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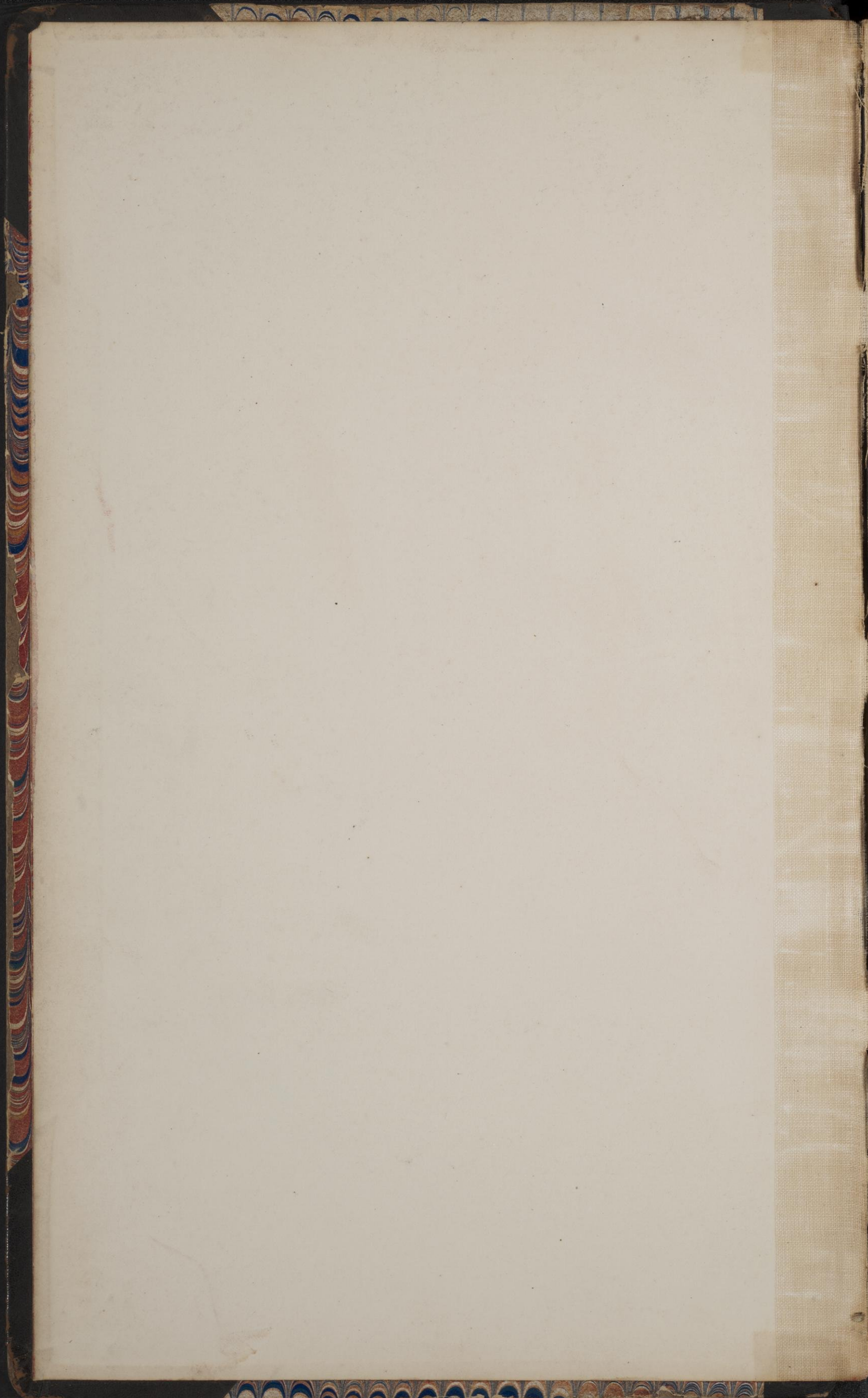
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U. S. Geological Survey,

Lithological Descriptions.

Book V.

The Huronian Mica Schists and Black Slates.

I.

The Penokee Gap Section.

Biotitic and Chloritic Greywacke.

C. R. Van Hise, January, 1886.

Macroscopic Description.

The rock has a fine grained uniform texture, and, while quite massive, breaks most readily along the obscure schistose planes. In color it is a light gray or pinkish gray. (Fiel. enlargement 15-55.)

Microscopic Description.

The section is chiefly composed of particles of feldspar and quartz, of greatly varying sizes and quite deeply interlocking. In fact at first sight the only indication of a clastic origin is the general roundish contour of the larger particles of quartz and feldspar. These grains are minutely and sharply angular upon their borders, but the general forms are oval or circular. Upon close examination many of the grains both of quartz and feldspar show indications of enlargements. The lines between the supposed nuclei and their enlargements are in no case so distinct as in the ferruginous fragmental quartzites, but consists of small detached particles of chlorite or kaolin, air bubbles and sometimes iron oxide. Oftentimes there are considerable breaks in the lines, and the whole line in any single grain might be taken to be ordinary inclusions in the quartz and feldspar. However, the constancy of the curved lines of inclusions near the exteriors of the large grains, in so many cases forming an imperfect oval, lead one to the conclusion that they mark the outlines of true clastic cores which have become enlarged and interlocking. These statements are as true of the fresher grains of feldspar as of the quartz and one grain of plagioclase seems to be the most unmistakably enlarged

9537

Sl. 3314

2039 Wis.Muscovitic Biotite Schist.

C.A. Van Hise, Feb. 20. 1886

Microscopic Description.

