each of them. The dike which cuts this point, however, has not the direction of that cutting the other point, but runs into the lake southeast, while the other seems to run into the bay, lying to the north of this. This dike, moreover, is about one-third the width of that. N. H. W.

## NO. 615. DIABASE.

Pigeon point. Dike twelve feet wide which cuts No. 614 above.

*Ref.* Annual Report, ix, page 69; Annual Report, x, page 58; Bulletin ii, page 108.

*Meg.* Medium-grained diabase.

*Mic.* This rock, which is rather fresh, shows, like numerous others that have been examined, two generations of *augite*, viz.: one is earlier than the plagioclases, and is considerably decayed, and the later is fresh and ophitic, though occasionally

Quartzite.]

a little diallagic. This distinction is not sharp. The section also shows some *quartz* in large isolated grains.

One section.

*Age.* Cabotian(?) dike.

N. H. W.

No. 616. QUARTZYTE. (*Metamorphosed.*)

Pigeon point. West side of the same little bay, north of the last.  
*Ref.* Annual Report, ix, page 69; Annual Report, x, page 58.

*Meg.* Spotted red and dark gray, medium grained. An incipient granite, resembling some rock on the east side of the bay.

*Mic.* *Quartz* is abundant, but the matrix of the grains is stained red with oxide of iron. The *feldspars* are unidentifiable as to species.

N. H. W.

No. 617. QUARTZYTE.

Pigeon point. From near the base of the hill about half a mile west of the "Little portage," at the south shore.

*Ref.* Annual Report, x, page 58.

*Meg.* A brown, hardened sandstone.

*Mic.* *Quartz* grains, in a reddened cement, compose the most of this rock, but amongst the latter may be seen some fibrous grains that are *chloritic* or *hornblendic*, as well as some of *mica*.

One section.

*Age.* Animikie.

N. H. W.

No. 618. QUARTZYTE. (*Metamorphosed.*)

Pigeon point. Near the summit of the same hill.  
*Ref.* Annual Report, x, pages 58, 59.

*Meg.* Gray quartzite.

*Mic.* This rock contains much granular *quartz*, constituting about two-thirds of the whole, and some fine grains of *plagioclase*. Owing to the presence of several *hypersthene* crystals, which are, so far as discovered hitherto, characteristic of the contact belt between the basic irruptives and the clastics of the region, as well as the existence of remains of older plagioclases, this rock may have originated as one of the "intermediate rocks" (of Bayley), *i. e.*, it may have solidified from a new magma produced by the fusion of some of the sedimentaries and the mingling of this matter with the magma that rose from a deep source. The gray color of the rock is not in keeping with that of the rock that results from the simple metamorphism of the clastics, which produces a red rock. At least, *hypersthene*, as a mineral of the basic rocks when cooling near the reactionary rim of the clastics, seems to point to this rock as a changed basic rather than as a changed quartzite. One section.

*Age.* Animikie at contact on a Cabotian intrusive.

N. H. W.

NO. 619. GRANITE. (*Porphyritic, granophyric.*)

Pigeon point. From the same hill as the last, but from the south side where the structure is basaltic. Compare No. 1845.

Ref. Annual Report, x, page 59.

*Meg.* Red, granitic rock, somewhat porphyritic with feldspar and with quartz.

*Mic.* The *quartz* permeates the *feldspars* in a micrographic manner, which is sometimes spherulitic. It also forms many grains which are sometimes aggregated like the grains of a fragmental quartzite. Quartz phenocrysts of much larger size also appear, forming bipyramidal crystals like those of a quartz-porphry. Occasionally such phenocrysts show embayments into which the molten rock entered. In one such case is seen a beautiful illustration and demonstration of the very early origin of the granophyric and pseudo-spherulitic structure. This is illustrated by figure 11 of plate I. The embayment was filled with the original (molten?) magma, and on consolidation this has also become crystallized and has assumed an imperfectly granophyric structure. This is continuously traceable through the neck of the embayment and into the surrounding rock mass, and in the latter the same structure is developed on a more perfect scale. It is impossible but that the material filling the embayment and that surrounding the phenocryst were in the same molten condition at the same time. They must have assumed simultaneously these low crystalline structures at once on consolidation, or very soon thereafter. If the consolidated matter were at first glassy, and this structure were then developed as a result of devitrification it might be considered a secondary structure, but it was probably not glassy, since in the near vicinity of this quartz phenocryst, and generally distributed through the section, are other minerals whose outlines are confusedly linked in with the outlines of the granophyric figures. These are *biotite* and an occasional indistinct form of *feldspar*. There are also many quartzes, as already mentioned, which must date from the second consolidation. The section illustrates one of the steps in the transition from a quartz-porphry to a granite, being not fairly referred to either. One section.

*Age.* Acid Cabotian.

*Remark.* In the foregoing it is assumed, as is usual, that the existence of bipyramidal quartz crystals is demonstrative of the former molten condition of the quartz-porphry in which they occur; and that is perhaps assuming too much, inasmuch as such crystals are known to arise in the aqueous transformation (with heat) of quartzites of Pigeon point in portions adjacent to the great dikes, and in which there is no possibility of a former molten condition, since the most of the rock retains its rounded clastic grains. This rock may therefore have resulted from a clastic which was transformed by hot solutions, but was not molten, and hence the quartz phenocrysts may be of secondary origin.

N. H. W.

Aporhyolite. Mesolite. Stilbite. Diabase.]

## NO. 620. APORHYOLYTE.

Eastern palisades.

*Ref.* Annual Report, ix, page 58; Annual Report, x, page 59. Compare No. 230.

*Meg.* The hand specimen is red in color, and is much fissured and in places decayed. Small porphyritic quartzes and feldspars are embedded in an aphanitic groundmass which shows distinct flow structure.

*Mic.* In section the *quartz* phenocrysts are seen to be much corroded and sometimes show embayments of the groundmass. The *feldspar* phenocrysts are highly altered and reddened and their species cannot be determined. The groundmass is brownish red in color and in places appears homogeneous under a low power, but under a high power it is seen to be not glassy, but is probably composed of very minute quartzes and reddened feldspars, the product of devitrification. Some areas show larger quartzes, probably of secondary origin. Another section shows the groundmass to be composed of small, irregular quartz areas holding the feldspathic part of the groundmass poikilitically.

Two sections.

*Age.* Cabotian.

U. S. G.

## NO. 621. MESOLITE, ETC.

Gathered from the beach at Lover's bay, S. W.  $\frac{1}{4}$  sec. 32, T. 61-1 W. (compare Annual Report, ix, page 50).*Ref.* Annual Report, x, page 59.

*Meg.* These pebbles are somewhat varied, but are of a light or pinkish white color. They may be compared to Nos. 535B and 535C, and are probably from the same general trap-sheet, which was apparently a surface flow, extending from Cascade river, at least, to Good Harbor bay.

No section.

*Age.* Manitou.

N. H. W.

## NO. 622. STILBITE, MESOLITE, ETC.

Mouth of False Poplar river; from the rock.

*Ref.* Annual Report, x, page 59.

*Meg.* These zeolites have the color and cleavage of stilbite, and embrace a small amount of what appears like mesolite.

No section.

*Age.* Manitou.

N. H. W.

## NO. 623. DIABASE.

From the upper layer of the point that encloses Eclipse beach on the east. This is two and a half feet thick.

*Ref.* Annual Report, ix, page 49; Annual Report, x, pages 59, 60.

*Meg.* Medium grained, greenish gray, non-amygdaloidal, but chloritic from decay.

*Mic.* The section shows an ophitic rock, but interspersed in the mass of the rock are areas filled with a very fine aggregately polarizing substance, and others that are green in common light. The former are quite translucent in common light, but nearly dark between crossed nicols, though crypto-crystalline. The latter, green in common light, are occasionally so macro-crystalline that they lighten and extinguish throughout their whole area.

The green areas are largely derived from alteration of the original *olivines*, but not wholly, for some of them appear to be associated with *augite* of the first generation. *Bowlingite* is probably the mineral which, when greenish, or brownish, still gives distinct general extinction.

*Thomsonite* and some *saponite* (thalite) also are seen in this section.

One section.

*Age.* Manitou (same as the rock forming Terrace point).

N. H. W.

#### NO. 624. AMYGDALOID.

Underlying No. 623. This bed, by its easy disintegration, forms two small harbors, one protecting from the northeast, and one from the southwest. This bed is about eight feet thick, but varies some, as the characters of No. 623 fluctuate up and down.

*Ref.* Annual Report, x, page 59.

*Meg.* Brownish red, fragile, charged with thalite and laumontite, both in the rounded cavities and in veins.

*Mic.* An ophitic structure is apparent, but some of the *augites* also preceded the *feldspars*. The olivine is either entirely lost or remains only in the form of a brownish mineral, resembling *bowlingite*. Occasionally a distinct cleavage perpendicular to the extinction is visible in this mineral.

One section.

*Age.* Manitou.

N. H. W.

#### NO. 625. DIABASE.

Eclipse beach, sec. 26, T. 60-3 W. From this bed are derived the "thomsonites" of Eclipse beach. Thickness cannot be made out, as it forms the coast line eastward. It has a close relationship with Nos. 623 and 624, and in many places they probably could not be separated from each other stratigraphically. At this point, however, No. 625, in general, lies below Nos. 623 and 624. It is nearly, if not exactly, on the same horizon as the amygdaloid at Terrace point, judging from the run of the beds as they extend along the coast from that place. The same horizon extends to Poplar river without much deviation.

*Ref.* Annual Report, ix, page 49; Annual Report, x, page 60.

*Meg.* The rock itself is dark green, amygdaloidal, but not so easily disintegrating as No. 623. It is blotched with fine and coarse thalite masses, which are frequently coated with a red scale of some zeolite, perhaps of heulandite. It also embraces the mineral which has been generally known as thomsonite, but which does not exhibit the optic characters of that zeolite. This is sometimes in large masses.

*Mic.* This rock, or others like it, has been described already. It is ophitic, the *olivine* is not preserved, but has contributed to the formation of the abundant *thalite*.

Mesolite.]

Owing to the abundance of this green substance, which is crypto-crystalline and has replaced some earlier idiomorphic mineral, it is probable that *augite* of an earlier generation has shared in its formation. The later augites are well preserved. They embrace many microlitic *feldspars* and occasionally some of the thalite areas. It is to be noted also that, while most of these green areas have shapes showing they are changed from an early generation of some mineral, either olivines or first augites, there are a few that are ophitic in their relation to some of the feldspars. These probably resulted from an alteration of small portions of the magmatic residue. This is evident from the fact that the ophitic augites are all quite fresh. *Heulandite* appears in clear grains in the slide.

One section.

*Age.* Manitou.

N. H. W.

NO. 625A. MESOLITE.

Picked from the rock at Eclipse beach.

*Ref.* Annual Report, x, page 60.

*Meg.* Strongly but finely radiated, pinkish white, filling large cavities in the trap (No. 625). The fibres are strong, straight and rigid, but fine, differing from those of thomsonite and scolecite, which are coarser and have a glassy reflection and greater transparency.

Some of the masses of this mineral are three or four or even ten inches across; but in the case of large masses the mineral lies rather in sheets with radiating points on the upper and lower contact surfaces. Some large masses two inches across have also two or three points of radiation. When polished on the beach the pieces that result from the disintegration of the larger masses are pyramido-triangular, but there are also many round and oval which have not been broken on separation from the rock. These show the circular radiating eyelets of different colors on the outer surfaces when polished on the beach. The colors are pink, red, white and green—at least the same green mineral is found here, always smaller than the others, as is found at Terrace point. This green mineral ("lintonite") often surrounds the pink and white radiating masses. It is itself not evidently radiated, the radiations of the mesolite penetrating it. Sometimes little nests and rosettes of lintonite grow in the mesolite, prevailing about the peripheries of the mesolite masses.

*Mic.* In very thin section this mineral is nearly unresponsive to all changes of the stage, whether in parallel or convergent light. All the sections made from this number seem to contain two minerals very intimately intermixed. The sub-opaque white fibres are interspersed with parallel translucent ones, but between crossed nicols these translucent fibres are constantly dark and are generally much coarser than the sub-opaque ones. Indeed these transparent larger fibres show

geometric crystalline forms. They lie in and also cut obliquely or even perpendicularly across the mass of the finer fibres. Their cross sections are quadrilateral and sometimes rectangular, in proportion as they are cut more or less obliquely. The fine opaque fibres are so densely compact that their crystalline forms cannot be made out. These both have positive elongation. Between crossed nicols the fine fibres are the only illuminated portion of the section, as enough light gets through to render them distinctly separable from the transparent fibres which in that condition are wholly dark. In natural light, however, the larger transparent fibres are the more illuminated. The mass of finer fibres, which are sub-opaque, are seen to be charged with minute dark impurities, and these are sometimes so large as to indicate that they are iron-stained, and are probably due to partial decay. The larger, transparent fibres are free from such impurities, but show a scant cleavage nearly or or quite perpendicular to the elongation. The specific gravity of this substance is 2.26.

Micro-chemical test (Boricky) gives evidence of the presence of considerable soda, along with lime, or lime and magnesia. The rods (hexagonal) of fluosilicate of soda are innumerable, but so fine that they are likely to be overlooked in the presence of the conspicuous monoclinic crystallites of the alkaline earth. They are brought out to view by removing the upper nicol and lowering the lower nicol, when they seem to equal, if not exceed, in total amount, the crystallites of lime. This prevalence of soda indicates a zeolite of the natrolite group, in which Dana has only three recognized species, viz.:

Natrolite (or mesotype).

Scolescite.

Mesolite.

These are all subject to ready alteration and to partial or total loss of the power to polarize light.

1. Natrolite is orthorhombic.
2. Scolescite is monoclinic.
3. Mesolite is monoclinic (or triclinic, Descloizeaux).

The first contains soda only as a base; the second contains lime only, and the third has lime and soda. The Boricky test determines this of these three, to be the last, viz.: *mesolite*.

It seems quite possible, if not probable, that two zeolitic minerals of the natrolite group of Dana are here concerned, viz.: *mesolite* the finest and somewhat altered, and *mesotype* the clear and transparent, the latter being older than the former. Both kinds of fibres have a close striation or parallel cleavage, and a distant fissuring perpendicular to their elongation.

*Age.* Manitou.

*Remark.* These numbers (625A and 625B) also cover other zeolitic minerals.

N. H. W.

Scolescite, thomsonite, lintonite.]

## No. 625B. SCOLESCITE, THOMSONITE(?), LINTONITE, ETC.

From the same place as No. 625A, but gathered from the beach.

*Meg.* Structure and general appearance the same as of No. 625A.

*Mic.* A good section made by Marchand, shows two minerals closely mixed. One has sharp, rigid fibres, which pierce the other, running through several individuals, forming about one-half of the whole. This is of low double refraction, negative elongation and oblique extinction, and can be safely taken to be *scolescite* or *mesolite*.

The other mineral is so thickly pierced by the fibres of the former that it appears to have a similar fibrous structure, but that is illusory. Still, when the coarse fibrillation is wanting in any one of these grains, this mineral nevertheless reveals a very fine and dense fibrillation by reason of the black bars of a cross which it gives between crossed nicols, which remain on rotation of the stage. These fine fibres, which also give to the grains an imperfect elongation and which are invisible even on lowering the condenser, have a positive elongation. The axial plane is parallel to these fine fibres, and the optic angle is so small that the bisectrix  $n_p$  appears like a constant black cross, only being dislocated sufficiently to detect the opening between the hyperbolas. It occurs, hence, that some of the broad longitudinal sections are nearly dark continually, and some show color. The double refraction appears to be but little more than that of quartz; yet, when, in some parts of the slide, the axis  $n_m$  is perpendicular, the color reaches yellow or yellowish red. This may be due to variation in the thinness of the section. The mineral contrasts greatly with the fibres which pierce it, in its range of coloration and of light which pierces it parallel to  $n_m$ , and especially in its habit, which is blunt, roundish; spreading, and, as cut in the slide, approximating granular. It might be mistaken for quartz, were it fibrous and not biaxial with  $n_p$  in the acute angle, or for thomsonite were not its axial plane parallel with its elongation. Some of its forms are very much like the spreading fans of thomsonite. It remains unidentified. (Compare thomsonite found on Isle Royale, Nos. 573 and 575.)

The slide also shows a little lintonite, and another contains only lintonite.

Some of the pebbles from the beach are small, hard, fine grained and light green in color. They consist of *lintonite*. They have  $n_e$  for acute bisectrix, the optic axes being very nearly together ( $2E$ —about  $60^\circ$ ), the elongation is positive and negative, and hence, the axial plane is transverse to the elongation, resembling thomsonite in that respect.\* The double refraction of lintonite is but little more than that of quartz. For the purpose of making an approximate measure, a slide was prepared on which were ground simultaneously, to the same thinness, four plates of barite,

\*In a discussion of lintonite in the *American Geologist*, vol. xxii, p. 349, the writer inadvertently stated that the axial plane of this mineral is parallel to the elongation.

two of scolecite and a pebble of lintonite, the last being in the centre. In the fine, short-fibred lintonite the highest color, being that presented by sections parallel to the axial plane, compared with the color given by barite in the same position, showed that the double refraction of lintonite is about 0.017 to 0.018, that of thomsonite being 0.028. A comparison with scolecite cut in the same position gave the same result. The single refraction of lintonite is also less than that of thomsonite. Its specific gravity is 2.372.

In a thin section of lintonite the negative fibres are more light than the positive, the latter being nearly dark. Indeed, the negative fibres are nearly as highly doubly refractive as those which present  $n_m$ , and can be distinguished from them only by their shapes, the  $n_m$  sections being squarish. Five sections.

*Age.* Manitou.

N. H. W.

NO. 626. AMYGDALOID AND TUFF. (*Submarine.*)

About midway between Poplar and Temperance rivers (Nos. 177 and 178). This lies in regular beds of a few inches, or less than an inch, like a sedimentary rock. The specimens may represent the red amygdaloid of several miles along here, though the sedimentation is not so plain in all cases. Over these layers is a heavy bed of trap, massive or coarsely jointed, which forms arched purgatories and tables extending into the lake, the amygdaloid being eaten out by the friction of the beach line under the action of the waves.