The section has a fine grained ground mass of quartz and feldspar in which are abundantly found muscovite and biotite. Many of the larger quartz grains include numerous folia of mica. The feldspar areas are reticulating and include quartz and both the micas. The muscovite and biotite besides being found in the small folia thus included in the quartz and feldspar are present in numerous large blades. This section taken by itself would be considered a completely crystalline mica schist in which the interlocking and mutual inclusions of the different minerals are of the most intricate sort. But, like the other Huronian mica schists of this region, it is believed to be an ordinary clastic rock in which the series of metamorphic changes have been great. The large areas of quartz including folia of mica represent clastic individuals of feldspar. As the feldspar has altered to mica the excess of silica has separated out as quartz and the area, as stated above, which was once orthoclase or plagioclase, in most cases the former, is now a complex most intricately interlocking area of quartz and mica. Frequently the alteration of a single feldspar has resulted in the formation of a single individual of quartz in which case the more or less detached areas polarize together. In other cases the decomposition of a feldspar has resulted in the formation of many grains of quartz as well as numerous folia of mica. The proof of these alterations in this single section is not complete but taken in connection with the other mica schists of the series it is conclusive. These reticulating areas of saturating quartz often yet contain detached cores of feldspar which polarize as a unit. Sometimes these feldspars have not altered to such an extent as described above. In almost every case their rounded exteriors are lost but considerable irregular areas quite frequently remain, which include but few folia of biotite or little saturating quartz, or both. It is probable that a portion of this saturating quartz comes from extraneous sources.

9537 (con.) of any particle of either mineral in the section. While
 Sl. 3314 the smaller of the grains of quartz and feldspar are small, all of them are large enough to be distinctly made out. Whether these are all or in part only, elastic enlarged grains it is impossible to say. The feldspars are considerably kaolinized, but usually sufficiently fresh, when triclinic, to show sharply defined twin lamellae. Flakes of brown biotite and green chlorite are very plentiful, being distributed quite uniformly through the rock. The chlorite is certainly in part an alteration product of feldspar, as is the biotite also, apparently. Included in the various minerals are numerous little opaque particles of iron oxide.

9540

Sl. 3316

Biotitic Greywacke.

C. R. Van Hise, Jan. 1886.

Macroscopic Description.

The specimen is very similar to 9537.

Microscopic Description.

The minerals and their general arrangements are the same as in 9537. The differences are that the feldspars are fresher and in addition to biotite and chlorite quite a number of relatively large flakes of muscovite are found. The cores of a few of the larger quartz individuals are clearly made out.

9536 SiO₂ 74.92% . Thompson

9546

A. 3093

Sericitic Quartzite.

C. R. Van Hise, Jan. 1886.

Macroscopic Description.

The rock is a little coarser grained than 9537 and 9540 but is otherwise like them.

Microscopic Description

The section is composed of coarse grains of quartz, having general oval or roundish forms set in a fine matrix which also appears to be chiefly quartzose, although with it are feldspar, chlorite and sericite. While there ^{is a wide gradation} are all grades in the size of the quartz grains from those larger than any found in 9537 or 9540 to those smaller than any in those sections, yet there is an ^{approximate} tolerably good separation of the coarse and fine quartz. At first sight the section differs from those of the rocks mentioned in the ^{apparent} ~~apparent~~ ^{to have but a} small amount of coarse fragmental feldspar. However, upon closer examination it is seen that the remnants of many coarse feldspars are present. In some cases these grains are honey-combed by saturating quartz, many detached areas in the section often bring a single individual. Again a feldspar area contains many small individuals of quartz mingled with chlorite and sericite or kaolin, and occasionally a feldspar particle is found which is only badly kaolinized.

Evidently this rock was originally mostly composed of rounded fragmental particles of quartz and feldspar. The fragmental quartz grains have enlarged and thus become sharply angular. The particles of feldspar are largely replaced or decomposed as above described, and consequently the rock has now become, at first sight, an almost completely crystalline one. Had the process continued until all the feldspar had thus been replaced and altered the only trace of any original fragmental material would be the general oval or roundish character of the larger particles of quartz.

9544

Sl. 3092

Biotitic and Muscovitic Greywacke.

C. R. Van Hise, Jan. 1886.

Macroscopic Description.

The rock is coarse grained, massive, with conchoidal fracture and of a gray color.

Microscopic Description.

Large fragmental grains of quartz and feldspar, with the alteration and replacing products of the latter, make up the mass of the rock. The areas of quartz are enlarged and consequently minutely angular although still retaining their general roundish forms. The feldspar is much fresher than in 9546, many individuals showing no alteration except a little kaolinization. Other individuals, however, include many grains of quartz, or a large reticulating quartz individual with numerous flakes of muscovite and biotite. Here the quartz is plainly a replacing mineral and the muscovite and biotite are alteration products of the feldspar. In many cases this alteration has proceeded so far as to leave but irregular partly replaced and altered cores which are entirely surrounded with the replacing quartz and secondary biotite and muscovite. Again in other cases the original rounded outlines of the feldspars are distinct, the replacing and alterations having occurred in spots through the grains. The finer portions of the rock are composed of quartz, biotite, and muscovite, often without any feldspar. These portions are also probably alteration products of feldspar, some of the individuals perhaps being small, or at least alteration products of feldspar mingled with detrital quartz. Through the finer portions of the rock are numerous small particles of black opaque material which is taken to be iron oxide.

(Beautiful section to show alterations of feldspar.)

9545
Sl. 3319

Biotitic Greywacke.

C. R. Van Hise. Jan. 1886.

Macroscopic Description.

The rock is coarse grained, massive, of a gray color, having conchoidal fracture. The numerous particles of limpid quartz and the less plentiful ones of white or pale pink feldspar are so large as to enable one easily to see their rounded forms. The whole appearance is that of a gray quartzite.

Microscopic Description.

Very large, rounded, often complex areas of quartz are very numerous. These grains as to general form are well rounded, but upon the edges they are minutely irregular, and these irregularities are doubtless due to enlargements. Feldspar also is found in rounded areas. The feldspars are often more or less decomposed, the method of alteration, and the products produced being precisely as in 9544, but the stages and illustrations of it are not so good. There are large areas composed almost entirely of finely crystalline quartz, brown folia of biotite mingled with small remnants of feldspar. There is but little doubt, but these areas are altered feldspathic ones.

1442 Wis.Biotitic Schist.

C. A. Van Hise. Feb. 27. 1886.

Microscopic Description.

The description of 9539 applies almost exactly to this section. It is, however, not so rich in biotite. This is true both of the matrix and the partly altered feldspars. Pyrite is an abundant accessory throughout the rock, the individuals usually, however, being of greater size in the matrix than in the feldspar areas. Here and there folia of muscovite are seen.

9539

sl. 3315

Biotitic Rock.

C. R. Van Hise. Feb. 9. 1886.

Macroscopic Description

The rock is dark gray to black in color, mottled, fine grained and quite massive. The mottling is due to numerous ^{small} cleavage surfaces of some black mineral.

Microscopic Description.

The cleavage areas ^{seen} spoken of in the ^{ally} macroscopic description are found to be well rounded, altered areas of feldspar. These areas are set in a ground mass which consists of intimately mingled small grains of quartz and small brown ^{particled} folia of biotite, with a considerable quantity of ferrite. The partial decomposition of the clastic feldspars has resulted in the formation of very numerous small folia of biotite ^{and} a few larger ones of muscovite. ^{the transformation being beautifully shown} In places also the feldspar is replaced by saturating quartz. In each of the feldspar areas the secondary biotite and muscovite are found most plentifully at or near the exteriors of the grains, although in almost every case the alteration has proceeded, in a greater or less degree, quite to the centers. In the matrix it is impossible to determine what part, if any, of the quartz is fragmental. The biotite of the matrix is precisely like that found in the feldspars. The ^{is all} folia are deep brown and very strongly dichroic, and therefore probably bearing a large percentage of iron. The feldspar plainly shows this rock to have been fragmental and the alteration of clastic feldspar to both biotite and muscovite is most beautifully shown. The large quantity of dark brown and black ferrite has doubtless furnished the iron required for the alteration of feldspar to biotite. The peculiar spotted appearance of the section when held up to the light, gives a clear idea of the manner in which the rock reached its present condition, when taken in connection with its appearance under the microscope.

1494 Wis.Biotite Schist

C. R. Van Hise. Feb. 20. 1886

Microscopic Description

This section is like that of 9543.

1493 Wis.

These sections are very thick and there is in

1496 Wis.

them nothing found which adds to what is given in

2104 Wis.

the descriptions of the rocks from 9541 to 9549.

2108 Wis.

9543

Sl. 3318

Biotite Schist.

C. R. Van Hise, Feb. 9. 1886

Macroscopic Descriptions.

This rock differs from 9539 only in that the dark spots, while plainly perceptible, are much less distinct than in 9539.

Microscopic Description.

At first glance the section appears like an ordinary biotite schist. It ^{they} contains a ground mass of quartz through which are plentifully and uniformly scattered brown folia of biotite and less numerous flakes of muscovite. Many of the larger grains of this quartz are plainly fragmental and they have often been enlarged. The biotite is, to a large extent, secondary to feldspar, many flakes of this mineral often being found mingled with a small quantity of feldspathic material, which, throughout considerable areas, acts as units. In a few places elastic areas of feldspar, both orthoclase and plagioclase, are found in which the micaceous decomposition has but begun; but in the greater part of the section but little of the original abundant feldspar remains. We now see the explanation of the vaguely outlined spots seen in the hand specimen. They represent original clastic feldspars which composed a very large proportion of the rock, but now, in most cases, they have so completely altered to biotite and muscovite that only here and there in the ^{thin} section is an area well outlined. This rock was then originally like 9539 ^{subsequently described} but now approaches very closely to a typical mica schist. In 9539 there ^{is} ~~was~~ everywhere a plain difference between the feldspathic and non-feldspathic areas. In 9543 ^{and 1424} the larger portion of the section resembles the fine-grained matrix of 9539. Ferrite is an abundant inclusion in small particles in the biotite, feldspar, and much of the quartz. The quartz containing such quantities of this ferrite is taken to be secondary. The larger grains, above described as fragmental, are free from ferrite.

9569

Sl. 3378

Biotitic Black Slate.

C. A. Van Hise, Feb. 16. 1886

Macroscopic Description.

The rock is a very fine grained black one breaking with conchoidal fracture.

Microscopic Description.

Very small clastic particles of quartz and feldspar compose one-half the area of the section. The quartz grains are ordinarily distinctly enlarged. While quite a good many of the feldspar grains are tolerably fresh the greater number of them are altered to some extent to biotite, while frequently they are almost completely thus altered. All stages of this process of alteration are seen and while the particles of feldspar and the secondary folia of biotite are very much smaller than in the previously described mica schists, the transformation is just as clearly made out. The interstitial material making up the other half of the section consists of exceedingly finely crystallized quartz, of minute folia of biotite, and of an abundant black opaque material, which is doubtless ferriferous and probably also carbonaceous. All of the biotite in the section is believed to be of secondary origin.

9572

Sl. 3379

Black Chlaestolitic Biotite Slate.

C. R. Van Hise. Feb. 16. 1886.

Macroscopic Description.