*Ref.* Annual Report, ix, page 47; Annual Report, x, page 60.

*Meg.* Pinkish, red, or brownish, specked with laumontite, and sometimes largely made up of secondary minerals, frequently zeolitic. Evidently consisting principally of eruptive matter originally, perhaps in the form of coarse ash, but distributed by water. Some parts, however, are completely pumiceous, the cavities filled now by laumontite. Fragmental, red, shaly matter is mingled confusedly more or less in these layers. Probably represents the so-called "ash-bed diabase."

*Mic.* The fine, rusty, groundmass is crowded with microlitic *plagioclases*. In many spaces, which appear to have been occupied originally by porphyritic feldspars, are grains of *laumontite* whose optic axial angle (2 E) is quite small, apparently not over  $10^\circ$ , which causes the interference figure in convergent light to present, on rotation, a deceptive approach to the manner of revolution of a uniaxial interference figure. The axial plane is parallel with the fibration, and consequently some of the grains show the bisectrix  $n_p$  and some  $n_m$ , while the most of them are cut intermediate between those axes; and the elongation is hence continually positive.

There is also a sparse representation of what appears to be a *pyroxenic* mineral. The section being of a thickness of about .035 millimeter, the highest polarization color of this mineral is greenish blue, the fringes running downward through red and yellow, thus indicating *augite*. It is a remarkable illustration of the preservation of that mineral in the same mass where the original feldspars are wholly replaced by a zeolite. One section.

*Age.* Manitou.

Diabase. Conglomerate.]

*Remark.* This thin section, necessarily from one of the more firm parts of this rock, does not bring out the fragmental characters.

N. H. W.

NO. 627. DIABASE. (*Amygdaloidal.*)

Three-fourths of a mile west of Cross river. Forms an arched rock at the shore.

*Ref.* Annual Report, ix, page 32; Annual Report, x, page 61.

*Meg.* This rock is hardly amygdaloidal, originally, but it contains many grains of secondary minerals, such as *stilbite*, *heulandite*, *thalite* and *calcite*, making partially a pseudamygdaloid.

*Mic.* The rock is ophitic, with large *augites* which embrace numerous *plagioclases*. The *olivine* is replaced by opaque ferruginous products. *Thalite*, with a very finely fibrous structure, fills some spaces.

One section.

*Age.* Manitou.

N. H. W.

NO. 628. DIABASE. (*Gabbroidal.*)

Mouth of Manitou river. At this place about thirty feet of trap that shows red surfaces in falling to pieces, lies on an amygdaloid conglomerate, the two together forming precipitous bluffs on either side of the river, with lower stretches where the trap, which is somewhat basaltic, runs unbroken down to the water. This kind of coast extends east at least to the west point of Pork bay and west to Little Marais. (Compare No. 160.)

*Ref.* Annual Report, ix, pages 41, 42; Annual Report, x, pages 61, 63.

*Meg.* Compact, medium grained, gray or grayish brown, with a slight tint of chloritic green.

*Mic.* The rock is not ophitic, yet the numerous *augites* were mainly thrust aside by the generation of the *feldspars* so as to lie thickly alongside of the feldspars in a pseudophitic embrace and are sometimes embraced within the feldspars. The *olivine* is charged and the feldspars are stained by chloritic accumulations.

One section.

*Age.* Manitou.

*Remark.* This rock was probably a surface flow, and assumed a basaltic columnar structure in part, on cooling. A few small porphyritic *augites* can be seen in the hand sample, but none are cut by the slide.

N. H. W.

## NO. 629. CONGLOMERATE.

Mouth of Manitou river.

*Ref.* Annual Report, ix, page 41; Annual Report, x, pages 61, 63.

*Meg.* Crumbling, soft, red, amygdaloidal, the form and original structure of the pebbles being obscured or lost. The pebbles are mainly of basic and sometimes apparently of amygdaloidal trap, but occasionally they embrace a piece of red shale.

*Mic.* The section, which is too thick, shows a scoriaceous rock, in the vesicles of which are *laumontite* and *calcite*.

One section.

*Age.* Manitou.

N. H. W.

## NO. 630. DIABASE.

Two miles west of Little Marais point; forms perpendicular cliffs. Resembles the rock of Eclipse beach.  
*Ref.* Annual Report, ix, page 41; Annual Report, x, page 62.

*Meg.* Grayish, with medium grain.

*Mic.* Ophitic, and charged with *thalite*. The olivine is lost. The abundant *thalite* in a thick section shows, along with parallel extinction, a coloration about the same as the plagioclase, but a trifle higher.

One section.

*Age.* Manitou.

*Remark.* This probably lies below the Little Marais conglomerate, since the heavy trap sheet on the east point of Little Marais, which lies on the conglomerate, strikes (westward) from the shore at an angle and disappears in the lake, letting the western shore line on to lower strata.

## NO. 631. AMYGDALOID.

Same place as No. 630.

*Ref.* Annual Report, ix, page 41; Annual Report, x, page 62.

*Meg.* The cavities are filled with *thalite* and *calcite*, the latter lying frequently within the former.

*Mic.* The rock is ophitic, and was evidently the superficial portion of an eruptive flow. One section.

*Age.* Manitou.

N. H. W.

## NO. 631A. BASALT (?)

From No. 631. Occurs in the form of veins accompanied by stilbite and calcite. Seems to be foreign to No. 631.

*Ref.* Annual Report, x, page 62.

*Meg.* Very dense, brown or reddish brown.

No section.

*Age.* Manitou.

N. H. W.

## NO. 632. BASALT.

From a point of rock on sec. 29, T. 57-6, separated from the green trap No. 630 by a conglomerate thirty-five feet thick. Thickness, twelve feet.

*Ref.* Annual Report, ix, page 41; Annual Report, x, pages 62, 63.

*Meg.* Dark, brownish red, dense, blotched with red, on account of the red partings along all the joints, crossed by siliceous red seams and veins like those seen in No. 631, and contains large lumps and geodes of quartz.

*Mic.* The minute *feldspars* and *augites* lie in an abundant *residuum* of the magma, which appears to have been consolidated as a *glass*, but is now filled with indistinct crystallites.

One section.

*Age.* Manitou.

N. H. W.

Clasolyte. Quartz. Amygdaloid.]

## NO. 632A. CLASOLYTE.

From a point about half a mile west of No. 630.  
*Ref.* Annual Report, x, page 63.

*Meg.* Vein about half an inch wide, composed of a central band about one-fourth of an inch wide of hard, granular substance of a brown color, and on each side a band of reddish "chalcedonic" quartz, each about an eighth of an inch wide. The first appears to be composed of fine clastic materials, but the quartz band on either side of it is evidently of chemical deposition and is in wavy layers similar to the layering in agates.

*Mic.* The framework of the clastic grains is dark with iron oxides. The grains are partly of *quartz* and partly of *plagioclase*, and there are occasionally areas of greenish thalite (?) These grains are sometimes rounded and sometimes angular.

One section.

*Age.* Manitou.

*Remark.* The term clasolyte is adopted from Wadsworth (Michigan Geological Survey Report, published 1893, page 147), which is applied by him to a fragmental rock which fills fissures in an older rock from above.

N. H. W.

NO. 632B. QUARTZ. (*Geode.*)

In the same beds as No. 632A. Quartz geodes in basalt, with some amethyst and agates. Lying just above a conglomerate.

*Ref.* Annual Report, x, page 63.

*Meg.* The specimen consists of the quartz crystals of a siliceous geode presenting their terminal facets, becoming massive quartz and finally agate-like bands, the last serving as attachment to the basalt in which the geodic mass was originally formed.

No section.

*Age.* Manitou.

N. H. W.

## NO. 633. AMYGDALOID.

Immediately underlies No. 632. Thin, irregular beds of amygdaloidal trap containing red amygdules graduating into No. 634.

*Ref.* Annual Report, x, page 63.

No section.

*Age.* Manitou.

N. H. W.

## NO. 634. AMYGDALOID.

Immediately underneath No. 633, near the top of the conglomerate.  
*Ref.* Annual Report, ix, page 41; Annual Report, x, pages 63, 64.

*Meg.* Contains agate, stilbite, laumontite and chlorite. The red coatings, which are apparently of heulanditic material, prevail along the red seams that cross and recross the rock. In some cases the red material penetrates the whole, and is

disseminated generally through the mass, especially coating the amygdules and sometimes filling them.

No section.

*Age.* Manitou.

N. H. W.

NO. 634A. HEULANDITE, ETC.

Amygdules picked from No. 634. They consist of heulandite, agate, stilbite, calcite and thalite(?)  
*Ref.* Annual Report, x, pages 63, 64; Annual Report, xi, pages 171, 181.

*Meg.* These vary in size from that of a mustard seed to masses two or three inches across. They are usually coated with red.

*Heulandite*, which, though resembling stilbite, is distinguished from it readily by the interference figure, which is that of a bisectrix, which its cleavage plates afford in convergent light, is the most abundant of these amygdaloidal minerals. Its cleavages give a bright, even silvery, lustre, and they are so small sometimes that they can only be discerned with a magnifier. This mineral fills some large openings in the rock. It also becomes granular and then is reddened by ferric oxide, and in this condition it gives color to large surfaces, lining veins, coating the globular bodies that are detached from the rock and at the same time coloring more or less the molds from which they are loosened.

*Stilbite* is in large masses and also becomes red, passing through a light flesh-red tint. It also becomes confusedly lamello-fibrous, and fibrous with radiated structure, when it presents the characters of *pufferite*, and in this form it also coats the outer surfaces of the detached amygdules, except that the fibrous structure is then not so perfect, passing, probably in association with more or less of heulandite, to finely granular. A thin section cut so as to cross both the lamellar and the reddened and fibrous portions indicates that the whole is still in more or less distinct lamellæ, which always show a negative elongation, but lose their optic characters in places in consequence of the prevalence of much *hematite*.

The stilbite is in large masses. Sometimes its undulating cleavage surfaces give a colored iridescence, which is doubtless owing to the action of the highest double refraction, which takes place perpendicular to the cleavages. This phenomenon is not observed in heulandite.

The siliceous secretions are in the forms of banded agate and coatings. A banded, agate-like layer frequently was the first deposit on the walls of the cavities, particularly the larger ones. Next within this is frequently stilbite, but between the banded siliceous layer and the stilbite is also frequently a band of massive or granular quartz. The globular agates are finely and exquisitely striped.

In a thin section, which is mainly red, a greenish thalite(?) is permeated and pierced by slender spicules of red hematite(?)

*Age.* Manitou.

Basalt. Amygdaloid. Granite.]

*Remark.* The association of these trap sheets with amygdaloidal conglomerates and fine crumbling clastic material, which is wholly wanting, so far as known, from the Animikie, is the guide to their age.

Prof. J. A. Dodge made an analysis of this red mineral with the following result (Annual Report, xi, page 171):

		Oxygen.	Oxygen ratio.
Silica,	62.73	33.45	14.61
Alumina,	13.62	6.35	6.87
Oxide of iron,	1.75	.52	
Lime,	5.87	1.67	2.52
Magnesia,	.65	.26	
Soda,	1.83	.48	
Potash,	.68	.11	
Water,	12.25	10.89	4.71

The composition seems to bring this mineral under the species *mordenite*.

N. H. W.

NO. 635. BASALT.

Immediately underlies No. 634. Nos. 633, 634 and 635, together, have a thickness of only three or four feet, and are variously affected by proximity to the conglomerate. They seem to have constituted a single thin lava sheet. This rock also has stilbite of the fibrous kind above mentioned. Heulandite coats all seams and joints. *Ref.* Annual Report, ix, page 41; Annual Report, x, pages 63, 64.

*Meg.* The rock is dense and nearly black, though sparsely vesicular.

*Mic.* Resembles rock No. 632.

*Age.* Manitou.

*Remark.* There are here three beds of crumbling conglomerate separated by trap sheets which were surface flows, cotemporary with the accumulation of the conglomerate.

N. H. W.

NO. 635A. AMYGDALOID.

A part of No. 635.

*Ref.* Annual Report, x, page 63.

*Meg.* Coarsely amygdaloidal with all the minerals mentioned under No. 634A, the agates being conspicuous and producing a knobbed exterior surface.

No section.

*Age.* Manitou.

N. H. W.

NO. 636. GRANITE. (*Pegmatitic.*)

Sec. 1, T. 56-7. Makes a high point with a perpendicular face toward the south. It occupies but a small area at this place, but appears at a number of other places along this part of the shore, and on one or two islands. Compare Nos. 119, 134, 157, 526 and 643.

*Ref.* Annual Report, ix, page 40; Annual Report, x, pages 64, 66.

*Meg.* Light-red, very quartzose granite, with no apparent ferro-magnesian minerals, but with small inclusions of what appear to be portions of a basic porphyryte (xenoliths). The coarseness of the grain varies much.

*Mic.* The *quartz* and *feldspar* have a coarse micro-pegmatitic structure, each mutually surrounding areas of the other, the adjacent portions extinguishing in unison. The feldspar is much obscured by oxide of iron, but it can be observed that extinction is about parallel to the cleavages, indicating *orthoclase*.

There is also a small amount of accessory *epidote*, and apparently of *biotite*.

Two sections.

*Age.* Cabotian.

*Remark.* This rock might be called pegmatyte, except for the fact that is in a massive bulk instead of being in form of a vein. It was probably formed by solution rather than fusion. It may represent a transformed basic rock. N. H. W.

No. 637. LABRADORITE. (*Anorthosyte.*)

From a large detached mass, one of several at the west point of Beaver bay (see No. 120).

*Ref.* Annual Report, ix, page 32; Annual Report, x, pages 64, 140; Bulletin vi, plate XV; Final Report, vol. i, pages 196-199; American Association for the Advancement of Science, vol. xxx, page 163.)

*Meg.* Gray, coarse, fresh, glittering with cleavage surfaces, one of which is an inch in length. Consists apparently wholly of feldspar.

*Mic.* The section shows nothing but *labradorite* feldspar, except as accessories, along a fissure, some ferruginous accumulations and *calcite*.

It is hardly necessary to repeat observations on this feldspar. The plate at hand is large and presents a beautiful section of this beautiful rock. However, in a slide, 010 gives extinctions in three different crystals, respectively 20°, 24° and 31°. There are no good sections,  $n_v$  or  $n_e$ , but in one instance an oblique section on  $n_e$  gives extinction at 54°, and one on  $n_v$ , at 55° 30', both indicating *anorthite*. Still, the preponderance of evidence is in favor of a labradorite, as before.

Three sections.

*Age.* Cabotian.

N. H. W.

No. 637A. THOMSONYTE AND MESOTYPE.

From seams in No. 637. This mineral comes off the joint surfaces of the rock No. 637 as a scale about a quarter of an inch thick, but sometimes half an inch.

*Ref.* Annual Report, x, page 64; Annual Report, xi, pages 172, 181.

*Meg.* Light flesh-colored or white, finely fibrous divergently, with numerous points from which the fibres radiate, situated in the walls of the fissure. Thus the growths from opposite sides of the fissure meet along the centre of the seam. Scattered calcite crystals were formed on the walls of the fissure before the zeolite was deposited, and these were then buried under the zeolite. On weathering out they leave their hexagonal impress as molds in the compact and hard zeolite.

*Mic.* This mineral is both positive and negative in elongation, and has rather high double refraction and parallel extinction. It is plainly quite pure. A micro-chemical test showed lime and soda. The zeolite may therefore be pronounced thomsonite, which is a prevalent mineral in situations where labradorite alone seems to have contributed to its formation.

There is another section, numbered "637A, across the vein," which appears different, and it is probable that one or the other is misnumbered. This mineral

Diabase.]

has  $n_g$  parallel with the fibres, and hence always positive elongation and parallel extinction, with quadrangular basal sections in which  $n_p$  runs to the angle, as seen in figure 31, between the sides, as in *mesotype*. (See Dana's System of Mineralogy, figure 1, page 600.) A micro-chemical test of this gives only soda. Prof. Lacroix, in connection with this determination considers this specimen illustrates the same structure as figured by him in *Minéralogie de France et de ses Colonies*, figure 7, page 265. It is possible both slides are from this vein, but it is not probable. This is the first identification of mesotype in Minnesota.

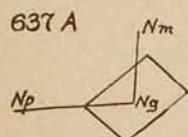


FIG. 31. BASAL SECTION OF MESO-TYPE.

Analysis by Prof. J. A. Dodge resulted as follows:

		Oxygen.	Ratio.
Silica,	47.25	25.19	6.47
Alumina,	24.78	11.54	11.68
Oxide of iron,	.48	.14	
Lime,	1.23	.35	4.52
Magnesia,	.71	.28	
Soda,	15.05	3.19	
Potash,	traces		
Water,	10.37	9.22	2.37
	99.87		

N. H. W.

NO. 638. DIABASE.

Rock at the base of Encampment island, on the north side. Compare No. 106.

Ref. Wadsworth, Bulletin ii, page 110; Annual Report, ix, page 28; Annual Report, x, page 64.

*Meg.* A dark, heavy diabase, rather coarse.

*Mic.* The ophitic structure is conspicuous, and green spots appear to have resulted from alteration of non-differentiated portions of the magma, as remarked by Wadsworth. The spherulitic polarization which appears in some places in this slide is probably produced by a zeolitic mineral, such as *scolecite*. This radiated fibrous zeolite is surrounded by another, which is probably *thomsonite*, as its confused fibres are elongated, sometimes positive and sometimes negative, and its double refraction is near that of thomsonite.

One section.

*Age.* Cabotian.

N. H. W.

NO. 639. DIABASE (*with olivine*).

One mile east of the mouth of Silver creek. Forms a high bluff (see Nos. 105, 819.)

Ref. Wadsworth, Bulletin ii, page 104; Annual Report, ix, page 28; Annual Report, x, page 64.

*Meg.* Similar to the last.