The rock is aphanitic, of a very dark gray color, and breaks with a conchoidal fracture. Everywhere through it are seen minute particles of pyrite.

Microscopic Description.

The rock is excessively fine grained. It is made ^{up} of minute particles of quartz, feldspar, biotite and ^a black opaque substance. How far this material is fragmental it is difficult to say. ~~Quite a good~~ Many areas of quartz and feldspar are seen which are taken to be clastic as they have roundish outlines and are considerably larger than the particles of the mass of the section. Much of the black material is doubtless somewhat decomposed pyrites although mingled with it there may be a good deal of oxide of iron and perhaps carbonaceous substance. The alteration of the minute grains of feldspar to biotite is as clearly shown as in 9569. Scattered sparsely through the fine material of the section are quite large grains of chlaestolite. These chlaestolite individuals include such quantities of the other minerals of the section as to be almost indistinguishable from other parts of it. The particles of the black substance are arranged in parallel lines which doubtless correspond to the somewhat obscure slaty cleavage of the rock. While this section is much finer grained than that of 9569, there is little essential difference between them. The rock is ^{then} an altered fragmental quartz feldspar one in which biotite is an abundant secondary alteration product.

SiO ₂	70.72%	} Thompson.
Al ₂ O ₃ , Fe ₂ O ₃	16.317%	
Fe. 29%, Al ₂ O ₃	12.174%	
CuO	6.22	
MgO	2.55	
Total & choice of Mn, alkalies, carbon & H ₂ O		95.807

9574

Sl. 3380.

Black Biotitic Slate.

C. R. Van Hise. Feb. 16. 1886.

Macroscopic Description.

The rock is an exceedingly fine grained, black one, finely laminated, and cleaving readily along the plane of lamination.

Microscopic Description.

The section of this rock is coarser grained than that of 9572 but in all essential respects is like it. In places folia of biotite are concentrated in quite large areas. These areas are believed to be due to secondary alteration of relatively large grains of feldspar. As evidence of this, such feldspar areas are found which are sometimes slightly and sometimes almost completely thus altered. A few small chiastolite individuals are found and also here and there folia of muscovite. This rock in its characteristics and fineness of grain is intermediate between 9569 and 9572.

1480 Wis.Black Biotitic Slate.

C. R. Van Hise, Feb. 20. 1886

Microscopic Description.

In every respect this section is exactly like that of 9550, except perhaps that it is slightly coarser grained and contains less pyrite.

1440 Wis.Biotitic Slate

C. R. Van Hise, Feb. 20. 1886

Microscopic Description.

The section is very fine grained and consists of intimately mingled quartz feldspar biotite and minute particles of dark opaque material which is probably pyrite. The biotite is so abundant as to compose about one half of the mass of the rock. A portion of it is certainly secondary to feldspar but the section is very thick and it is difficult to determine how great a portion.

Black Biotitic Slates.

9546

Sl. 3381

C. V. Van Hise. Feb. 17th. 1886.

9547

Sl. 3094

Macroscopic Descriptions.

9548

Sl. 3320

9549

Sl. 3321

9550

Sl. 3322

These rocks are all exceedingly fine grained and finely laminar, cleaving readily along the plane of lamination. In color they vary from dark gray to black. A lens shows them to contain numerous small particles of pyrite; this mineral being particularly abundant in 9549 and 9550. Finely pulverized, the last mentioned rocks contain material which adheres to the magnet. This material is believed to be magnetic pyrites. Very numerous rounded black areas are contained in the fine gray material in all the rocks. These areas in some cases show distinctly cleavage surfaces and are taken to be large fragmental particles which when showing cleavage surfaces are much less altered than in the other cases.

Microscopic Description.

These rocks all consist of two parts, a finely crystalline matrix and coarse, well-rounded, fragmental feldspars which are always altered to a greater or less extent. This alteration of the feldspars has resulted in the formation of biotite. Many small folia of biotite are always found in a single individual of feldspar. Every gradation in this change is seen, from grains of feldspar which contain but few folia of biotite, to those in which the remaining feldspar is just sufficient in quantity to enable one to perceive that the detached areas are parts of an individual. Doubtless also the alteration to biotite has completely taken place in many cases when the outlines of the original clastic area would be entirely lost. Accompanying the biotite thus secondary to the feldspar is much black opaque material in minute particles. This is, in all probability, also secondary as its quantity steadily increases as the quantity of biotite increases. The black roundish spots spoken of under the macroscopic description are evidently these altered clastic feldspars. The extent of their alteration as determined by the thin section corresponds exactly to their appearance as seen in the hand specimens. In 9550, in which the feldspar areas are well outlined and show clearly marked cleavage surfaces,

9576 +c the biotitic alteration has taken place to but a small
 (con.) extent; ~~while~~ In 9549 and 9576 the obscurely out-
 lined feldspar areas and irregular cleavage surfaces cor-
 respond with great biotitic alteration of the feldspars.

The matrices of the rocks are composed of inti-
 mately mingled quartz, feldspar, biotite, and black
 opaque material which is ~~taken to be~~ mostly somewhat
 altered pyrite but may contain, mingled with it, carbona-
 ceous matter. A portion of the quartz is certainly fragment-
 al, as is evidenced by secondary enlargement. The biotite
 is all believed to be due to the alteration of feldspar,
 much of it certainly being of this nature. The matrices
 of the different sections vary in coarseness and in the
 relative proportions of the various mineral constituents, but
 are alike in all essential points. In 9550 the pyrite is
 especially plentiful where it ordinarily shows its character-
 istic brilliantly reflecting surfaces.

9592.

Sl. 3330

Biotite Schist or Slate.C. R. Van Hise, Feb. 9th, 1886.Macroscopic Description.

250 E 50 S

N.W. cor Sec. 4

T. 44, R. 11, N. 15.

The rock is fine grained, dark gray in color, and contains numerous small cleavage areas of some black material. It resembles quite closely 9539, differing from that rock in being finer grained and in that the spotted cleavage areas are less numerous.

Microscopic Description.

In all essential particulars this rock is like 9539. It differs from that rock in that its matrix is much finer grained and in that the feldspar areas are less numerous. The alteration of the feldspar has taken place in the same manner as in 9539, the resultant folia of biotite, however, being of much smaller size. The matrix consists of minute grains of quartz, flakes of biotite, areas of feldspar, and particles of ferrite. In this matrix a few grains of quartz larger than most of those found in the matrix are present, and these have a fragmental appearance. It seems most probable that this rock was originally a fragmental one being composed mostly of feldspar and quartz. These particles of feldspar and quartz were mostly of small size but mingled with them were quite plentiful, much larger grains of feldspar. From the finer material the matrix, as now found, has resulted by alteration of the feldspars to biotite and by infiltration of quartz. The larger grains of feldspar have been affected by this same biotitic alteration but upon account of their greater size it has left ~~the~~ a large portion of their interiors as feldspar. Scattered through the matrix are quite numerous small areas of pyrite.

3172 Wis.Biotite Greywacke or Schist.C. R. Van Hise. Feb. 20th 1886.Microscopic Description.

In essential particulars this rock resembles very closely 9586. It is finer grained; the micas are more plentiful; it has a more thoroughly crystalline appearance, approaching in this respect 2039 Wis. Much of the mica is plainly secondary to feldspar. A large portion of the biotite bears the same relation to black ferrite (magnetite or pyrite) as in 9586.

9586.

Sl. 3329

Biotitic Greywacke.Macroscopic Description.

540 ft, 20 ft.

The rock is fine grained, light-gray in color, N.E. cor. Sec. 5, quite massive, and breaks with a sub-conchoidal fracture J. 44, R. 2 W. 1/2 W. 1/2

Microscopic Description.

The rock is largely composed of fragmental particles of quartz and feldspar. Mingled with these minerals are plentiful flakes of brown biotite and less numerous ones of muscovite. Many of the larger quartz grains have taken a second growth and their exteriors are therefore minutely angular. Much of the feldspar is quite fresh although in many places it is altered, to a large extent, to biotite. Less frequently it is replaced by saturating quartz. While much of the biotite is secondary to feldspar and while probably all of it is of this nature, this statement could not be made with certainty. Quite plentiful black grains of ferrite are scattered through the section but are much the most plentiful in the biotite. Is it not possible that the position of these ferrite grains has controlled the position of the secondary flakes of biotite? Of the chemical constituents of the biotite the feldspars could readily furnish all but the iron, and this, upon this hypothesis would come from the ferrite.

3164 Wis.Chloritic and Muscovitic Greywacke.

C. A. Van Hise Feb. 20. 1886.

Microscopic Description.

The rock was originally composed of rather small clastic particles of quartz and feldspar. The quartz grains are mostly enlarged. Secondary interstitial quartz has appeared. The feldspars have largely decomposed, their places now being occupied by chlorite, muscovite, saturating quartz, and, to a small extent, biotite.

9584

Sl. 3327

Biotite Schist or Slate

C. R. Van Hise, Feb. 10. 1886.

Macroscopic Description.

600 N. S. E. cor

Sec. 5, T. 44,

R. & W. Wis.

This rock differs from 9592 only in being slightly lighter colored.

Microscopic Description.

The description of 9592 applies to this rock with few modifications. The ground mass is finer than in 9592 and no grains of quartz are here found which are certainly fragmental. The biotitic alteration has so affected the larger fragmental grains of feldspar that, with a high power, these areas cannot be distinguished from the matrix. With a lower power these feldspar areas are readily made out.

9582

Sl. 3326

Biotitic Quartzite.

C. R. Van Hise, Feb. 10. 1886.

Macroscopic Description.

700 N. S. E. cor

Sec. 5, T. 44,

R. & W. Wis.

This rock is like 9586.

Microscopic Description.

As in 9586, plentiful ~~of~~ ^{quartz and} elastic particles of feldspar are found, but they are less uniform in size and are set in a matrix of much finer material, which is largely quartzose. Biotite is also less plentiful than in 9586, a portion of it is certainly secondary to feldspar and probably it is all of this origin. The quartz is frequently enlarged, ^{and} a portion of the feldspar is plagioclase. Much of the finer interstitial quartz is probably secondary.

9630.

Sl. 3345

Chlorite Sericite Schist.

C. R. Van Hise, Feb. 10. 1886.

Macroscopic Description

The rock is of a light gray color, banded, very fine grained and breaks with a sub-conchoidal fracture.

Microscopic Description.

The section consists of a ground mass of small blades and fibres of pale green chlorite and sericite(?) mingled with some biotite in which is set numerous small fragmental grains of quartz, with a few grains of feldspar.

9628

Sl. 3344

Biotite Schist.

C. R. Van Hise, Feb. 10. 1886.

Macroscopic Description.

The rock is exceedingly fine grained, ^{and} of a very dark gray color. It has a mottled surface due to numerous small cleavage surfaces of some mineral and contains very numerous minute particles of pyrite.

Microscopic Description.

The section is exceedingly fine grained and consists chiefly of biotite, quartz and feldspar, the latter mineral being much less abundant than the other two. Much of the feldspar has partially undergone biotitic alteration and it is wholly possible that all the biotite is thus secondary. Scattered ^{through} uniformly the section are rather plentiful grains of pyrite.