*Mic.* *Augite* is ophitic with respect to the feldspars, and is fresh; also, in the same manner it surrounds the *olivines*, which are considerably altered to a yellowish green, sub-opaque, or sometimes brownish substance, which frequently goes by the name of serpentine. There is also a considerable amount of the same greenish alteration product which is referable to the original magma. This is ophitic in its relation

to the feldspars, and imperfectly so in respect to the augite, yet there are inclusions of it and other microlitic forms in the feldspars, which date probably from the last consolidation of the magma.

In general, this rock, and the last, are fresh, the minerals all being clear and fresh, except for the slight effects of the reactions resulting from the hot waters and gases that accompanied the intrusion and the congealation.

One section.

*Age.* Cabotian.

N. H. W.

NO. 640. BASALT.

At the water level under the hill formed by No. 639, about a mile east of Silver creek. Separated from No. 639 by a red amygdaloid (as seen at Two Harbors\*), eighteen or twenty feet thick.

*Ref.* Annual Report, x, page 64.

*Meg.* Dense, fine-grained, nearly black rock.

*Mic.* This rock resembles Nos. 632 and 635. In the section examined, with an abundant matrix of devitrified glass, which is brownish and charged with fine opaque matter (*magnetite?*), are many microliths of *feldspar*. These are the only identifiable original minerals. No augite nor olivine can be seen. In some areas, however, has been generated secondary *quartz*, which sometimes embraces poikilitically some of the rock matter adjacent. Quartz does not generally permeate the rock, but the undifferentiated magma serves throughout as a cement for the feldspars.

One section.

*Age.* Cabotian(?)

*Remark.* It seems likely that this basalt is a thin lava sheet cotemporary with those that alternate with amygdaloidal conglomerates, as noted, westward from Little Marais. (Compare Nos. 629-632; also No. 117.) Still, it may be distinct from them, and may prove to run below the Beaver Bay diabase, by reason of a fault.

N. H. W.

NO. 641. AMYGDALOID.

Mouth of Knife river at the lake shore.

*Ref.* Annual Report, ix, page 24; Annual Report, x, page 64.

*Meg.* Like No. 91. Grayish green, much amygdaloidal, with thalite.

*Mic.* The section examined is not much amygdaloidal, but exhibits the ophitic structure on a grand scale. The *augite* is considerably altered, but extinguishes sufficiently to show the size and orientation of the crystals, which embrace generally a large number of *feldspar* microliths, comparable to the illustration by Irving in plate IX, of his Monograph on the Copper-Bearing Rocks of Lake Superior. The similarity is still further seen in the existence in both rocks of a large amount of

\*Two Harbors, as here referred to, is not the town of Two Harbors, since established and grown into an important shipping point of iron ore, but a small double bay, known by this name in 1877 and 1878, just west of Splitrock river. The name is here preserved, as it has entered into the literature of the survey, while the locality of Two Harbors (since named) is designated Agate bay, as long known and as referred to in the survey reports.

Granite.]

devitrified glass. A dissimilarity exists in the absence from No. 641 of olivine. Irving's rock is, however, from near the same place, viz.: S. E.  $\frac{1}{4}$  sec. 9, T. 51-12 W., about four miles southwest from the mouth of Knife river.

One section.

Age. Cabotian.

N. H. W.

No. 642. GRANITE (*fine and red*).

"From about one mile north of the centre of T. 62-1 E. on Mayhew's trail;" perhaps in section 17, near the present Grand Marais and Rove Lake road.

Ref. Annual Report, x, pages 66, 67.

*Meg.* A very fine-grained sample of the red rock; reddish brown on a fresh fracture and brick-red on weathered surfaces. Small reddish feldspars mixed with a greenish and a black mineral and small amounts of quartz.

*Mic.* The section is composed of *feldspar*, *quartz*, *magnetite* and yellowish and greenish alteration products. The feldspar, as is usual in the red rocks, is clouded and reddened and frequently is developed in lath-shaped forms. It frequently shows a zonal structure which is indicated by the disposition of the reddened parts; some of the crystals have a red exterior, then a band of transparent substance and a centre of red. In one case such a crystal appeared to be entirely replaced by quartz, but this is not the case with all of them. The feldspar shows practically no polysynthetic twinning and appears to be orthoclase, although its species was not determined with certainty. The quartz is sometimes in small grains, but is more usually intergrown with the feldspar to form the micropegmatyte which is so characteristic of these red rocks. One side of the slide shows an area which perhaps represents part of a porphyritic feldspar now highly altered.

One section examined.

Age. Cabotian.

*Remarks.* The original nature of the rock is not certain, but, if the quartz is assumed to be largely original, the rock would best be called a very fine-grained red granite.

U. S. G.

No. 643. GRANITE (*with augite*).

Hill range in the north tier of sections in T. 62-1 E. Probably near the northwest corner of section 3 on the present Grand Marais and Rove Lake road.

Ref. Annual Report, x, pages 66, 67.

*Meg.* There are two small hand specimens of this rock. One is of a brick-red color and drusy texture; it is a medium-grained aggregate of reddish feldspar and quartz, the compact mass of feldspar making the quartz appear as almost porphyritic. There are a few feldspars, brighter red in color, which are sub-porphyritic. The other specimen is of the same general character but is of a flesh color. The quartz is not in such prominent grains and there are a few scattered grains of a black mineral (augite). The slides examined were made from this second specimen.

*Mic.* The section shows one of the usual medium-grained red rocks, the only uncommon feature being the presence of practically fresh, green augite. This occurs in small grains of irregular outlines. The feldspar is the usual clouded, but little reddened, variety and is very intimately and abundantly intergrown with quartz to form micropegmatyte.

Two sections.

*Age.* Cabotian.

U. S. G.

NO. 644. GABBRO. (*Altered.*)

From the top of the hill mentioned under No. 643. Probably from the top of Pine mountain in S. W.  $\frac{1}{4}$  sec 34, T. 63-1 E. This rock may be a dike protruding through No. 643.  
*Ref.* Annual Report, x, pages 66-68; Bulletin ii, pages 79, 80.

*Meg.* A rather coarse-grained granitoid rock, pale reddish-brown in color, composed of feldspar, a black mineral (augite) and small amounts of quartz.

*Mic.* The following is the description of this rock, written by M. E. Wadsworth:\*

"In the section the feldspars are seen to be much altered, showing aggregate polarization, while much of the area is taken up by the graphic arrangement of secondary quartz in a feldspathic groundmass. Considerable augite with some diallage was observed. The latter is largely altered to a greenish-brown fibrous product, which retains the extinction point of the remaining diallage. Part of the augite shows the common prismatic cleavage, but in other portions of the same crystal the fibrous alteration of the diallage is to be seen, thus supporting the views of those authors who hold that diallage is derived, in part at least, from the alteration of augite. Apatite and magnetite are common, and some biotite was observed.

"From this section and others observed, the writer has but little doubt that most, if not all, of Irving's augite syenytes are altered conditions of gabbro and diabase the same as this rock is. This view, Irving's language would indicate, he partially shared."†

Two poor sections examined.

*Age.* Cabotian.

U. S. G.

NO. 645. GRANITE. (*Red.*)

"'Red granite,' like No. 642, from this hill range, S. W.  $\frac{1}{4}$  sec. 35, T. 63-1 E., on a little creek."  
*Ref.* Annual Report, x, page 67.

*Meg.* A brownish-red rock of medium grain composed essentially of red feldspar and a black (magnetite) and a yellowish mineral.

*Mic.* The slide shows *feldspar*, *quartz*, *magnetite*, yellowish alteration products and a little greenish material. The feldspar is very highly clouded and reddened,

\* *Bulletin ii*, pp. 79, 80.

† *Copper-Bearing Rocks*, 1883, pp. 112-124.

Granite. Apotrachyte. Gabbro.]

and it is intergrown with the quartz to form the beautiful micropegmatyte so common in these red rocks.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 646. GRANITE. (*Red.*)

"Red granite, southeast corner T. 63-1 E."

*Ref.* Annual Report, x, page 67.

*Meg.* A rock quite similar to No. 645, only a little darker colored and of some finer grain.

*Mic.* Section composed of reddened *feldspar*, *quartz*, much yellowish alteration products and a little *magnetite*. There is much fine-grained micropegmatyte and many of the feldspars are almost completely saturated with quartz.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 647. APOTRACHYTE.

"Red rock, like Nos. 643 and 645, making hills in the northwest corner of T. 62-2 E. and the northeast corner of T. 62-1 E."

*Ref.* Annual Report, x, page 67.

*Meg.* This rock is very similar macroscopically to No. 645, but a little finer grained.

*Mic.* The texture of the rock is clearly porphyritic, the porphyritic crystals being of clouded and reddened feldspars, small in size and sometimes arranged in irregular clusters. The groundmass is also reddened, and consists of an intergrowth of *quartz* and *feldspar*, with some *magnetite* and yellowish alteration products. Under crossed nicols this groundmass breaks up into the irregular "patchy" areas, which are frequently seen in the devitrified groundmass of the acid rocks.\* The patches are composed of poikilitic quartz areas in which are crowded small, much altered feldspars.

*Age.* Cabotian.

*Remarks.* This rock is thought to have had an original glassy groundmass, which has now devitrified to the "patchy" aggregate of quartz and feldspar. Compare Nos. 68 and 129, and see figure 3 of plate I.

U. S. G.

NO. 648. GABBRO (*with quartz*).

Same locality as No. 647.

*Ref.* Annual Report, x, pages 67, 68; Bulletin ii, page 78.

*Meg.* A medium-grained, dark-gray, dioryte-like rock, made up of flesh-colored feldspar and much black material which appears to be both magnetite and augite.

\* Cf. F. BASCOM: *U. S. Geol. Survey, Bulletin cxxxvi*, plate XVII, figure b, 1896. R. D. IRVING: *U. S. Geol. Survey, Mon. v*, plate XIII, figures 13 and 14, 1883.

*Mic.* The section shows a rock of granitoid texture, somewhat altered. The minerals are *feldspar*, *quartz*, *augite*, *hornblende*, *biotite*, *apatite*, *magnetite*, *pyrite* and greenish and yellowish alteration products.

The feldspar is in places considerably altered to a fibrous mass appearing like sericite, and in other places is gray and almost opaque. Albite twinning is rather common and one of the fresher grains gives equal extinctions of  $26^\circ$  on both sides of the twinning line, which would indicate a feldspar at least as basic as acid labradorite with the composition  $Ab_1An_1$ . Another grain cut approximately perpendicular to  $a$  gives an extinction angle of  $64^\circ$ , and another approximately normal to  $c$  gives  $4^\circ$ ; the first of these angles would indicate a feldspar near *labradorite*, and the second a more acid one, but neither of these two measurements is entirely satisfactory, as neither section was cut exactly perpendicular to the bisectrix.

The augite is largely decomposed to a mass consisting of hornblende, biotite, magnetite and confused greenish and yellowish alteration products. The yellowish material is in part of the nature of a stain which has penetrated the cracks in the feldspar. A little unaltered augite is present.

Quartz is quite common, sometimes appearing in grains which might be original and sometimes among the alteration products of the augite and also intergrown with feldspar (micropegmatyte) and apparently replacing some of the more altered feldspars.

Magnetite is abundant, and associated with it is a little pyrite. Apatite needles are common.

Two small sections examined.

*Age.* Cabotian.

*Remarks.* This rock is now a quartz gabbro and is so designated. But it is not intended by this to affirm that the quartz, or part of it, is original, although such may be the case. On the other hand all of the quartz may be of secondary origin; some of it at least is of that nature.

U. S. G.

No. 649. PORPHYRYTE (*with augite?*).

"Sample of the rock seen in loose pieces along the trail going north between sec. 36, T. 63-1 E. and sec. 31, T. 63-2 E. A high hill runs along the east of the trail, the trail being west of the town line."

*Ref.* Annual Report, x, pages 68, 69; Bulletin ii, pages 78, 79.

*Meg.* A brownish-red rock, showing elongated grayish feldspars and irregular elongated dark masses (augite) in a reddish groundmass; but the distinction between the groundmass and the rest of the rock is not very sharply marked. It might be called sub-porphyrific in texture.

*Mic.* The section shows many elongated feldspars, which are in general highly altered (but are gray instead of reddened), and *augite* in a groundmass composed of

Melaphyre.]

rather fine-grained, opaque, reddened feldspar and some *quartz* with *magnetite*, *apatite* and the usual alteration products. The augite does not appear to be idiomorphic, although its alteration would more or less obscure any idiomorphic tendency which it might have had originally. The feldspar in places shows that it is older than the augite.

One section examined.

*Age.* Cabotian.

*Remarks.* This specimen, as well as others (Nos. 644 and 648) in this general vicinity (and for that matter many in northeastern Minnesota), can be explained by assuming that the basic gabbro magma absorbed from the surrounding rocks more or less acid material. In the specimen here described the porphyritic feldspars, which appear to be lime-soda feldspars, although from their altered condition this point was not determined with certainty, and the augite, *i. e.*, the more basic minerals, crystallized out first as porphyritic crystals, and the rest of the rock—the more acid part—solidified later under different conditions as acid feldspar and quartz.

In this connection it is of interest to note that it appears to be only the acid feldspar which alters to the opaque red material so common in the red rocks of the north shore of lake Superior, while the more basic feldspar does not alter in this manner.

U. S. G.

## NO. 650. MELAPHYRE.

"This is so abundant that it must be in place near, but cannot be seen." Evidently from approximately the same place as No. 649.

*Ref.* Annual Report, x, page 68; Bulletin ii, pages 101, 102.

*Meg.* A dark-gray rock, apparently granitoid in texture, composed of gray feldspar and much black material.

*Mic.* The following is the description of this rock written by M. E. Wadsworth:\*

"Is a dark grayish brown, somewhat porphyritic rock, whose section is composed of lath-shaped and tabular feldspars, with *augite*, *olivine*, *quartz* and *biotite*, lying in a brownish groundmass. The feldspar is both orthoclase and plagioclase, while part is secondary. The groundmass is now the replacement of a former basaltic groundmass, together with part of its porphyritically inclosed minerals. At the present time this groundmass is the same as that of many quartz-porphyrines, and is composed of a confused aggregation of quartz, feldspar, ferrite, magnetite, microliths, mica scales, etc. The section, in certain portions, with its larger secondary quartz, could well pass for a felsyte or quartz-porphyrine. The augite is brownish and shows a strong tendency to alter into pale yellowish grains and irregular crystals associated with feldspar and quartz. This is seen most commonly in the vicinity of magnetite masses. The pale yellowish grains and crystals show the general characters of

\*Bulletin ii, pp. 101, 102.

olivine, as well as the interference figures of orthorhombic crystals. They are also positive, with strong double refraction. They are therefore referred to olivine. However, their general appearance is slightly different in coloration, etc., from the common basaltic olivines, and this is naturally the case since one cannot suppose a mineral formed by secondary agencies to be identical with one formed primarily, even if chemically and mineralogically they are the same. This olivine appears to represent a case parallel to the secondary olivine of the St. Paul's rocks as described by the present writer.\*

"Another alteration product is shown in the formation of scales and masses of biotite, which partially replace the augites, which in most cases remain, forming an elongated central band. The augite, in the earlier stages of alteration, is filled with a brown dust and sometimes it is feebly pleochroic, the color varying from chiefly brown to yellow. Apatite microliths are common, not only in the secondary groundmass, but also transfixing the olivine crystals."

We fail to see why Dr. Wadsworth regarded the olivine as secondary. It has all the appearance of the original olivines of diabases or gabbros, and at times has a tendency to assume a crystal form. The large feldspars are usually of earlier date than the augite. They are evidently andesine-labradorite, showing equal extinction angles in sections perpendicular to 010 as high as 21°; moreover, a section cut almost exactly normal to the least axis of elasticity gave an extinction of 12°, and another closely normal to the greatest axis of elasticity gave 64°.

One section examined.

*Age.* Cabotian.

*Remarks.* Perhaps a mixture of a basic and an acid magma, the latter being represented by the groundmass of quartz and reddened feldspar. See remarks under No. 649.

U. S. G.

No. 651. GABBRO. (*Rich in magnetite, with olivine.*)

"From boulders, seen along the same trail, twenty to thirty rods north of the last (No. 650). This same rock forms a hill along the right of the trail."

*Ref.* Annual Report, x, pages 68-70; Bulletin ii, page 90.

*Meg.* A rather coarse-grained, dark-gray rock, evidently containing feldspar and much magnetite.

*Mic.* The section shows a rather coarse-grained granitic aggregate of *feldspar*, *magnetite*, *olivine* and *augite*. The feldspar and magnetite are the most abundant minerals, and the latter makes up fully one-third of the rock. The rock itself is not attracted by the magnet and it is probable that the magnetite, like most of this mineral in the Minnesota gabbros, contains a considerable amount of titanium. In addition to the usual albite twinning the pericline twinning is common in the

\**Science*, 1883, i, 590-592; *Lithological Studies*, 1884, pp. 123-125.

Gabbro. Apotrachyte.]

feldspar, which is probably near *labradorite* in composition. In one part of the section is a small area composed of smaller lath-shaped plagioclases and small, more or less rounded augite and magnetite grains.

One section examined.

Age. Cabotian.

U. S. G.

No. 652. GABBRO (*with hornblende*).

"From a point about one-fourth mile from the Brulé river and half a mile west of the town line." Evidently from near the centre of N.  $\frac{1}{2}$  sec. 36, T. 63-1 E.

Ref. Annual Report, x, pages 68-70; Bulletin ii, pages 102, 103.

*Meg.* A medium-grained, dark-gray, granitoid rock composed of gray feldspar and much black material.

*Mic.* The following is M. E. Wadsworth's description of this rock:\*

"A grayish-brown crystalline aggregation of *feldspar*, *augite* and *magnetite*. In the section the feldspar is partly altered and replaced by kaolinized material interstitially arranged with graphic quartz. Part of the feldspar is distinctly plagioclase, and part of the augite has been changed to brown hornblende and brown biotite. Apatite rods and microliths are to be seen associated with the graphic or eozoön quartz."