SiO₂ 58.87% } Thompson.
MgO. 3.386 }

9627

Sl. 3343.

Biotitic Greywacke Slate.

C. R. Van Hise, Feb. 10. 1886.

Macroscopic Description.

The rock is an aphanitic, banded, dark gray ^{slate}.

Microscopic Description.

The section is exceedingly fine grained. It consists of a confused mass of mingled quartz, feldspar, chlorite, biotite and ferrite with perhaps some sericite.

9605

Sl. 3338

Biotite Schist or Slate.

C. R. Van Hise, Feb. 10. 1886.

Macroscopic Description.

This rock is like 9628.

Microscopic Description.

This rock differs from 9628 in being still finer grained, ^{and} containing less pyrite, but otherwise is very much like it.

9607

Sl. 3339

Biotitic Greywacke.

C. R. Van Hise, Feb. 10. 1886.

Macroscopic Description.

The rock is a dark gray, medium grained, massive one, breaking with sub-conchoidal fractures.

Microscopic Description

Clastic particles of quartz and feldspar of medium size are set in a fine matrix consisting of the same minerals mingled with chlorite, biotite, ferrite and pyrite. Many of the larger particles of quartz are distinctly enlarged. The feldspar is in part orthoclase and in part plagioclase. The grains are often quite fresh and also often very largely altered to biotite and muscovite. In the matrix a considerable quantity of black opaque ma-

2098 Wis.

Biotite Slate.

C. A. Van Hise. Feb. 20. 1886

Microscopic Description.

This section differs from that of 9608 only in being finer grained.

9607 (con.) terial is found which may be somewhat decomposed pyrites or possibly mingled carbonaceous material and ferrite.

9608
Sl. 3340

Biotitic Slate.

C. R. Van Hise. Feb. 11. 1886.

Macroscopic Description.

The rock is fine grained, dark gray in color, and breaks readily across the stately cleavage with a sub-conchoidal fracture.

Microscopic Description.

The section consists of intimately mingled minute particles of quartz, feldspar, biotite, chlorite, and dark opaque patches of ferrite or altered pyrite. Here as in the previously described sections the biotite is plainly, in part at least, secondary to feldspar.

9615
Sl. 3099

Biotitic and Chloritic Greywacke.

C. R. Van Hise. Feb. 11. 1886

Macroscopic Description.

The rock is fine grained, of a uniform light gray color, is quite massive and breaks with a conchoidal fracture. Upon its cleaved surface are seen numerous, minute glistening ~~or~~ cleavage surfaces of white mica.

Microscopic Description.

The chief constituents of the section are clastic particles of quartz and feldspar, the former being ^{the} more plentiful and ordinarily enlarged. Between these feldspar and quartz grains, or included in the feldspars are very numerous small folia of biotite and white mica (sericite?).

9611

Sl. 3341

Chloritic Greywacke.C. R. Van Hise, Feb. 11th. 1886Macroscopic Description.

The rock is rather fine grained, of uniform texture and light gray color. While cleaving most readily along the plane of stratification, it breaks easily across this plane with a sub-conchoidal fracture. It resembles closely 9607.

Microscopic Description

This rock is ^{slightly} coarser grained than 9607, ~~but~~ ^{and} in ~~every~~ many respects resembles it. Well rounded clastic particles of quartz and feldspar are set in a matrix consisting of quartz, chlorite, biotite, and kaolin. The chief point of difference between this rock and 9607 is that the decomposition of feldspars has resulted in the formation of much less biotite and much more chlorite.

9613

Sl. 3342

Biotite Slate or Greywacke.

C. R. Van Hise, Feb. 11. 1886

Macroscopic Description

This rock is like 9608.

Microscopic Description

This rock is slightly coarser grained than 9608 but in every essential respect is like it.

9598	SiO ₂	82.1%	} Thompson
	Fe ₂ O ₃ , Al ₂ O ₃	11.6%	
	Fe ₂ O ₃ 3.514		
	Al ₂ O ₃ 8.055 (diff)		
	CaO	15.3%	
	MgO	7.2%	
	Total	95.90%	Eq. alka. carbon, 82014.

9595

Sl. 3332

Biotitic Greywacke.C. R. Van Hise. Feb. 11th. 1886.Macroscopic Description.

The rock is rather fine grained, of a gray color, massive, and breaks with a sub-conchoidal fracture.

Microscopic Description.

^{In thin section} Medium sized elastic particles of quartz and feldspar are set in a finer matrix which consists of particles of these minerals mingled with much biotite in small folia and with less plentiful white mica (sericite.) As in the previously described mica schists, many of the feldspar particles are altered to biotite to a greater or less degree.

9598

Sl. 3334

Biotitic Greywacke.C. R. Van Hise. Feb. 11th. 1886.Macroscopic Description.

The rock is medium grained, of uniform texture, dark gray in color, and breaks with a conchoidal fracture.

Microscopic Description

This ^{section} ~~rock~~ is coarser grained than ^{any} of the previously described biotitic greywackes but resembles them in essential appo^{ints}. Elastic particles of quartz and feldspar, well rounded, compose two-thirds or more of the mass of the rock. A few of the quartz grains are finely complex and nearly all of them are distinctly enlarged. The alteration of feldspar to biotite is very nicely shown. The freshest of the feldspar grains are surrounded by, and more or less deeply intersected with secondary biotite. These grains yet retain their well rounded form but in many cases the original exterior forms of the feldspar grains are lost. Often the entire surfaces of the feldspars include very numerous particles of the biotite, there remaining throughout such areas here and there little spots of ~~such~~ feldspar which together

9598 (con.) polarize as units. The rather sparse matrix of the rock consists of finely crystalline quartz, of feldspar and of biotite. Much of this fine quartz is doubtless a secondary infiltration material and the biotite is believed to be secondary ^{to} feldspar.

This section is one of the finest yet described ^{is shown} illustrating the alteration of feldspathic areas into numerous small folia of biotite.

9170

St. 792

Biotite Greywacke.

C. R. Van Hise, Feb. 12th, 1886.

Macroscopic Description.

The rock is fine grained, dark gray in color, ~~and~~ massive, and breaks with a conchoidal fracture.

Microscopic Description.

The ground mass of the rock consists chiefly of ~~fragmental~~ quartz. Mingled with this is some feldspar. Between the quartz particles are very abundant brown folia of biotite. Associated with the biotite are rather numerous needles and radiating clusters of needles of actinolite. A portion of the quartz is clearly fragmental and many of the grains have ~~been~~ enlarged. These clastic cores of these grains are never cut by the actinolite needles. The enlargements, however, and many grains of quartz which are believed to be secondary are penetrated through and through by the needles of actinolite. The actinolite is therefore believed to be secondary. A portion of the biotite has resulted from the alteration of feldspar and all of it may be of this origin. Here and there are found small opaque particles of ferrite or altered pyrite.

9119
Sl. 3798

Quartzite.

C. R. Van Hise. Feb. 12th, 1886.

Macroscopic Description.

The rock is a coarse grained, light gray, vitreous quartzite.

Microscopic Description.

Large well rounded fragments of quartz and feldspar compose the greater portion of the rock. Some of the clastic areas of quartz are very large and they are sometimes complex. A few of the feldspar areas are also of great size. They have largely decomposed into large, well defined, brilliantly polarizing flakes of kaolin and are here and there partly replaced by saturating quartz. Between the large clastic grains of quartz and feldspar are found smaller particles of these same minerals, the greater number of which are also taken to be fragmental. Mingled with this finer quartz and feldspar is a considerable quantity of chlorite, kaolin, and ferrite.

9118
Sl. 2906

Quartzite.

C. R. Van Hise. Feb. 12th, 1886.

Macroscopic Description

The rock is a coarse grained, gray, vitreous quartzite resembling closely 9119.

Microscopic Description.

The chief ^{fragmental} constituents of the rock are the same as in 9119. The decomposition of the feldspar, however, has resulted chiefly in the formation of biotite and muscovite. These minerals are plentifully found in the interstices of the fragmental particles and surrounding and included in the large feldspar areas. Some of the clastic quartz grains have been enlarged and the enlargements frequently include flakes of muscovite and biotite. This section nicely illustrates the micaceous decomposition of feldspar.

9116

Sl. 7905

Quartzite.C. R. Van Hise. Feb. 12th 1886.Macroscopic Description.

Like 9118 and 9119 this rock is a coarse grained gray vitreous quartzite. A portion of the specimen is so coarse, in fact, as to make the name more properly conglomerate, it here containing pebbles nearly an inch in diameter.

Microscopic Description.

As in 9119 fragmental particles of quartz and feldspar, the former, as in it, being much the more abundant, compose the greater part of the rock. Interstitial material is, however, quite plentiful. It consists of finely crystallized quartz and of very numerous bundles of actinolite needles. This fine interstitial quartz is cut ^{through and through} in every direction ~~from~~ by needles of actinolite. These actinolite needles are also always included in the enlargements of the clastic quartz grains but never in the cores. This actinolite is then plainly a secondary mineral and about it the infiltrated quartz has crystallized. There seems good reason for believing that feldspar has furnished the elements out of which the actinolite has formed; for in one or two places large clastic feldspars are found which include abundantly both biotite and actinolite. Here and there are found small, black opaque areas of ferrite.

9113

Sl. 7903

Biotite Schist or Slate.C. R. Van Hise Feb. 12th 1886.Macroscopic Description.

This rock resembles very closely 9592 differing from it only in being of a slightly lighter color.

Microscopic Description.

This rock resembles very closely 9592. As in it, an abundant matrix consisting of quartz, biotite, with perhaps a small portion of some other minerals, includes numerous well rounded areas of feldspar. This feldspar has all, to a greater or less degree, altered to biotite. Each area of the former mineral contains very numerous individuals of the latter. In origin the rock is doubtless the same as 9592 and 9584.

9112

Sl. 7923

Biotitic Greywacke Slate.C. R. Van Hise Feb. 12th 1886.Macroscopic Description.

The rock is dark gray, fine grained and finely laminated.

Microscopic Description.

This rock is finer grained than in 9586 but in all essential particulars is like it. Fragmental particles of quartz and feldspar mingled with much biotite and some muscovite compose the rock. The fragmental quartz grains have been enlarged. The biotite is secondary to feldspar.

9111

Sl. 2790

Biotitic GreywackeC. R. Van Hise Feb. 12th, 1886.Macroscopic Description.

This rock differs from 9112 only in that it lacks a lamellar structure and consequently has a sub-conchoidal fracture.

Microscopic Description.

The rock differs but little from 9112. It is finer grained and the interstitial fine quartz and biotite are more plentiful. The biotite is, however, all believed to be secondary to feldspar much of it certainly being of this origin.

9110

Sl. 2902

Biotitic Greywacke.C. R. Van Hise. Feb. 12th. 1886Macroscopic Description.

This rock is coarser grained than 9111 but in other respects it is like it.

Microscopic Description.

Here also the rock differs but little from 9111 except in containing larger clastic particles of quartz and feldspar. The matrix is as fine grained as in 9111 and in all essential respects is like it, except that it contains a noticeable quantity of chlorite.

9107.

Sl. 2789

Chloritic Greywacke Slate.C. R. Van Hise, Feb. 12th 1886.Macroscopic Description.