The main mass of the feldspar is plagioclase, and equal extinction angles in sections normal to 010 run up to  $33^\circ$ , indicating a feldspar as basic as *labradorite*. Another section was made. This shows the presence of some olivine which has considerably altered to a yellowish-brown substance—perhaps *bowlingite*.

Two sections.

Age. Cabotian.

U. S. G.

No. 653. APOTRACHYTE.

"From the Brulé, some west of the town line." Evidently from the S. E.  $\frac{1}{4}$  sec. 25, T. 63-1 E.

Ref. Annual Report, x, page 68.

*Meg.* A dark, brownish-red rock with small, porphyritic red feldspars, and a little of a yellowish material. The groundmass of the rock is very fine grained.

*Mic.* The section shows much reddened, almost opaque, porphyritic feldspars in a groundmass which is also reddened, consisting of *quartz*, *feldspar*, *hematite*, *magnetite* and a greenish alteration product. Under crossed nicols the groundmass breaks up into the irregular patches of poikilitic quartz which are so frequently found in the "red rocks" of northeastern Minnesota.

One section examined.

Age. Cabotian.

*Remark.* This rock is very similar to No. 647. See, also, figure 3 of plate I for the "patchy" groundmass.

U. S. G.

\* Bulletin ii, pp. 102, 103.

NO. 654. DIABASE. (*Fine grained.*)

"This sample is from a ridge rising about one hundred and seventy-five feet, crossed by the section line running east, S. E.  $\frac{1}{4}$  sec. 18, T. 63-2 E."

Ref. Annual Report, x, page 69.

*Meg.* A very fine-grained, dark, greenish-gray rock of uniform composition, except for a very few areas of sub-porphyrific feldspar.

*Mic.* The section is composed essentially of *feldspar* and *augite*. The former is in small lath-shaped individuals which are polysynthetically twinned; equal extinction angles in sections normal to 010 are as high as  $33^\circ$ , indicating *labradorite*. The *augite* is in small grains between and within the feldspar laths, and only rarely do larger grains, showing a tendency to the ophitic texture, appear. The slide also shows *magnetite* and a green alteration product which, perhaps in part, represents original olivine.

One section examined.

*Age.* Cabotian.

*Remark.* This rock, quite probably, is a dike rock cutting the earlier gabbro and red rock, but whether it is of Cabotian or Manitou age is uncertain. It resembles some of the Keweenawan dike rocks found on the lake Superior shore. U. S. G.

NO. 655. GRANITE. (*Red, fine grained.*)

N. E.  $\frac{1}{4}$  sec. 20, T. 63-2 E. Appears in a low ridge:

Ref. Annual Report, x, page 69.

*Meg.* A fine-grained reddish rock, somewhat mottled and of a porous texture. The cavities, which are irregular in outline, are more or less filled with quartz and a dull green earthy mineral (perhaps chlorite).

*Mic.* The section shows one of the usual fine-grained "red rocks" composed of *quartz*, reddened *feldspar*, *magnetite*, *hematite* and yellowish alteration products. Micropegmatite is common.

One section examined.

*Age.* Cabotian.

U. S. G..

## NO. 656. APOTRACHYTE.

A short distance east of No. 655.

Ref. Annual Report, x, page 69.

*Meg.* A fine-grained reddish rock of porous texture. Many small light-gray porphyritic feldspars are present. Macroscopically this rock is quite similar to No. 655, but lacks the quartz.

*Mic.* A few small, much altered, porphyritic feldspars are seen in a fine-grained groundmass composed of a confused aggregate of *quartz*, reddened *feldspar*, *magnetite* and *hematite*. In the section there are a number of sharply outlined cavities.

One section examined.

*Age.* Cabotian.

U. S. G.

Andesyte. Apotrachyte.]

NO. 657. ANDESYTE (*with quartz*).

South line of sec. 16, T. 63-2 E., just east of a creek.  
*Ref.* Annual Report, x, pages 69, 70.

*Meg.* A fine-grained, dark-brown rock, reddish brown on weathered surfaces, containing a few small scattered porphyritic plagioclases.

*Mic.* The section consists of a few much altered porphyritic feldspars in a groundmass composed of a more or less confused aggregate of *feldspar*, *quartz*, *epidote*, *magnetite*, *hematite*, indistinct green alteration products, and a few *apatite* needles. Two of the porphyritic crystals are not particularly reddened, but are partly altered to a gray cloudy material and to epidote; these two feldspars are evidently plagioclases, but the species could not be determined.

The feldspar of the groundmass occurs in the form of small more or less lath-shaped crystals and in grains of irregular outline; these two forms, however, are not sharply separated from each other. In reflected light, the lath-shaped feldspars in general are seen to have altered to a gray cloudy material, while the rest of the feldspar is somewhat reddened. These laths are quite commonly polysynthetically twinned, and extinction angles in sections approximately normal to 010 do not indicate a plagioclase more basic than *andesine*. Much of the other feldspar shows no polysynthetic twinning and is perhaps orthoclase, but owing to the alteration of both forms of the feldspar, and also to the small size of the grains, satisfactory determinations of the species cannot be made.

The green alteration product and the epidote of the groundmass gave no certain evidence as to the original material now represented by them, but it seems probable that this was a mineral (either augite or hornblende) rather than a glassy residue. The green alteration product is one of the chlorites, and from its double refraction is thought to be most probably *clinochlore*.

One section examined.

*Age.* Cabotian or Manitou.

*Remark.* In this, as in many of the altered post-Animikie rocks of the north shore of lake Superior, it is quite probable that the quartz of the groundmass is secondary. If this be the case, the original rock was an andesyte. U. S. G.

NO. 658. APOTRACHYTE. (*Spherulitic.*)

Near, probably a short distance east of, No. 657.  
*Ref.* Annual Report, x, pages 69, 70.

*Meg.* A fine-grained rock, porous in texture and of a reddish-gray color. A few small red porphyritic feldspars occur. The groundmass is indistinctly mottled with small reddish and greenish-gray areas. This rock resembles macroscopically Nos. 655 and 656.

*Mic.* Porphyritic feldspars, much altered and reddened, probably *orthoclase*, are seen in a groundmass which consists of reddened feldspar, *quartz*, *hematite*, indistinct greenish-yellow alteration products, *chlorite*, *magnetite* and a small amount of *epidote*. The most noticeable feature of the groundmass is the presence of many spherulitic areas, which are usually more apparent in ordinary than in polarized light. The spheruliths have a distinct concentric, as well as the radiating, structure. The different zones are not clearly developed in each individual, but the most perfect ones show the following zones, beginning with the centre: (1) A nearly opaque mass showing an indistinct radiating structure. Under crossed nicols this structure disappears, and sometimes the mass breaks up into a fine mosaic, probably of quartz and feldspar. (2) A more transparent zone, without radiating structure, and showing under crossed nicols a very fine-grained mosaic of probably quartz and feldspar. (3) An opaque greenish-yellow band. (4) A more transparent zone, similar to the second zone just mentioned. (5) A broad zone, commonly the largest part of the spherulith, somewhat opaque and of a red color. The radiating structure is very pronounced, and under crossed nicols the less reddened spheruliths give in this zone the arms of a black cross. The fibres of this radiating zone show approximately parallel extinction and a negative elongation; they can thus be orthoclase elongated in the direction of the inclined axis (*a*).

It is quite frequently the case that the porphyritic feldspars are surrounded by spherulitic growths in which the central nearly opaque zone mentioned above is immediately in contact with the feldspars.

Aside from the spheruliths, which make up a large part of the rock, the groundmass consists of the minerals already mentioned. In places a fine mosaic of quartz and feldspar is evident, most likely a product of devitrification, and in other places larger quartz grains occur; these commonly show undulatory extinction and some of them exhibit a tendency to a radial structure. There are some altered areas of the groundmass which appear to have been originally biotite.

Two sections examined.

*Age.* Cabotian.

*Remark.* This is the first specimen known to us of the red rocks in Minnesota containing spheruliths. With such a large number of occurrences of acid surface rocks along and near the north shore of lake Superior, it is a little surprising that spherulitic structures have not been found. It is to be expected that future search will reveal such occurrences. (Compare Nos. 686 and 687.)

In rock No. 132A a spherulitic structure is described in red rock inclusions in a basic eruptive.

Porphyryte. Trachyte.]

NO. 659. PORPHYRYTE. (*Diabase.*)

"This rock appears to be in place, but can be seen only in the form of numerous loose pieces. It has the appearance of constituting the top portion of the ridge (No. 658). \* \* \* This ridge runs east and west nearly, on the north side of the trail, and rises about two hundred feet." This specimen is evidently from a trail on the south line of sec. 16, T. 63-2 E., and east of Nos. 657 and 658.

*Ref.* Annual Report, x, pages 69, 70.

*Meg.* The rock is markedly porphyritic, with numerous white feldspar crystals. The groundmass is of quite fine grain, dark gray in color, and consists of feldspar and a black material. Some of the feldspar, both the porphyritic and that in the groundmass, has a pinkish shade.

*Mic.* The section shows porphyritic *feldspars*, usually lacking in crystal outline, in a groundmass consisting of smaller lath-shaped feldspars, *augite*, *magnetite* and alteration products. Almost all the feldspars are highly altered, gray and almost opaque, sometimes showing *epidote*. The alteration products of the groundmass are a green material (mostly chlorite), quartz, apparently feldspar much reddened, magnetite and hematite. It seems probable that the alteration products of the groundmass represent in part something besides augite, but just what, it is impossible to say. Notwithstanding the highly altered nature of the rock there is still considerable augite remaining.

One section examined.

*Age.* Cabotian or Manitou.

U. S. G.

NO. 660. PORPHYRYTE. (*Diabase.*)

From the trail at the crossing of the line between ranges 2 and 3 east. Evidently at the extreme southeast corner of sec. 13, T. 63-2 E.

*Ref.* Annual Report, x, page 70.

*Meg.* Macroscopically this rock is very similar to No. 659.

*Mic.* This section resembles that of No. 659, except for the facts that the feldspars of the groundmass are not so markedly lath-shaped and that the augite has entirely disappeared.

One section examined.

*Age.* Cabotian or Manitou.

U. S. G.

## NO. 661. TRACHYTE (?)

"One mile east of the town line (S. E. corner of sec. 13, T. 63-3 E.) is a reddish crystalline rock in place, and this continues east two miles from the town line."

*Ref.* Annual Report, x, page 70.

*Meg.* A reddish-brown rock, consisting of numerous small, red, porphyritic and sub-porphyritic feldspars and a darker groundmass.

*Mic.* Porphyritic feldspars are seen in a groundmass of *feldspar*, *quartz*, yellowish and greenish alteration products (among which are *chlorite* and *epidote*),

*magnetite* and *hematite*. The rock has been considerably altered and the feldspars are much reddened, the porphyritic ones, however, less than those of the groundmass.

One section examined.

Age. Cabotian.

U. S. G.

NO. 662. ANDESYTE.

S. W.  $\frac{1}{4}$  sec. 14, T. 63-3 E.

Ref. Annual Report, x, page 70.

*Meg.* A very dark gray rock with an aphanitic groundmass and a few gray to reddish porphyritic plagioclases.

*Mic.* The porphyritic plagioclases are not very abundant and are considerably altered,—in part to *epidote* and *chlorite*; the species was not determined. The groundmass is composed of very minute, altered, elongated feldspars and a black, opaque material usually in small rounded or irregular grains. Much of this material is *magnetite*, some of it is *hematite* and part of it may represent an unindividualized base. In places this black material is collected in irregular areas, almost or entirely free from the minute feldspars, and this gives a blotched appearance to the section. A little epidote also occurs in the groundmass. One area of chlorite was seen surrounded by a rim of magnetite; this may represent an original ferro-magnesian porphyritic constituent such as hornblende.

One section examined.

Age. Cabotian or Manitou.

U. S. G.

NO. 663. PORPHYRYTE. (*Diabase.*)

"S. W.  $\frac{1}{4}$  sec. 19, T. 63-4 E., on McFarland's trail. Here is a short east and west ridge, rising about fifteen feet, in which the rock is the stellar porphyry seen in pebbles on the lake (Superior) shore. It is fine grained and brown, but is beautifully set with intersecting tabular crystals of flesh-colored feldspar."

Ref. Annual Report, x, page 70.

*Meg.* A rock composed of numerous gray to flesh-colored porphyritic feldspars and a very dark gray, almost aphanitic groundmass.

*Mic.* Considerably altered porphyritic plagioclases are seen in an altered groundmass composed largely of feldspars, many of which are lath-shaped in form. Besides the feldspar there are *magnetite*, *hematite*, *quartz* and green alteration products (mostly *chlorite*). There are also a few opaque grains, flesh-colored in reflected light, which are perhaps the alteration products of ilmenite. Some of the chlorite areas, by their relation to the lath-shaped feldspars, suggest altered ophitic augites. There are also some areas of chlorite which may represent altered olivines.

One section examined.

Age. Cabotian or Manitou.

U. S. G.

Diabase.]

NO. 664. DIABASE. (*Coarse.*)

"A little more than two miles from Horseshoe bay (north shore of lake Superior)." Evidently from McFarland's trail, and probably near the southwest corner of sec. 4, T. 62-4 E.

*Ref.* Annual Report, x, pages 70, 71, 140; American Association for the Advancement of Science, vol. xxx, page 163; Bulletin ii, pages 97, 98.

*Meg.* Hand specimen not found.

*Mic.* M. E. Wadsworth's description of this section is as follows:\*

"Has a section composed of brownish *augite* dissected by divergent *feldspars* and containing *magnetite* and some secondary products. As a rule the *augite* is a clear brown or yellowish brown, containing rows of *magnetite*, vapor cavities, and other inclusions arranged along fissures. It also shows in places the fine parallel cleavage of *diallage*. This is usually towards the edges or in altered portions of the crystal. Yet these points are of very minor importance compared with *augite* proper, which occupies about two-thirds of the section. The *feldspar* is *plagioclase* and in some places shows *kaolinization*. Both the *pyroxene* and the *feldspar* are traversed by numerous fissures which are bordered by yellowish and brownish ferruginous stainings. A serpentinous material forms brownish patches which may possibly be *pseudomorphs* after *olivine*, but it, with *apatite*, appears oftener to be formed by the alteration of the original interstitial base of rock.

"The section is traversed in one portion by a brownish and greenish vein of serpentinous material.

"The *magnetite* is either of foreign origin or was the earliest mineral to crystallize. This is followed by the *feldspar*, and lastly by the *augite*; the interstitial base being left an uncrystallized and easy altering material. In structure and character there is no reason this rock should not be called a *gabbro*, except that the *pyroxene* is essentially *augite*. The structure is decidedly *granitoid*."

The *plagioclase* shows abundant *twinnings*, and approximately equal *extinction* angles in sections cut nearly normal to 010 are as high as 31°. Two sections cut normal to a gave *extinction* angles of 61° and 60° respectively. The *feldspar* is thus clearly near to *labradorite* of the composition  $Ab_1 An_1$ .

There is chance for a difference of opinion in regard to whether that which is spoken of above as the interstitial base is really such; it seems possible that it is decomposed *augite*.

The texture of the rock is markedly *ophitic*, the *augite* occurring in the large plates which inclose the *feldspars*. The name *diabase* is therefore especially appropriate.

One section examined.

*Age.* Cabotian.

U. S. G.

\*Bulletin ii, pp. 97, 98.

NO. 665. DIABASE. (*Lustre-mottled.*)

From the hill back of Grand Marais and 800 feet above lake Superior. This specimen was taken on the old trail ("Iron trail") which ran from Grand Marais north and northwestward past South Devil Track lake. The locality of the specimen is not certain, but it probably was obtained from near the northwest corner of sec. 17, T. 61-1 E.

*Ref.* Annual Report, x, pages 65, 71.

*Meg.* A quite fine-grained rock of a dark-brown color. It shows clearly the lustre-mottled character due to augite plates of considerable size.

*Mic.* The most noticeable feature of the section is the presence of large plates of augite thickly studded with small lath-shaped *plagioclases*. The *augite* plates do not usually touch each other, and between them the feldspar is more abundantly developed and the lath-shaped individuals are not sharply separated from a background of more or less allotriomorphic *plagioclases*. Besides the augite and *plagioclase* there are considerable amounts of a black opaque substance which is largely *magnetite* and *hematite* and which may in part represent an unindividualized base and in part possibly olivine. This black substance occurs in areas of irregular shape in the spaces between the augite plates, and some of it represents decomposed augite. *Chlorite* and *apatite* are also present. From extinction angles in sections normal to 010 the feldspars appear to be as basic as *labradorite*.

One section examined.

*Age.* Cabotian or Manitou.

U. S. G.

## NO. 666. RHYOLYTE.

From the northeast side of South Devil Track lake; E.  $\frac{1}{2}$  sec. 31, T. 62-1 E. Many loose pieces of this rock occur here, but no rock is seen in place.

*Ref.* Annual Report, x, page 71.

*Meg.* A fine-grained, reddish-gray rock containing a few small porphyritic quartzes and feldspars.

*Mic.* The section shows rounded porphyritic *quartzes* in a fine-grained groundmass of quartz and the usual reddened *feldspar*, *magnetite* and *hematite*. It is possible that this groundmass is a product of devitrification, although we do not think that this is the case. In ordinary light many needle-like transparent areas are seen to penetrate the groundmass in all directions; they remind one somewhat of *apatite* needles, but in polarized light they are seen to be quartz which extinguishes in connection with the surrounding quartz areas.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 667. GRANITE (*with augite*).

Beach on south shore of Devil Track lake at the Iron trail; S. W.  $\frac{1}{4}$  sec. 30, T. 62-1 E. This rock is not in place, but from its abundance and its fresh angles it is evidently the country rock.

*Ref.* Annual Report, x, page 72.

Granite. Diabase.]

*Meg.* A dark reddish-brown, fine-grained, compact rock with a few small red porphyritic feldspars and sub-porphyritic areas of a dark mineral. The weathered surface is pitted by the more rapid decay of the dark mineral.

*Mic.* The section is composed of the usual reddened *feldspar*, *quartz*, *augite*, *magnetite*, *hematite*, *hornblende*, *chlorite* and confused greenish and yellowish alteration products. The quartz and feldspar are most frequently intergrown to form beautiful micropegmatyte, and commonly this takes a radiating structure around the feldspar grains. This is evidently a coarse form of the granophyric texture. This feature of the specimen is well represented in Mon. v, U. S. Geol. Survey, plate 14, figures 1 and 2.

The augite is in grains of considerable size and frequently shows a decidedly idiomorphic tendency. This mineral is of earlier date than the feldspar and quartz, some of the longer individuals extending through one or more feldspar grains in a manner similar to the diopside in rock No. 132A. The augite is almost colorless to green and usually shows no pleochroism. It has altered in places to an almost opaque yellowish material. A few small dark-green pleochroic grains appear to be hornblende, perhaps original, and there is also some secondary hornblende and chlorite.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 668. GRANITE (*with augite*).

"About one-third way across the portage from Owl lake to Little Pine lake." Probably a short distance north of the centre of sec. 1, T. 62-1 W.

*Ref.* Annual Report, x, pages 73, 74, 140; American Association for the Advancement of Science, vol. xxx, page 165.

*Meg.* A compact rock of red color, rather fine grained and granitoid texture. The minerals are red feldspar, sometimes sub-porphyritic, quartz and a dark greenish-yellow mineral. The weathered surface of the specimen is pitted, due to the weathering out of the last mineral.

*Mic.* The section shows one of the characteristic red rocks of rather coarse grain, *i. e.*, coarse for these rocks. The important point of difference between this section and most of the other red-rock sections is the presence of green augite, which is more or less altered.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 669. DIABASE. (*Lustre-mottled.*)

"Is from what appears to be a dike, about half way between Owl lake and Little Pine lake, though the exposure is not sufficient to show whether a dike or not." Probably in N. E.  $\frac{1}{4}$  N. W.  $\frac{1}{4}$  sec. 1, T. 62-1 W.

*Ref.* Annual Report, x, page 73.

*Meg.* A dark-gray rock of fine grain and showing lustre-mottling. It weathers to a much lighter gray.

*Mic.* The section shows small lath-shaped feldspars and large ophitic *augites*, also *magnetite* and the usual alteration products. Some of the altered areas may quite probably represent original olivines. The section resembles that of No. 665.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 670. DIABASE. (*Coarse.*)

"From one-fourth mile south of lake Abita, in the large hill over which the trail passes." N. E.  $\frac{1}{4}$  N. E.  $\frac{1}{4}$  sec. 28, T. 63-1 W.

*Ref.* Annual Report, x, page 74; Bulletin ii, pages 76, 95.

*Meg.* M. E. Wadsworth's description of this rock is as follows:\* "It is a rusty brown coarsely crystalline rock, discolored by surface weathering. Composed macroscopically, chiefly of brownish ferruginous stained feldspars and dark silicates traversed by hexagonal apatite needles."

*Mic.* "The section is composed of feldspar (*plagioclase* chiefly) pyroxene, secondary *hornblende*, and *magnetite*. Much *limonite* occurs, lining the fissures and staining the feldspars. The *pyroxene* is brownish and has the characteristic fractures and general characters of augite, but in portions of its mass the structure of *diallage* is clearly to be observed, as a secondary structure arising through the alteration of the augite."

One poor section examined.

*Age.* Cabotian.

U. S. G.

NO. 671. GRANITE (*with augite*).

From the hill near the south shore of lake Abita; S. E.  $\frac{1}{4}$  S. E.  $\frac{1}{4}$  sec. 21, T. 63-1 W. Not certainly in place.

*Ref.* Annual Report, x, page 74.

*Meg.* A reddish-gray rock of rather fine granitoid texture. The minerals are quartz, feldspar and a black mineral (augite).

*Mic.* One of the characteristic red rocks, but having some augite still remaining. This section is similar in general character to No. 668.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 672. GABBRO (*with hornblende*).

From the same locality as No. 671, but near the top of the hill.

*Ref.* Annual Report, x, page 74; Bulletin ii, page 78.

*Meg.* A coarse-grained gray rock, granitoid in texture and composed of flesh-colored and gray feldspar, magnetite and a black substance (mostly augite).

*Mic.* M. E. Wadsworth's description of this rock is as follows:† "The section is composed of partially altered *plagioclase*, *augite* partially changed to *diallage*,

\*Bulletin ii, p. 76.

†Bulletin ii, p. 78.

Granite.]

*magnetite*, and secondary *hornblende*. Considerable secondary eozoön or graphic quartz was observed in the feldspathic material, giving the rock there the structure of a graphic granite. Some pyrite occurs associated with the magnetite which, in places, is surrounded and penetrated by the pyrite. Considerable *apatite* was observed in the section."

One poor section examined.

Age. Cabotian.

U. S. G.

NO. 673. GRANITE. (*Red.*)

Top of Brulé mountain; N.  $\frac{1}{2}$  sec. 21, T. 63-1 W. This rock is not well seen *in situ*.  
Ref. Annual Report, x, pages 74, 75.

*Meg.* A brick-red, granitoid rock of medium grain, composed of red feldspar, a little quartz and considerable of a black mineral.

*Mic.* A few small porphyritic feldspars, much reddened, are seen in the fine-grained groundmass of the red rocks. Certain dark areas in the slide, which probably represent original augite, are filled with secondary products, among which magnetite is important. It seems quite probable that the slide of this number was not made from the specimen of similar number; the slide shows a finer-grained rock than the hand sample.

One section examined.

Age. Cabotian.

U. S. G.

NO. 674. GRANITE (*with augite*).

"A rather fine-grained deposit, with quartz, which occurs on the north face of Brulé mountain, forming a perpendicular wall about twenty feet high, but is only seen (so far as examined) a little east of but near the trail. It is 240 feet below the top of the mountain, and makes a more or less continuous jog or shoulder." Perhaps in S.  $\frac{1}{2}$  sec. 16, T. 63-1 W.

Ref. Annual Report, x, page 75.

*Meg.* A gray rock of medium grain, granitoid texture, and composed of gray to flesh-colored feldspar, augite and quartz.

*Mic.* The section is composed of *feldspar*, *augite*, *quartz*, *magnetite*, *hornblende*, *biotite*, *apatite* and brownish, yellowish and greenish alteration products.

The feldspar occurs in two ways: First, as nearly idiomorphic crystals which appear to be *oligoclase* and *orthoclase*; and second, intergrown with quartz to form micropegmatyte, which frequently surrounds the other feldspars. The low equal extinction angles in sections cut normal to 010, or nearly so, and the presence of two sections, each of which gives an extinction angle of  $2^\circ$ , cut practically normal to *c* indicate that the first form of feldspar is not more basic than *oligoclase* or *oligoclase-andesine*. The feldspar of the micropegmatyte is usually altered to an almost opaque cloudy mass, while the other feldspar is much less altered; none of it is reddened.

The augite is older than the feldspar and sometimes shows an idiomorphic form. It is usually light green in color, but some of it approaches to the clear cinnamon

color so common in the augites of the associated diabases and gabbros. A considerable part of the augite has altered and among the alteration products hornblende is common.

Quartz is common and occurs in well-defined grains and also in the micropegmatyte. Biotite is rare and is secondary. Apatite occurs in needles of considerable size. Areas of brownish semi-opaque alteration products are common; at times these show marked absorption and possibly are of the nature of *bowlingite*. Magnetite is abundant.

One section examined.

*Age.* Cabotian.

*Remark.* See under No. 675.

U. S. G.

NO. 675. GRANITE (*with hornblende*).

"In the northern face of Brulé mountain, 300 feet below the top, about south from the east end of the westerly lake in Brulé river. This reddish granitoid rock forms a perpendicular wall of sixty feet in height." Probably near the southwest corner of sec. 16, T. 63-1 W.

*Ref.* Annual Report, x, pages 75, 142; American Association for the Advancement of Science, vol. xxx, page 165; Bulletin ii, page 81.

*Meg.* A pinkish-gray rock of medium grain and granitoid texture, composed of pink feldspar, hornblende and quartz.

*Mic.* The section very closely resembles that of No. 674, except for two particulars: First, the augite is very largely altered and the hornblende is more abundant; and second, much of the feldspar, especially that of the micropegmatyte and the outer parts of the partly idiomorphic individuals, is reddened in a manner similar to the feldspar of most of the red rocks. Much of the larger feldspar individuals show polysynthetic albite twinning and low extinction angles in sections normal to 010, or nearly so. One section cut almost exactly normal to  $\alpha$ , gave an extinction angle of  $78^\circ$  and two others cut practically normal to  $\alpha$  gave angles of  $80^\circ$  and  $81^\circ$  respectively. The feldspar in part is thus clearly oligoclase, and no evidence of a more basic plagioclase was seen. One section examined.

*Age.* Cabotian.

*Remark.* This rock and the preceding (No. 674) are interesting from the fact that they represent facies of the red rocks which are coarser grained than usual and which appear to be approaching the gabbros. The latter appearance, however, is less evident on a study of the rock. Augite is present in large amounts; thus these specimens differ from the main mass of the red rocks, which, even in their freshest conditions, show a comparatively small amount of augite. There is no necessity for considering the quartz as largely secondary, and the feldspars are clearly alkaline acid species rather than the more basic lime feldspars of the gabbros. There thus seems to be no good reason for regarding these rocks as altered gabbros. U. S. G.

Gabbro.]

## No. 676. GABBRO.

"At a lower level another perpendicular wall of rock is found on the north side, a little west of the section line between sections 16 and 17 (T. 63-1 W.), rising about seventy-eight feet. This rock resembles No. 674, but the bluff cannot be said to consist entirely of this." Near the same place as No. 675.

Ref. Annual Report, x, pages 75, 76.

*Meg.* A somewhat crumbling, brownish-gray rock of medium grain, composed of feldspar and a black mineral (largely augite).

*Mic.* The section is composed essentially of *plagioclase*, *augite* and *magnetite*. The plagioclase is *labradorite*. Yellowish stains are common throughout the section and yellow and brownish alteration products are abundant. One large grain, considerably altered and stained, appears to be *olivine*, and some of the areas of brownish alteration products may also represent this mineral. In texture the rock is quite similar to the gabbros, although there is frequently a tendency to an idiomorphic development of the feldspar, and in general the augite is of later date than that mineral.

One section examined.

*Age.* Cabotian.

U. S. G.

No. 677. GABBRO. (*Fine, granulitic.*)

In a hill about 100 feet east of the trail from the western lake in Brulé river, and a little more than half way from this lake to Little Trout lake, and south of Little lake; near the centre of the N.  $\frac{1}{2}$  sec. 8, T. 63-1 W.

Ref. Annual Report, x, pages 76, 81.

*Meg.* A fine-grained, compact, dark-yellowish, gray rock appearing considerably like a quartzite.

*Mic.* The section contains feldspar, *augite*, *olivine* and *magnetite*, all in abundance, and *biotite* and *apatite* in small amounts. Under a low power the augite and olivine present rounded outlines, but on careful examination with a higher power the augite is seen to have less rounded outlines than the olivine, and frequently the former mineral forms with the feldspar a completely allotriomorphic aggregate. The feldspar was, however, in general the last mineral to crystallize. It uncommonly shows polysynthetic twinning and is allotriomorphic\* in form except for a very few individuals which have a tendency to a lath-shaped development. The species was not determined with certainty, although it seems to be near *labradorite*. Sections cut nearly normal to a bisectrix failed to show any cleavage or albite twinning, and sections cut normal to 010 and showing the albite twinning are scarce. Moreover, the thickness of the section, causing the different grains to overlap, renders a careful determination of the feldspars difficult.

The olivine is less abundant and in larger grains than the augite. The magnetite frequently shows crystal outline and a few of the larger grains are moulded on or inclose olivine grains. The biotite usually is seen surrounding

magnetite grains. The rock is very fresh, even the olivines showing very little alteration. It is illustrated by figure 3, plate II.

One section examined.

Age. Cabotian.

U. S. G.

NO. 678. DIABASE.

"This hill extends to Little lake, and along the southeast side, where the superposition of the strata can be made out in descending order, the highest stratum being of the 'red granite.' Thus (with a dip 10° S.W.):

"Red granite (not actually seen in place),	15 feet
"No. 678, in a regular bed of the thickness of	4 "
"No. 676 [679], porphyry with red feldspar	8 "
"No. 679A, porphyry with gray feldspar	18 "
"No. 680, fine-bedded, crumbling, seen	

"The foregoing does not include all the strata, some being invisible, both at the top and at the bottom."

The specimens are from the southeast side of Little lake, which is a small lake near the centre of the north line of sec. 8, T. 63-1 W.

Ref. Annual Report, x, pages 76-78, 96; Bulletin ii, page 114.

*Meg.* A dark greenish-gray rock of medium grain, composed of feldspar and a greenish, black substance.

*Mic.* The section shows an ordinary diabase. The feldspar is in lath-shaped forms clearly earlier than the *augite*, which is in irregular grains and in ophitic plates of rather small size for a rock of this grain. The feldspar is near *labradorite*. The rock has been considerably altered, the feldspar is in part kaolinized and the *augite* replaced by a green alteration product (fibrous hornblende and chlorite), although much fresh *augite* remains. *Magnetite* is abundant, and *apatite* and secondary quartz occur in small amount. It is possible that some of the green alteration product represents an original unindividualized base.

One section examined, which possibly may not have been made from this hand sample.

Age. Cabotian.

U. S. G.

NO. 679. PORPHYRYTE. (*Diabase.*)

Same locality as No. 678, which see.

Ref. Annual Report, x, page 76.

*Meg.* Numerous reddish to brownish porphyritic feldspars occur in a compact, very fine-grained, almost black groundmass.

*Mic.* The section consists of numerous crowded *feldspar* phenocrysts in a rather sparse groundmass. The phenocrysts are much altered and frequently somewhat brown in color; some of them still show polysynthetic twinning and in others the alteration has gone so far that twinning cannot be seen, even if present originally. The groundmass is a confused greenish aggregate largely made up of alteration products. Some small lath-shaped feldspars are present in the groundmass, also much *magnetite*. Most of the green material is *hornblende* and *chlorite*. It is impossible

Porphyryte. Tuff.]

to determine whether the groundmass was originally holocrystalline. Two small sections examined.

*Age.* Cabotian.

U. S. G.

No. 679A. PORPHYRYTE. (*Diabase.*)

Same locality as No. 678, which see.

*Ref.* Annual Report, x, page 76.

*Meg.* Numerous brownish-gray porphyritic feldspars occur in a compact, very fine-grained, almost black groundmass.

*Mic.* The section is closely similar to that of No. 679, but differs slightly in having fewer phenocrysts and in the fact that the lath-shaped feldspars of the groundmass are more numerous, more sharply defined and a little larger.

One section examined.

*Age.* Cabotian.

U. S. G.

No. 680. TUFF. (*Volcanic.*)

Same locality as No. 678, which see.

*Ref.* Annual Report, x, pages 76, 77.

*Meg.* There are two small hand samples with this number. One is a very fine-grained, compact, reddish-brown rock with a few small red and gray porphyritic feldspars; the rock is perhaps an andesyte. The other sample is of a brown color and is thickly spotted with minute white areas. There are also some red feldspar crystals. On closer examination the rock presents a fragmental aspect. The section was evidently made from this second sample.

*Mic.* The fragmental character of the section is evident at a glance. The fragments are of very irregular outlines and they vary in size from mere shreds to those about an eighth of an inch across. In color they vary from brownish semi-transparent ones to those which are opaque and black. All the fragments have the appearance of having been glass originally, but now are in part at least devitrified. Some of them have a vesicular texture, the vesicles being filled with the materials which make up the cement between the fragments. A few minute elongated feldspars are seen in some of the fragments, and in one these feldspars are arranged somewhat as in a flow. One fragment contains a twin crystal, evidently of a glassy feldspar cut nearly normal to an optic axis. A reddened feldspar is also among the fragments. The cement of the rock is colorless to brownish or greenish, and is composed largely of very fine-grained *quartz*, *chlorite*, a little *epidote* and probably *feldspar*.

It seems clear that this tuff is not an acid one, although its exact nature is not evident. It seems quite likely, however, from its general nature and from the character of the associated rocks that it is a rather basic andesyte tuff.

One section examined.

*Age.* Cabotian.

*Remark.* This adds another one to the few occurrences of volcanic tuff in the post-Animikie rocks of northeastern Minnesota. Other tuffs have been reported by the authors from Duluth,\* and Dr. A. H. Elftman has collected similar tuffs from the vicinity of Baptism river on the north shore of lake Superior. (See figure 4, plate II.)

U. S. G.

## NO. 681. ANDESYTE.

"The hill at the right of the portage from Little lake to Little Trout lake is made up of the numbers 681, 682 and 683 is [in] downward order, with the thickness stated below (dip 20° S. E.):

"No. 681 (seen twenty feet; may have more above). A very fine, black rock, approaching aphanitic slate.

"No. 682 (thirty-five feet). Porphyry, both with red and with gray feldspar crystals. This is a part of the great formation lying below the cupriferous, already mentioned, and is in beds of an inch, where weathered, or in heavy layers of five or six feet. The groundmass seems to be the rock No. 678. The red color seems to come from weathering, the original color being gray. This is shown in one of the small samples. It has free quartz.

"No. 683 (twenty feet; there is a talus below of fifty feet in which the rock is unknown). A fine-grained, heavy, dark rock, apparently consisting of triclinic feldspar and diallage, with a little uralite and magnetite.

"No. 684. Further north is a layer of four feet of a fine black rock, evidently crystalline, somewhat like Nos. 678 or 683, included between some of the beds of the foregoing porphyry, near the bottom of the same."

These rock samples are from near the centre of S.  $\frac{1}{2}$  sec. 5, T. 63-1 W.

*Ref.* Annual Report, x, pages 77, 78.

*Meg.* A very fine-grained, compact, brownish-gray rock, evidently breaking like a shale.

*Mic.* The section is quite fine grained and is more than half composed of a felted aggregate of somewhat reddened plagioclases, some of which assume a lath-shaped form. In addition to the plagioclase there are *magnetite*, *chlorite*, fibrous hornblende and a finely granular strongly doubly refracting mineral, which appears to be *epidote*. It is possible that some of the latter substance is augite in small grains. It seems quite probable that the rock was originally holocrystalline.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 682. PORPHYRYTE. (*Diabase.*)

Same locality as No. 681.

*Ref.* Annual Report, x, pages 77, 78.

*Meg.* There are two hand samples of this number. One is a dark brown, rather fine-grained rock, with numerous porphyritic gray plagioclases, the largest of which is about an inch in length. On one side of the sample closely welded to it is a small amount of dense black aphanitic rock, looking like the rapidly cooled edge of a diabase dike or flow. The other sample is similar to the first, except that most of the feldspar, both of the phenocrysts and of the groundmass, is brownish red in color, making the sample appear much redder than the first.

*Mic.* Sections from the darker hand sample show porphyritic plagioclases (near *labradorite*) embedded in a considerably altered groundmass, which consists of more or less reddened *feldspar*, *augite*, *magnetite*, *chlorite*, *quartz*, *apatite* and confused alter-

\**American Geologist*, vol. xviii, pp. 211-213, October, 1896.

Diabase.]

ation products. The feldspar is in part at least plagioclase, although the alteration has in most places gone so far as to obscure its original nature. The feldspar frequently has a tendency to an idiomorphic form and the augite has an ophitic relation to it. The augite is largely altered to a confused gray mass containing much magnetite. The quartz is most probably secondary.

One section shows on one side a narrow band, about one-sixteenth of an inch in width, of a black opaque substance. In it are a few minute, elongated feldspars and some small transparent areas which are now filled mostly with chlorite. This black band undoubtedly represents part of the dense black rock which is attached to one side of the darker hand sample. This dense black rock is evidently later than the diabase porphyryte to which it is attached, and the narrow band in this slide is a small mass of the latter rock, which was chilled very rapidly and solidified at the contact practically as a glass, filling a crack in the other.

A section of the red hand sample is similar to that just described. The feldspar, both of the phenocrysts and of the groundmass, is much reddened and the whole rock is more highly altered than the first mentioned sample. No fresh augite is present, and epidote is common. There is in the slide one apparently pseudo-amygdaloidal area filled largely with epidote and a clear, transparent, isotropic substance whose exact nature was not determined.

Three sections examined.

Age. Cabotian.

U. S. G.

No. 683. DIABASE (*with olivine*).

Same locality as No. 681.

Ref. Annual Report, x, page 77; Bulletin ii, page 107.

Meg. A medium-grained, very dark-gray diabase.

Mic. M. E. Wadsworth's description of this rock is as follows:\*

"A gray crystalline rock containing lath-shaped *plagioclase* crystals and in the section it is seen to be composed of lath-shaped plagioclases with a few tabular feldspars forming diverging angles with each other and cutting the yellowish-brown *augite*, which approaches *diablage* in its cleavage. Some greenish altered olivine pseudomorphs of *serpentine*, carrying *magnetite*, occur, while the *augite* is in part replaced by *hornblende*, *chlorite*, and *viridite*, which alteration products occupy much of the mass of the section, whose structure otherwise is ophitic."

Among the alteration products is fibrous *hornblende*; a little *biotite* also occurs.

One section examined.

Age. Cabotian.

U. S. G.

\*Bulletin ii, p. 107.

NO. 684. DIABASE. (*Altered.*)

Same locality as No. 681, which see.

*Ref.* Annual Report, x, pages 76, 77, 84, 96.

*Meg.* A fine-grained very dark-gray diabase.

*Mic.* The section shows numerous lath-shaped *labradorites* in a groundmass which is now completely altered to a confused greenish-gray mass in which magnetite is abundant.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 685. APOTRACHYTE (*with augite.*)

Near the south line of sec. 32, T. 64-1 W., on the portage from Little Trout lake to Misquah lake.

*Ref.* Annual Report, x, pages 75, 77, 78.

*Meg.* A compact, very fine-grained, reddish-brown rock, containing porphyritic crystals of red feldspar and smaller black porphyritic crystals apparently of augite.

*Mic.* The groundmass of the section is composed of a very fine-grained aggregate of quartz and reddened *feldspar*, and in places the quartz is in larger areas, so that under crossed nicols there is an approach to the "patchy" areas so frequently seen in the devitrified groundmass of acid rocks. The groundmass of this specimen may be regarded as a product of devitrification. *Magnetite* is common. Some clouded and reddened porphyritic feldspars occur, and some of these appear to be near oligoclase. A few small porphyritic grains of dark green *augite* are seen, and there are also much smaller green areas in the groundmass; some of these are now *chlorite* and others seem to be somewhat altered augites.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 686. GRANOPHYRE. (*Keratophyre?*)

From the east side of Misquah lake; sec. 32, T. 64-1 W.

*Ref.* Annual Report, x, page 78.

*Meg.* This rock is medium grained, brick red, basaltified and massive, forming mountain-like hills several hundred feet in height. The main structure dips at a high angle toward the east.

*Mic.* The reddened substance has an incipiently radiated arrangement, appearing like spheruliths, the centres of which are less reddened, but this structure only appertains to the coloring matter, since each of the spheruliths has a feldspathic background, which extinguishes regularly over the whole radiated mass. There are other feldspars which are not thus reddened, and others in which the reddened (feldspathic?) substance is distributed in the manner of a micro-pegmatyte. Within such a crystal, whose idiomorphic outlines are distinct, are a great many minute

Apotrachyte.]

idiomorphic feldspathic remnants, whose orientations are the same, and the same as that of the large crystal in which they lie. Even their forms are distinct and parallel with those of the large enclosing crystal. The perimeter of the large crystal excluded the reddened substance, and forms a continuous feldspathic band about as wide as the enclosed remnants. It appears, therefore, that a porphyritic triclinic crystal has been almost wholly removed by the entrance of the reddened substance in the manner of a micro-pegmatyte (or more properly in the manner of a micro-perthite), the original crystal only remaining in the remnants. These remnants are frequently so grouped and shaped that they are plainly outlined by the cleavages of the original feldspar. Some of these feldspars are striated distinctly, and have a nearly parallel extinction, indicating oligoclase, and others do not show any striation.

Quartz is not abundant, indeed is rare, but is seen in a few isolated small grains. And there is still less of magnetite and of chlorite. The rock is essentially coarsely crystalline, but poorly differentiated, almost quartzless, one of the forms of the "red rock" of the state. Small grains that seem to be *augite* (or *diopside*), more or less chloritized, are grouped so as to appear to be originally parts of a larger crystal which pierces the reddened substance idiomorphically.

*Age.* Cabotian.

*Remark.* This rock appears to have been the result of a profound alteration of some earlier rock (perhaps a basic one) by the entrance of the reddened element and some quartz. If quartz had been more abundant in this invading element it is quite probable that much micro-graphic structure would have resulted, and if iron had been less abundant the reddened substance would have been some distinct secondary feldspar and would have constituted, with the remnants of the original feldspar, a micro-perthite. As a whole the rock is similar to the "intermediate rocks" of Bayley along the gabbro contact.

N. H. W.

NO. 687. APOTRACHYTE. (*Spherulitic.*)

Same locality as No. 686.

*Ref.* Annual Report, x, page 78.

*Meg.* A very fine-grained, reddish-brown rock, somewhat porous in texture and earthy in appearance.

*Mic.* A few highly altered porphyritic feldspars are seen in a reddish groundmass in which *magnetite* and *hematite* are abundant. The groundmass is considerably reddened and consists of numerous circular areas which have a more or less distinct radial structure. Typically each area is composed of (1) A central deeply reddened mass, (2) A zone of lighter color, and (3) A zone like the centre. The radiating structure passes through all three zones but is more marked in that of lighter color. This radiating structure is made by indistinct fibres with approximately parallel

extinction and a negative elongation. They are regarded as feldspar and may be orthoclase elongated in the direction of the inclined axis (*a*). In places there are areas between these spherulitic masses which are filled in with a reddened substance (feldspar), the *iron ores*, *quartz* in distinguishable grains, and *chlorite*.

Scattered all through the section are yellowish-green needle-like bodies which have little or no effect on polarized light. At times they assume a feather-like form. They are thought to represent original crystallites, possibly of augite.

Two sections examined.

*Age.* Cabotian.

*Remarks.* Compare Nos. 658 and 686.

U. S. G.

NO. 688. GABBRO.

Cross lake; from the outcrop first seen on the right when coming from the portage between Misquah and Cross lakes; N. W.  $\frac{1}{4}$  sec. 32, T. 64-1 W.

*Ref.* Annual Report, x, pages 78, 82; Bulletin ii, pages 88, 89.

*Meg.* A gray, rather coarse-grained rock consisting of grayish and pinkish feldspar, pyroxene and magnetite. On the weathered surface most of the feldspar is white.

*Mic.* M. E. Wadsworth's description of this section is as follows:\*

"Under the microscope this rock is seen to have its *diallage* much altered, principally to a uralitic product. The *plagioclase*, in places, exhibits its twinning only at the point of extinction, as was shown by the writer to be the case with the plagioclase of the Bishopville meteorite.†

"The feldspar is also much altered and the section in places shows the structure of graphic granite or the eozoön character occurring in the granites and felsites of Keweenaw point. In No. 688 this structure is evidently produced by the aggregation of the silica in the midst of the feldspar through the medium of the percolating waters, while the remaining feldspar itself is much changed and stained by ferruginous material. Much *apatite* occurs in the section."

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 689. GABBRO.

This rock makes the shore and islands of Cross lake. Probably from sec. 29, T. 64-1 W.

*Ref.* Annual Report, x, pages 78, 79; Bulletin ii, page 75.

*Meg.* A light-gray, rather coarse-grained rock composed of white and a little pinkish feldspar, augite and magnetite.

*Mic.* M. E. Wadsworth's description of this rock is as follows:‡

\*Bulletin ii, pp. 88, 89.

†American Journal of Science, 1883 (3), xxvi, 34; Lithological Studies, 1884, p. 200.

‡Bulletin ii, p. 75.

Diabase. Gabbro.]

"Is a gray crystalline rock with its *feldspar* turned chiefly to a gray or pink color. Under the microscope the feldspar is seen to be in lath-shaped crystals, with triangular interspaces containing *magnetite*, *viridite*, etc. The feldspar is much altered and filled with kaolin and micaceous scales; but in places it is clear, showing the polysynthetic twinning of plagioclase. Some secondary *quartz* and feldspar occur, and the pyroxenic constituent is replaced by *viridite*."

One section examined.

Age. Cabotian.

U. S. G.

NO. 690. DIABASE.

Near a small lake at the north end of the portage from Caribou lake. This small lake is called Little lake (or Straight lake) and lies in the N. W.  $\frac{1}{4}$  sec. 18 and S. W.  $\frac{1}{4}$  sec. 7, T. 64-1 W.  
Ref. Annual Report, x, page 79.

*Meg.* A fine-grained, very dark-gray, compact diabase.

*Mic.* The section is composed of lath-shaped *plagioclases*, *augite* in ophitic grains, *magnetite* and confused grayish, greenish and yellowish alteration products. Some of the secondary materials clearly were derived from the augite, and it seems most probable that the rock was originally a holocrystalline aggregate of the three minerals mentioned above.

One section examined.

Age. Cabotian.

U. S. G.

NO. 691. GABBRO (*with olivine*).

Same locality as No. 690. "This is a sample of the usual 'trap' of the country. It weathers light, and is in that way in marked contrast with the last, though that difference seems to be due solely to the greater proportionate amount of feldspar in this, and of augite in that. This occurs in patches on and in the last, and especially on the north side. It also seems to cross and cut it in vanishing veins."

Ref. Annual Report, x, page 79; Bulletin ii, pages 92, 93, plate XII, figure 2.

*Meg.* Hand specimen not found.

*Mic.* M. E. Wadsworth's description of this slide is as follows:\*

"The section is composed of *feldspar*, *diallage*, *magnetite* and *olivine*, and is similar to No. 692. The olivine is largely altered to a yellowish-green fibrous serpentine. This alteration has proceeded in a peculiar manner. In some of the olivine grains are bands of black and brown plates and needles, which for the most part are arranged parallel to the axis of the greatest elasticity, although a few are at right angles to it. The olivine also has two well-marked cleavages parallel to these directions, along which lines the serpentinous alteration extends. But as the alteration is the greatest at right angles to the line of greatest elasticity, the more highly altered olivines present an alternate series of parallel bands of *serpentine* and partially altered olivine. In some places the planes of greatest alteration coincide with the line of greatest elasticity, while in some of the entirely changed olivines the serpen-

\*Bulletin ii, pp. 92, 93, plate XII, figure 2.

tine is arranged in fine fibrous parallel bands occupying the entire surface. The diallage contains much magnetite dust and grains arranged mostly along the cleavage lines, as a product of alteration.

"Plate XII, figure 2, shows the structure of some of the less altered olivines."

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 692. GABBRO (*with hypersthene*).

Forms a series of low hills and bluffs along the south side of Little lake. The rock resembles that of No. 691; extends also round the shores of Poplar lake.

*Ref.* Annual Report, x, page 79; Bulletin ii, pages 59, 91, 92, plate II, figure 2.

*Meg.* Medium grained, with gabbro aspect.

*Mic.* The rock consists almost wholly of feldspar, *hypersthene* and *augite*, the last usually in the form of *diallage*.

The rock is fresh, and the relation of the *hypersthene* to the other minerals is interesting, as it forms large crystals which extend more than across the whole field of the microscope when a moderately low power is used (objective No. 3, of Nachet), embracing in a poikilitic manner several crystals of each of the other minerals. It was, therefore, the last mineral to be formed. The hypersthene is dichroic, having a faint green color when the crystallographic axis  $c$  is brought into approximate parallelism with the vertical spider line, and a brownish pink tint when perpendicular to it. As the outlines of the earlier-formed minerals are rounded, apparently by resorption, the forms of the hypersthene are irregular and serpentine, surrounding and entering the curvilinear angles, embayments and interspaces that remained to be occupied.

*Olivine* in small rounded grains is sparsely sprinkled in the diallage.

Three sections.

*Age.* Cabotian.

*Remark.* This rock is illustrated by Wadsworth, from one of the sections examined above (Bulletin ii, pages 91, 92, plate II, figure 2), but by him the included mineral was considered enstatite, and the including mineral diallage. A section of the hypersthene cut so as to present the axis  $n_g$ , showing the prismatic and pinacoidal cleavages, also shows, by the quick disappearance of the hyperbolas on rotation, and their tardy nature, that this orthorhombic pyroxene has the greater angle of the optic axes toward the basal pinacoid, a fact which distinguishes it from enstatite.

The diallage is fresh and original, not due to weathering nor decay, having its diallagic lamellation perpendicular to the optic plane, *i. e.*, parallel to 100. (Compare No. 300.)

It is hard to explain the remarkable freshness of this and other similar rocks, already noted, since they consist of some of the most easily destructible rock-forming

Forellenstein. Gabbro. Cumberlanddyte.]

minerals, such as are frequently seen much altered. It cannot be due to greater surface abrasion by the glacial epoch, exposing the fresher masses, since where such abrasion certainly occurred, these rocks [*i. e.*, the Keweenawan] are often seen to be still greatly altered. It is left to infer that by far the greatest amount of such alteration is not due to weathering, but to some cause in the original environment of the rocks themselves.

N. H. W.

NO. 693. FORELLENSTEIN.

West end of Poplar lake, at the portage to Duck lake; N. W.  $\frac{1}{4}$  S. E.  $\frac{1}{4}$  sec. 2, T. 64-2 W.  
*Ref.* Annual Report, x, pages 79, 80, 84; Bulletin ii, page 91.

*Meg.* A gray rock, rusty in appearance; is of granitoid texture and rather coarse grained; composed of plagioclase, magnetite and olivine.

*Mic.* The section is composed essentially of *plagioclase*, in small part kaolinized, *magnetite* in abundance, and *olivine*. The plagioclase, as well as the olivine, is considerably fissured and the fissures are frequently filled with a yellowish stain. On the peripheries of some of the magnetite grains are small *biotite* scales; and a very small amount of *augite* is present.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 694. GABBRO (*with olivine*).

South shore of Iron lake, a little east of the west line of sec. 33, T. 65-2 W.  
*Ref.* Annual Report, x, pages 80, 84; Bulletin ii, page 89.

*Meg.* A dark-gray granitoid rock, composed of gray feldspar and a large amount of black material which seems to be mostly magnetite.

*Mic.* M. E. Wadsworth's description of this rock is as follows:\*

"The section is composed of *plagioclase*, some possible *orthoclase*, *diallage*, *olivine* and *magnetite*. The latter is partially surrounded by well marked *biotite* borders, while it contains inclusions of the same. One of the olivines, which is apparently a unit in common light, its form and fracture lines indicating this, is seen in polarized light to be made up of four individuals. A little *biotite* occurs, but it is not attached to the magnetite."

One section.

*Age.* Cabotian.

U. S. G.

NO. 695. CUMBERLANDYTE.

North shore of Mayhew lake; E.  $\frac{1}{2}$  S. E.  $\frac{1}{4}$  sec. 36, T. 65-3 W.  
*Ref.* Annual Report, x, pages 48, 80, 81; Bulletin ii, page 109.†

*Meg.* The rock is a rather coarse-grained aggregate made up very largely of titaniferous magnetite. Numerous olivine grains can be seen, and also a few feldspars.

\*Bulletin ii, p. 89.

†The section described on page 109 of *Bulletin ii* was not made from the hand specimen of this number.

*Mic.* The section shows that the minerals other than the *magnetite* are more abundant than would be supposed by an examination of the hand specimen. This mineral acts as a sponge inclosing the others. Its outlines are not sharply angular, but are usually curved. The mineral next in abundance is *olivine*, which occurs in more or less rounded grains. It has altered some to a greenish-yellow *serpentine*, and at times there is a narrow, green, serpentine band where the olivine borders on the feldspar. The feldspar is apparently a basic plagioclase, although its species was not determined; it crystallized at a later date than the magnetite and olivine. One large grain of *augite* is seen, including rounded olivines. The augite contains numerous dark, plate-like inclusions.

*Biotite* is common in small flakes associated with magnetite, and it is almost exclusively confined to areas of magnetite bordered by plagioclase. The biotite sometimes, but not always, is arranged in plates radiating out from the magnetite. Some of the magnetite areas are bordered by a very narrow, continuous, brightly polarizing band which appears to be biotite.

Associated with the magnetite are a few small areas of an opaque mineral which has a metallic yellow color in reflected light. It is more yellow than ordinary pyrite, and is perhaps chalcopyrite. One section examined.

*Age.* Cabotian.

*Remarks.* This specimen represents the titaniferous magnetite of the great gabbro mass of northeastern Minnesota.

An analysis by Prof. J. A. Dodge is as follows:

SiO <sub>2</sub>	20.90
TiO <sub>2</sub>	2.23
Al <sub>2</sub> O <sub>3</sub>	1.75
Fe <sub>3</sub> O <sub>4</sub>	70.29
FeO	2.01
CaO	trace
MgO	2.63
P	none
	99.81
Metallic iron	52.46

In the above analysis the amount of FeO required to form FeO-TiO<sub>2</sub> is computed and the rest of the iron is given as Fe<sub>3</sub>O<sub>4</sub>.

The following rock samples are from this same locality (or near it) and they are all very similar to No. 695: Nos. 1288, 1291, 1292, 791W, 792W, 796W, 442H, 177G, 179G.

A determination of nickel in No. 177G, by Mr. F. F. Sharpless, gave .41 of one per cent.

U. S. G.

NO. 696. GABBRO.

Same locality as No. 695. Embraced as nodules in No. 695.

*Ref.* Annual Report, x, pages 81, 82; Bulletin ii, pages 69-71; Bulletin vi, page 135.

*Meg.* A light-gray rock of coarse grain, composed largely of gray to flesh-colored feldspar and some magnetite.

Gabbro.]

*Mic.* M. E. Wadsworth's description of this rock is as follows:\*

"Under the microscope it is seen to be composed principally of *plagioclase, diallage* and *titaniferous magnetite*. A little unstriated feldspar was observed. The diallage is of a brownish color and somewhat altered, in places passing into viridite. A very little *biotite* of secondary origin was seen in association with the diallage and magnetite. The feldspar is somewhat altered to the common grayish-white product of its change (kaolin?), but still retains its plagioclastic character, strongly marked by its broad polarization bands."

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 697. GABBRO (*with olivine*).

Same locality as No. 695. Embraced as nodules in No. 695.

*Ref.* Annual Report, x, page 81; Bulletin ii, page 96; Bulletin vi, page 136.

*Meg.* A dark-gray rock of medium grain, somewhat rusty in appearance. It is composed of feldspar and much black material, part of which is biotite.

*Mic.* M. E. Wadsworth's description of this rock is as follows:†

"The sections of this rock are composed of *olivine, diallage, feldspar, magnetite* and secondary *serpentine, hornblende, biotite, chlorite*, etc. In its general appearance it is closely allied to wherlyte and pieryte, but although its feldspar is subordinate to the other minerals yet it contains sufficient to carry it under gabbro. The olivine, in part, is clear, fissured, and traversed along the fissures by bordering serpentine or ferruginous staining. Other olivines are nearly or entirely replaced by the greenish serpentine. The diallage contains some of the black needle-like inclusions, etc., but for the most part it has been changed to a brown, felty, cleavable mass, or to chloritic and amphibole products. The feldspar in part is much altered. The biotite varies from a deep reddish-brown to a brownish-yellow color—colors to which its dichroism corresponds. The biotite is largely associated with the magnetite, often surrounding the grains of the latter."

The rock varies considerably as regards alteration. Some areas of the slides show all the original minerals in a comparatively fresh state, while in immediately adjoining areas these minerals (except the magnetite) have been completely altered. The feldspar is commonly twinned according to the albite law and its extinction angles show it to be near *labradorite*. The augite is of later date than the feldspar and olivine, and the latter mineral is later than at least some of the feldspar.

Among the secondary minerals in one of the slides are stout needle-like forms of an almost colorless mineral with a marked cleavage, high index of refraction and a strong double refraction. The extinction is parallel or nearly so and the optic

\*Bulletin ii, p. 70.

†Bulletin ii, p. 96.

plane is at right angles to the elongation and the cleavage. The mineral thus agrees with *epidote*, although colorless epidote with such a marked elongation has not been noticed in the other rocks of this region.

Two sections examined.

Age. Cabotian.

U. S. G.

No. 698. GABBRO. (*Granulitic.*)

Same locality as No. 695. "This is distributed through No. 695 in rounded lumps like some masses of No. 696. Some masses of No. 698 are very large, where they occur on the north side of the swamp."

Ref. Annual Report, x, page 81; Bulletin ii, pages 93, 94; Bulletin vi, page 136.

*Meg.* A fine-grained, granular, yellowish-gray rock, looking somewhat like a gray sandstone. It appears to be composed of feldspar and a dark mineral.

*Mic.* The section shows a fine-grained, almost completely granular, aggregate of plagioclase and pyroxene with some magnetite. Small flakes of biotite, usually in connection with the magnetite, are seen, and there are some indistinct greenish and yellowish alteration products. The pyroxene frequently shows somewhat rounded outlines and part of it is clearly earlier than the feldspar.

The feldspar is sometimes twinned according to the albite law, but is frequently untwinned. The twinned and untwinned grains appear to be of the same species. One section cut nearly normal to *a* gave an extinction angle of  $65^\circ$ , while another almost exactly normal to this axis gave  $60^\circ$ . In sections cut normal to 010 equal extinction angles as high as  $32^\circ$  occur. A cleavage fragment parallel to 010 gave an extinction angle of  $19^\circ$ . All these determinations point to a plagioclase near acid *labradorite*. The feldspar is commonly fresh, but shows a little alteration to *kaolinite*.

There appear to be two species of pyroxene present in the section, although their separation is not always certain. One is of a very light cinnamon color and closely resembles in habit and color the ordinary *augite* of the associated rocks. It frequently has the dark plate-like inclusions so common in *augite*. Very fine polysynthetic twinning is rather common, and a typical cross section was found showing the prismatic cleavages and the parting parallel to 100 and also parallel to 010. This section in converged polarized light gave an eye, and the optic plane was determined as normal to 100. This section showed fine polysynthetic twinning parallel to 100. The mineral is *augite* with the *diallagic* parting common to the *augite* of the gabbros.

The other pyroxene appears to be orthorhombic. It has a fine columnar structure (or twinning) parallel to the vertical axis, and some sections show a very slight pleochroism, changing from a very faint greenish to a weak tint of pinkish. This mineral is probably *enstatite*, or perhaps *hypersthene*. Some of its sections show bands crossing the columnar structure. These bands are sometimes of a

Gabbro.]

slightly different color from the rest of the mineral and also of somewhat higher index of refraction. They may represent bands of augite intergrown with the orthorhombic pyroxene.

One section examined.

*Age.* Cabotian.

*Remarks.* This specimen represents one variety of the rocks to which the name "muscovado" was applied in the Fifteenth and Sixteenth Annual Reports of this survey. This variety of "muscovado" is clearly a fine-grained gabbro. Rocks of similar nature are developed along the northern edge of the great gabbro mass and in general are of somewhat older date than the gabbro itself. (See description of the Akeley Lake plate, vol. iv.) Dr. Wadsworth regarded the present mineralogical composition and texture of this rock as secondary rather than primary,\* but we see no good reasons for considering the minerals and the texture of the rock as anything but original.

U. S. G.

NO. 699. GABBRO. (*Altered.*)

North shore of Mayhew lake, associated with the titanite magnetite of that locality.

*Ref.* Annual Report, x, pages 81, 82; Bulletin ii, page 93, plate III, figure 2; Bulletin vi, pages 136, 421.

*Meg.* Gray, coarse, with reflecting surfaces of magnetite and some mica.

*Mic.* The feldspar in a section 010, gives extinction on cleavage at  $32^\circ$ . It is somewhat shattered and alteration has begun cotemporary with the entrance of calcite, quartz and mica. Some of it appears to have been orthoclase.

*Pyroxene* is changed entirely and lost. In one section it is preserved in the form of *diallage*.

*Olivine* is converted into an isotropic but translucent substance, the seams in which are filled with *hematite*.

*Calcite* is rather abundant, forming a cement for the other minerals.

*Mica*, probably biotite, is visible, as occasional hexagonal crystals, and as minute scales distributed through the altered plagioclase. It is largely converted to

*Pennine*, which, in transmitted light, is light green. Between crossed nicols it is isotropic when parallel to the leaves, and blue when oblique or perpendicular to them. The fibres extinguish parallel with their elongation, and are always positive in elongation. This mineral is rather abundant. It presents the characteristic aureoles, and constitutes here the first instance yet discovered in which the polarization color is distinctly blue in a section whose thickness is less than .03 millimeter. This blue color, however, according to Michel Lévy (*Minéraux des Roches*, page 168), is not due to the polarization proper of the mineral, but to the fact that sub-microscopic lamellæ, crossing each other, imperfectly compensate themselves, reducing the resultant to a violet lilac, or gray of the first order.

\*Bulletin ii, p. 94.

*Zoisite* fibres and clusters are in a similar manner disseminated (though more frequently isolated) throughout the altered plagioclases. They are distinguishable from the biotite by their low birefringence and their usually less marked fibrillation. They appear grayish, or blue, in a normal thin section.

*Leucoxene* has resulted from the change of the ilmenite. It is strongly cleaved, its lamellæ being separated by films of hematite, which also is more or less disseminated through the whole mass of the mineral. By its increasing abundance, in the direction toward the original grain of ilmenite, the transparency of the leucoxene is lost by degrees, and it apparently blends with the original ilmenite. The coarse cleavage visible is probably due to the original zoned structure of the ilmenite.

Two sections.

*Age.* Cabotian.

N. H. W.

NO. 700. GABBRO (*with olivine*).

Same locality as No. 695. The ore (No. 695) lies on this rock, which seems to have furnished the rounded masses of No. 698 inclosed in the ore.

*Ref.* Annual Report, x, pages 81, 83; Bulletin ii, page 93, plate III, figure 2; Bulletin vi, page 136.

*Meg.* A rather fine-grained, dark-gray, granular rock, composed of feldspar and a dark mineral or minerals.

*Mic.* M. E. Wadsworth's description of this rock is as follows:\*

"Is a compact, dark-grayish, crystalline rock, composed of *diallage*, *olivine* *feldspar* and *magnetite*. Considerable of the secondary *biotite* is found associated with the magnetite and diallage. This section has its minerals somewhat altered, the magnetite dust and grains being quite abundant in the diallage, while a chlorite-like vein traverses the section.

"Plate III, figure 2, shows the general structure of the rock with its brownish diallage, yellowish altered olivines, black magnetite, reddish-brown biotite in the diallage and bordering the magnetite, and colorless feldspar."

The olivine is frequently in somewhat rounded grains and is in general earlier than the augite (diallage) and feldspar. Some of the augite is later than some of the feldspar, which in places has a tendency to a lath-shaped development. The augite sometimes shows twin lamellæ parallel to 100. The feldspar is commonly twinned according to the albite law. Equal extinction angles in sections normal to 010 run up to 32°, and a cleavage chip parallel to 010 gives an extinction angle of 22°. The feldspar is therefore *labradorite*. One section examined.

*Age.* Cabotian.

U. S. G.

NO. 701. GABBRO.

Near the centre of S.  $\frac{1}{2}$  sec. 36, T. 65-2 W.; north shore of Mayhew lake.

*Ref.* Annual Report, x, pages 78, 82, 84; Bulletin ii, page 72.

\*Bulletin ii, p. 93.

Gabbro. Cumberlandyte.]

*Meg.* A medium-grained, gray, granitoid rock, composed of plagioclase, biotite, titaniferous magnetite and other black material. A small amount of a bright yellow mineral (probably chalcopyrite) is present.

*Mic.* M. E. Wadsworth's description of this rock is as follows:\*

"In the thin section the *pyroxene* appears to have been principally altered to a fine matted mass of *actinolite* fibres and to *biotite*; but the plagioclase has suffered less change than would naturally be supposed from the amount of alteration in the pyroxene. Considerable biotite of a secondary origin is to be seen fringing the magnetite grains. The usual needles and inclusions common in the feldspar of gabbros occur here in a manner that indicates that they are the result of the commencement of the plagioclastic alteration rather than original forms."

The rock is clearly a gabbro. The *hornblende*, *chlorite* and part of the magnetite and biotite are evidently secondary minerals from the original augite, none of which remains. The feldspar is near *labradorite*, as is shown by its extinction angles in sections normal to 010 and in cleavage fragments.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 702. GABBRO.

Same locality as No. 701. "No. 702 is embraced in pockets and lumps in No. 701. It is the same rock but with much coarser crystals and a larger percentage of diallage (see No. 688 and No. 1D)."

*Ref.* Annual Report, x, pages 78, 82, 84; Bulletin ii, pages 70, 71.

*Meg.* A coarse-grained granitoid rock, composed of whitish feldspar, magnetite and augite, the last mineral being in large masses and especially abundant.

*Mic.* This rock affords an illustration of very coarse *diallage* associated with *plagioclase* and *magnetite*, all in large grains, the first especially being in large masses. The diallage appears to have formed not much later than the feldspars, and has more or less curving outlines, yet embraces occasionally small portions of the plagioclase. *Brown* ("basaltic") *hornblende*, much resembling biotite, is closely associated with the magnetite about its borders. There is also a small amount of *biotite*, *common hornblende* and *chlorite*.

One section.

*Age.* Cabotian.

N. H. W.

NO. 703. CUMBERLANDYTE.

Iron ore, at the east end of Pewabic island, in Mayhew lake.

*Ref.* Annual Report, x, page 82; Bulletin ii, pages 89, 90, plate IV, figure 1.

*Meg.* Titanic iron ore, mingled largely with pyroxene.

*Mic.* The *feldspar* has extinction on  $n_g$  at  $22^\circ$  and on 010 at  $25^\circ$ . It is entirely surrounded sometimes by the *magnetite*, and is separated from it by a border of brown

\*Bulletin ii, p. 72.

hornblende. It is less abundant than the pyroxene. It is likely to be flecked by decay, the colored polarization indicating the formation of mica scales, amongst which *zoisite* is occasionally found.

The *pyroxene* is usually in the form of *diallage*. It is not separated usually from the magnetite by any rim of hornblende, but it has an abrupt and clear contact with it. Yet in one place in the section such a rim separates the diallage from the magnetite. The *magnetite*, judging from the lack of leucoxene, is but little titaniferous.

That which is here called *bowlingite* is the same that Wadsworth (Bulletin iii, Minnesota Geological Survey) stated is "a substance of unknown character." It was named by Hannay (Mineralogical Magazine, i, 154, 1877), and has been further elucidated by Lacroix in his last work (Minéralogie de France, vol. i, page 442, 1895). It is always a product of decay of olivine rich in iron. In the section examined there are left traces of the olivine in the rims surrounding the feldspars embraced in the magnetite, which are sometimes so intimately associated with this mineral that the transition from olivine to it is evident.

In several of the gabbros already described the fact that olivine forms a narrow rim surrounding the magnetite grains has been noted (see No. 512). Its partial replacement, in such position, by brown hornblende is also common. The general transition from olivine to bowlingite is the cause of the bowlingite rims about the feldspars in this rock, this transition being simply one of natural decay of the olivine.

In general, bowlingite takes a wide range in color. According to Lacroix it is dark brown, or reddish brown, with little or no visible cleavage or micro-structure, or it is lighter colored (yet still brown), but laminated as if by cleavage. Other forms are yellowish and greenish, passing even to nearly translucent, though yet greenish, either laminated (similar to pennine) or finely fibrous. It is frequently pleochroic, but not in all cases. Its double refraction is strong, giving colors in red and yellow even in sections less than .03 millimeter in thickness.

In the section examined this rim is light-yellow in natural light, rarely greenish, becoming translucent as it is replaced by unchanged olivine.

In one section (that examined by Wadsworth) is much *olivine*. This is sometimes in the form of large grains and sometimes as rims separating the magnetite from the feldspar, giving place occasionally to the rim of bowlingite.

Besides the bowlingite rim, Prof. Lacroix has kindly called attention to the characters of the brown rims, which are frequently taken for biotite. They have a uniform extinction embracing sometimes the whole border, or a part of a border of a single grain or even the borders of contiguous grains. They do not remain dark on rotation, as biotite would if lying flat in that manner, and parallel to the cleavage.

Gabbro. Noryte.]

They are sometimes cleaved in two directions, and extinction is parallel to one of these cleavages. Biréfringence is low—*i. e.*, too low for a mica. The maximum of pleochroism, which is extreme, is parallel to  $n_c$  and with the direction of extinction. A grain cut perpendicular (nearly) to an optic axis does not show a black cross in convergent light, but the figure of a biaxial mineral. These characters exclude it from the mica series, and especially from biotite.

There are occasional clusters of *biotite* scales, strongly pleochroic.

Two sections examined.

*Age.* Cabotian.

N. H. W.

## NO. 704. GABBRO.

Mayhew lake, south from the little island crossed by the east and west town line.  
*Ref.* Annual Report, x, page 82; Bulletin ii, page 89.

*Meg.* A heavy, rusty, magnetited gabbro.

*Mic.* The *feldspar* has extinction on 010 at  $28^\circ$ —indicating *labradorite*. It followed the olivine in crystallization.

The pyroxene is partly *diallage* and partly *augite*. Besides the characteristic inclusions arranged in lines, it embraces many others that are scattered helter-skelter, and which sometimes have orientation and polarization of their own.

*Bowlingite*(?) the green and yellowish decomposition product from the olivine, is also seen in this rock, but not so often as rims between the magnetite and the feldspar.

*Biotite*, *pennine*, *olivine*, *brown hornblende*, *magnetite*, make up the rest of this rock, the last in great amount, and the second only as isolated scales in the altered feldspar. The olivine is in large grains, frequently surrounding the magnetite.

Two sections examined.

*Age.* Cabotian.

N. H. W.

NO. 705. NORYTE. (*Muscovadyte*.)

"Appears like a metamorphic rock, bedded and dipping north about  $45^\circ$  at a point a little back (north) from the shore, a short distance west from Mayhew's location, which underlies the iron-bearing rock, and the iron ore, and has been styled changed quartzite." Near the north shore of Mayhew lake and probably near the west line of sec. 31, T. 65-2 W.

*Ref.* Annual Report, x, pages 82, 83; Bulletin ii, page 94.

*Meg.* A rather fine-grained, gray, granitoid rock, composed of feldspar, pyroxene and a little biotite.

*Mic.* M. E. Wadsworth's description of this section is as follows:\*

"Its thin section under the microscope shows an irregular aggregation of short crystals, with rounded or irregular outlines, as seen in Nos. 777 and 698, which marks many rocks whose present structure is due in part or whole to the recrystallization of its constituents under the influence of water action. The pyroxenic constituents,

\*Bulletin ii, p. 94.

which may be the remains of original crystals, are in short, irregular, ragged crystals and grains considerably altered and belonging to *enstatite*. The feldspar is in part *plagioclase* and in part *orthoclase*, while *magnetite*, in part secondary, and secondary *biotite* and *quartz* are quite common. The rock is metamorphic, but in all probability a metamorphosed eruptive instead of a sedimentary one."

The texture of the rock resembles that usually seen in granites in the fact that the constituent grains vary considerably in size, there being many minute ones. These are, however, not due to dynamic action after the crystallization of the rock. The associated gabbros almost always have the constituent grains of approximately uniform size throughout a given section. The feldspar is both untwinned and twinned according to the albite law. Extinction angles show that the mineral is in most part near *andesine* and *labradorite*. The untwinned grains appear to be of the same species as the twinned; an untwinned grain cut almost normal to *c*, gave an extinction angle of  $28^\circ$ , indicating rather basic *labradorite*. Feldspar more acid than *andesine* may be present, but it was not determined. The feldspar is in places altering to *kaolinite* and *chlorite*. A careful search failed to reveal any quartz, although it is possible that some of the smaller grains are of this mineral.

The pyroxene is clearly orthorhombic. The section is about .04 millimeter in thickness, and this mineral is noticeably, although not markedly, pleochroic, *a* being very pale yellowish, *b* pale reddish, and *c* pale greenish. From its pleochroism and its double refraction, which is considerably higher than the feldspar, it may perhaps be referred to *hypersthene* rather than to *enstatite*. It alters to a gray, finely fibrous, brightly polarizing aggregate.

Considerable *pyrite* is present in the slide. One section examined.

Age. Cabotian.

U. S. G.

NO. 706. GRANITE. (*Fine grained.*)

"Through the iron-rock at the location No. 705 run seams, three to six inches in thickness, of pinkish rock consisting of quartz, orthoclase and hornblende, in rather fine grains. These seams and veins are parallel with the basaltic jointage of the rock No. 705. Sometimes a pinkish shade of color runs into the trap, accompanied by quartz."

Ref. Annual Report, x, page 83; Bulletin ii, page 70.

*Meg.* A fine-grained, granitoid, light-gray rock, of a pinkish shade on weathered surfaces. The minerals are quartz, white feldspar and a small amount of black micaceous substance.

*Mic.* The section shows a granitoid aggregate of *quartz*, *feldspar* and a little *chlorite* which in places appears to be an alteration product of *biotite*. The feldspar is much clouded and altered and some of it is nearly opaque. It is probably largely *orthoclase*, but some grains which still show polysynthetic albite twinnings appear to be *oligoclase*. One section examined.

Age. Cabotian.

U. S. G.

Gabbro. Dioryte.]

*Remark.* "These pinkish beds and seams, which simulate planes of bedding, are probably due to near contact with the underlying formation and infusion from it." There are two rocks represented by this number, although doubtless from the same place and closely related; one is the above fine-grained granite, which may be a recomposed acid debris (or graywacke), and the other is a coarser phase of the "intermediate" or contact rocks, a basic irruptive permeated by acid elements, showing granophyric structure, though mainly still of basic character. (Compare, also, rock No. 707.)

N. H. W.

NO. 707. GABBRO. (*Altered.*)

"In some places in the trap, where one of these red seams (No. 706) passes through it, the hornblende, which accompanies the red rock, greatly preponderates, or is very coarse and sometimes is fibrous and radiating, coating the walls of the seam. In such places mica also can be seen, and also, mixed with the fibrous hornblende, occasionally a crystal of quartz."

*Ref.* Annual Report, x, page 83; Bulletin ii, page 87.

*Meg.* A medium-grained, granitoid rock of a dark greenish-gray color. The rock is composed of gray feldspar and considerable quantities of dark minerals, among which can be recognized biotite, magnetite and fibrous hornblende.

*Mic.* The section shows a gabbro which has been considerably altered. The minerals are *plagioclase*, *augite*, *magnetite*, *hornblende*, *chlorite*, *quartz*, *biotite*, *kaolinite* and *apatite*. The plagioclase, augite, apatite and part of the magnetite appear as original minerals, and the others as secondary. The augite shows the diallagic parting well developed and it has largely altered to fibrous hornblende and chlorite. The apatite is in grains of considerable size.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 708. DIORYTE (*with quartz*).

Portage between Mayhew and Loon lakes; near the centre of the S. W.  $\frac{1}{4}$  sec. 36, T. 65-3 W.

*Ref.* Annual Report, x, pages 83, 86; Bulletin ii, page 118.

*Meg.* A rather fine-grained rock, greenish-gray in color and composed of white to pinkish feldspar and considerable hornblende. Reflections can be obtained from areas of small size, thus giving a lustre-mottled appearance to the rock.

*Mic.* The section is composed mainly of *feldspar* and *hornblende*. The former mineral is rather weakly polarizing and is considerably altered, *kaolinite*, *muscovite* and *chlorite* being developed in it. It is mostly untwinned, but a few grains show albite twinning. The uniformly low extinction in the twinned sections, as well as in cleavage fragments, indicates that the feldspar is mainly *oligoclase* or *oligoclase-andesine*, although this determination is not as certain as might be desired. This mineral occurs in rather large irregular grains making up the background of the rock and including the other minerals in a somewhat poikilitic manner.

The hornblende is in large amount and is colorless to green, usually the latter. A few brownish grains also occur. The hornblende is quite frequently fibrous, is in irregular areas of various sizes and does not show crystal boundaries. It is clearly a secondary or metamorphic mineral.

The section also contains *magnetite*, *sphene* and numerous small prisms of *apatite*, which are most frequently short but occasionally are much elongated. These apatites penetrate indiscriminately both the feldspar and the hornblende. A little *quartz* is present.

One section examined.

*Age.* Cabotian.

*Remark.* This rock seems to be a metamorphosed one, but what its original nature was is uncertain. It might have been a gabbro or a diabase, and in this connection we wish to suggest the possibility that this rock represents one of the diabase sills, in the adjoining Animikie strata, which was somewhat altered and then metamorphosed by the gabbro contact. If this be true the diabase sills are of earlier date than the gabbro, a conclusion which has some facts in its favor. (See remarks under No. 709.)

U. S. G.

NO. 709. DIABASE. (*Altered.*)

From the top of the hill near the base of the long point on the south shore of Loon lake; probably from S. W.  $\frac{1}{4}$  N. W.  $\frac{1}{4}$  sec. 35, T. 65-3 W.

*Ref.* Annual Report, x, pages 83, 84, 86; Bulletin ii, page 118.

*Meg.* This rock in general is similar to No. 708. The minerals are white to brownish feldspar and hornblende.

*Mic.* The section is composed of feldspar, *green hornblende*, *chlorite*, *magnetite*, *biotite*, *quartz*, *augite* and *apatite*. The feldspar is partly kaolinized, but is usually fresh and shows abundant albite twin lamellæ, as well as some pericline twinning. Equal extinction angles in sections normal to 010 are as high as 27°, showing a feldspar as basic as *andesine*. The hornblende is often fibrous. This mineral, the chlorite, biotite, quartz and part of the magnetite, are regarded as secondary. Only a small amount of augite remains.

One small section examined.

*Age.* Cabotian.

*Remark.* This rock is undoubtedly from one of the diabase sills of the Animikie. The metamorphism of such an altered diabase as this might readily, so it seems, make a dioryte like No. 708.

U. S. G.

NO. 710. DIORYTE.

This rock underlies No. 709 in the same hill, is five to ten feet in thickness and is in beds six to ten inches thick.

*Ref.* Annual Report, x, page 84.

Graywacke.1

*Meg.* A fine-grained, compact black rock, appearing like a diabase.

*Mic.* The section shows *feldspar*, *green hornblende*, *magnetite*, *biotite*, *chlorite*, and possibly a few small grains of *quartz*. The feldspar is usually in elongated grains, and is, in large part at least, plagioclase apparently near *andesine*. The hornblende and magnetite are frequently in elongated grains, and sometimes there is an indistinct radial arrangement of these grains.

One section examined.

*Age.* Cabotian.

*Remark.* This rock represents the finer grained lower portion of the diabase sill, of which No. 709 represents the main part. It is impossible to tell whether No. 710 was originally holocrystalline, and thus whether the secondary minerals may represent original augite or original unindividualized matter.

U. S. G.

NO. 711. GRAYWACKE. (*Slate.*)

Nos. 711 and 712 make up the lower part of the hill in which Nos. 709 and 710 occur. There is 100 to 125 feet in thickness of Nos. 711 and 712; they are slaty, and dip towards the south at angles of 10° to 15°. About nine-tenths of this slaty rock is made up of No. 711.

*Ref.* Annual Report, x, page 84.

*Meg.* A very fine-grained graywacke slate, showing small glistening flakes of some mineral with a marked cleavage.

*Mic.* The section shows a fine-grained slate, composed of *quartz*, possibly some *feldspar*, *biotite*, *muscovite*, *chlorite*, *magnetite* and *pyrite*. The biotite is quite abundant. There are a few irregular shaped areas of some transparent mineral which is in much larger grains than the other constituents of this rock. This mineral is evidently the same as that mentioned so abundant in No. 712.

One section examined.

*Age.* Animikie.

U. S. G.

NO. 712. GRAYWACKE. (*Slate.*)

Same locality as No. 709. See under No. 711.

*Ref.* Annual Report, x, page 84.

*Meg.* A fine-grained, slaty rock, in general resembling No. 711.

*Mic.* The most noticeable feature of the section under a low power, or when examined with a hand lens, is the apparent sponge-like texture of the rock, there being lighter areas enclosed in a general background of darker color. The section shows a banding due to the abundance of the iron ores in certain lines. The dark background of the section consists of a very fine-grained aggregate of *quartz*, possibly some *feldspar*, *biotite* in abundance, *chlorite*, *muscovite*, *pyrite* in abundance, *magnetite* and *hematite*. These minerals, except the quartz, are also scattered through the lighter areas in the section, but not in large amount, the dark color of the background being due to the great abundance of biotite and the iron ores.

The lighter areas in the section are of irregular and not sharply defined outlines, and each area is not always of one grain. The mineral is somewhat cloudy, and not completely transparent; this appearance may be due entirely to the numbers of inclusions it contains. It has approximately the index of refraction and the double refraction of quartz. No cleavage is to be seen. The interference figures obtained were very indistinct. A few were seen which are of a uniaxial, or closely uniaxial mineral, and the character of the double refraction is negative. This mineral may be *cordierite*.

One section examined.

*Age.* Animikie.

U. S. G.

NO. 713. GABBRO (*with olivine*).

North shore of Tucker lake. This lake lies in secs. 2, 3 and 4, T. 64-3 W. This embraces also masses of rock like No. 702.

*Ref.* Annual Report, x, page 84; Bulletin ii, page 71, plate I, figure 2.

*Meg.* A coarse-grained gray rock, composed of feldspar, augite, magnetite, biotite, hornblende and olivine.

*Mic.* The section shows a considerably altered olivine gabbro. The original minerals are *plagioclase*, *augite*, *olivine* and *magnetite*. Contrary to the usual order of alteration, this section shows the plagioclase and the augite frequently very highly altered while the olivine is usually comparatively fresh. The plagioclase has changed largely to "saussurite" which in this case consists of *chlorite*, *zoisite* and colorless micaceous minerals. The zoisite commonly shows the blue interference color which is so frequently given by this mineral. The augite has in many places changed to a mass of green fibrous *hornblende*, *chlorite*, magnetite, *biotite* and a little *brown hornblende*.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 714. GABBRO (*with olivine*).

From the hill range south of Tucker lake, in the north part of sec. 10, T. 64-3 W.

*Ref.* Annual Report, x, page 84; Bulletin ii, page 93.

*Meg.* A medium-grained, granular, dark-gray rock, composed almost entirely of plagioclase and augite.

*Mic.* The section shows a gabbro of finer grain than the main mass of the gabbro of northeastern Minnesota. The minerals are *plagioclase*, *augite*, *magnetite*, a little *olivine*, a few small flakes of *biotite*, and alteration products.

One section examined.

*Age.* Cabotian.

U. S. G.

Gabbro. Diabase.]

NO. 715. GABBRO (*with enstatite and olivine*).

"From an island in Poplar lake, near the portage coming from Little lake. The usual rock about Poplar lake." Probably near the centre of the west side of sec. 7, T. 64-1 W.

Ref. Annual Report, x, page 85; Bulletin ii, page 91.

*Meg.* The rock is closely similar to No. 714, except that this specimen (No. 715) is a little coarser grained than the other.

*Mic.* M. E. Wadsworth's description of this rock is as follows:\*

"Is a grayish granular rock, composed of plagioclase, some *olivine* and *pyroxene*, part of which has the cleavage and optical characters of *enstatite* and part that of *diallage*."

No section found.

*Age.* Cabotian.

U. S. G.

NO. 716. DIABASE (*with orthoclase, quartz and hornblende*).

From the top of Stair portage, between Mud and Duncan's lakes; N. W.  $\frac{1}{4}$  sec. 27, T. 65-1 W.

Ref. Annual Report, x, page 85; Bulletin ii, pages 115, 117.

*Meg.* A medium-grained, greenish-gray rock, composed of white feldspar, hornblende and magnetite.

*Mic.* M. E. Wadsworth's description of this rock is as follows:†

"A greenish-gray crystalline rock, somewhat altered, macroscopically, while the section shows that it is microscopically a much altered specimen. Some of the *augite* is distinguishable, but most of it is nearly or entirely altered to *viridite* and *green hornblende*, part of which, however, is stained brown. The feldspar is also much changed to the common dirty white kaolin-like substance, while its clear spaces are replaced by secondary *quartz*, *orthoclase*, and *plagioclase*. Considerable *apatite*, *biotite* and magnetite occur."

The texture of the section is markedly diabasic, the *augite* having an ophitic relation to the feldspar.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 717. DIABASE (*with quartz and hornblende*).

North side of South lake opposite the east line of sec. 24, T. 65-2 W.

Ref. Annual Report, x, page 85; Bulletin ii, pages 114-116.

*Meg.* A very dark-gray rock, rather fine grained and composed largely of feldspar, *augite* and hornblende.

*Mic.* M. E. Wadsworth's description of this section is as follows:‡

"The section shows that the rock has been much altered. Part of the original *feldspar*, *augite* and *magnetite* remain intact, but much of the *augite* has been replaced

\*Bulletin ii, p. 91.

†Bulletin ii, p. 117.

‡Bulletin ii, pp. 114, 115.

by *brownish hornblende*, particularly along the borders and ends of the crystal. Some of this hornblende shows the well-marked prismatic amphibole cleavage. The feldspar and augite are also both altered to *viridite*, while secondary *quartz*, replacing the feldspar, is abundant. In this rock we have a diabase showing a stage approaching near to the formation of a quartz dioryte by alteration."

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 718. DIABASE (*with quartz.*)

"Fine trap-rock, south side of Gunflint river, a little east of the location of No. 305 last year. This runs obliquely down to the river, and under the water, in angular basaltic blocks like trap, presenting a face (back in the woods) toward the north much the same as the highest bluffs of the country." Probably from near the centre of the W.  $\frac{1}{2}$  sec. 16, T. 65-2 W.

*Ref.* Annual Report, x, pages 85, 86.

*Meg.* A very dark-gray, fine-grained, diabasic rock, holding a few small porphyritic feldspars.

*Mic.* The section is in general similar to that of No. 717, except that this rock (No. 718) is finer grained and the augite has almost entirely disappeared. Greenish and grayish alteration products, the latter largely in the feldspar, are common. There is one apparently pseudamygdaloidal area in which there are numerous small flakes of *chlorite* in a background of *calcite*, which mineral also appears to make up a large part of the grayish alteration products in the feldspar.

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 719. DIABASE (*with quartz.*)

From the eastern of the two points which enclose the little bay, on the south side of Gunflint lake, from which there is a portage to Loon lake. Near the centre of the western side of the S. W.  $\frac{1}{4}$  sec. 24, T. 65-3 W.

*Ref.* Annual Report, x, page 86; Bulletin ii, pages 115, 116.

*Meg.* A very dark-gray, almost black rock, of medium grain, composed of feldspar and much black material among which is *magnetite*, *augite* and *hornblende*.

*Mic.* M. E. Wadsworth's description of this section is as follows:\*

"The section is similar to that of the preceding (No. 717) but contains secondary *biotite* from the alteration of the augite. The secondary *quartz* is abundant, and, together with the other secondary minerals, is traversed by numerous *actinolite* and *apatite* needles."

One section examined.

*Age.* Cabotian.

U. S. G.

NO. 720. DIABASE (*with quartz.*)

From the western of the two points which enclose the little bay, on the south side of Gunflint lake, from which there is a portage to Loon lake; S. E.  $\frac{1}{4}$  S. E.  $\frac{1}{4}$  sec. 23, T. 65-3 W.

*Ref.* Annual Report, x, pages 86, 87.

\*Bulletin ii, p. 115.