The rock is exceedingly fine grained, dark gray in color, finely schistose and shows upon the cleavage surface numerous minute, glittering particles of pyrite.

Microscopic Description.

Small clastic particles of quartz and feldspar are set in an exceedingly fine matrix consisting chiefly of quartz and chlorite. Mingled with the chlorite are numerous flakes of Kaolin or sericite. Throughout the section are numerous small areas of dirty somewhat decomposed pyrite.

9126

Sl. 2909

Chloritic Greywacke.C. R. Van Hise. Feb. 12th. 1886.Macroscopic Description.

The rock is rather fine grained, of a light gray color, showing a conchoidal fracture. Upon its broken surface is seen pyrite. ~~Other small fragmental grains of quartz and feldspar.~~

Microscopic Description

Rather small particles of quartz and feldspar, the former being greatly preponderant, compose two-thirds or more of the mass of the rock. Between these fragmental particles is a fine grained matrix consisting of the same minerals and in about the same proportions, mingled with much chlorite and some ferrite. This rock approaches more closely the typical greywacke ^{any} than of those previously described. The fragmental quartz grains are generally slightly enlarged.

9124

Sl. 2908

Chloritic Greywacke.C. R. Van Hise, Feb. 15th. 18869123

Sl. 2794

Macroscopic Description.

The rocks are fine grained, dark gray, massive ones, breaking with conchoidal fracture. They differ from 9126 only in being finer grained than it.

Microscopic Description.

In all essential respects these rocks are like 9126. The quartz grains have received enlargements. In the matrix mingled with the quartz, orthoclase and chlorite are quite plentiful flakes of sericite or kaolin. As in 9126 there are found in the matrix numerous irregular patches of opaque material sometimes gray sometimes black in color, which are taken to be some compound of iron but may be a mixture of ferrite and carbonaceous material.

9077

Sl. 3796

Sl. 2778

9078

Sl. 2892

9079

Sl. 2779

Chloritic Greywackes.

C. R. Van Hise, Feb. 15. 1886

Macroscopic Description.

9077 and 9078 are like 9123 and 9124. 9079 has a slaty cleavage.

Microscopic Description.

As in 9126, 9124, 9123, ^{in thin sections} fragmental particles of quartz and feldspar compose a large portion of the rocks. The quartz grains are most often enlarged. The feldspars comprise both orthoclase and plagioclase and are frequently quite fresh. The abundant matrices consist of finely crystalline quartz, of chlorite, of sericite or kaolin and of opaque brown or black ferrite. In a few places small flakes of biotite are seen. In fragmental material and siliceous paste, as in other particulars, these rocks are typical greywackes.

9072

Sl. 2890

9071

Sl. 3795

Chloritic Greywackes

C. R. Van Hise, Feb. 15. 1886

Macroscopic Description.

The rocks are light gray in color, rather fine grained, somewhat massive, and break with sub conchoidal fracture. While 9071 is more massive than 9072 they both show a tendency to cleave parallel to the bedding plane. They resemble closely the previously described chloritic greywackes.

Microscopic Description.

^{The thin sections of} These rocks are in essential particulars like the chloritic greywackes previously described. The fragmental grains of quartz are always distinctly enlarged. While many of the feldspar areas are quite fresh others are quite badly kaolinized and chloritized. The ^{abundant} matrix is of the same composition as in the previous chloritic greywackes. It however contains a little biotite and muscovite. Here and there are found quite large black opaque areas which appear to be ferrite but which may contain pyrite or carbonaceous material.

9068

Sl. 2922

Chloritic Greywacke.

C. R. Van Hise, Feb. 15. 1886

Macroscopic Description.

This rock is almost exactly like 9126.

Microscopic Description.

In no essential respect does this rock differ from 9126.

9163

Sl. 2925

Chloritic Greywacke.

C. R. Van Hise, Feb. 15. 1886

Macroscopic Description.

This rock is like 9126.

Microscopic Description.

In most points this rock ^{is} like the previously described greywackes. Many of the fragmental feldspars, however, are large and fresh. They comprise both orthoclase and plagioclase a portion of the latter being microcline. The alteration of feldspar to kaolin or muscovite is very nicely illustrated. Some of the feldspar areas contain very numerous flakes.

9034

Sl. 2918

Biotitic and Chloritic Greywackes.

C. R. Van Hise, Feb. 15. 1886

9032

Sl. 2770

Macroscopic Description.

9034 is medium grained, gray, massive, and breaks with a conchoidal fracture. 9032 differs from it in being considerably finer grained.

Microscopic Description.

As in the previously described chloritic greywackes fragmental quartz and feldspar compose two-thirds of the mass of the rock. The grains of quartz are often slightly enlarged. The feldspars are often fresh and often also much altered. This alteration has resulted in the formation of both chlorite and biotite and in 9032 in many places the feldspars are partly replaced by saturating quartz. 9034 contains large areas of feldspar which are

9034 (cont) now almost entirely altered to chlorite and biotite.

9037 However, 9037 shows the biotitic alteration much more extensively. The matrices of these rocks are the same as in the previously described chloritic greywackes except that biotite is also here found.

9030

Sl. 2917

Ferruginous Chloritic Greywacke Slate.

C. R. Van Hise, Feb. 15. 1886

Macroscopic Description.

The rock is fine grained, finely banded, dark brown in color, and cleaves readily along the plane of lamination.

In this section Microscopic Description.

Fragmental quartz and feldspar in grains of small size compose perhaps one half of the mass of the rock. The grains of feldspar are mostly badly chloritized or kaolinized. The particles of quartz have frequently been enlarged. The abundant filling material is chlorite, finely crystalline quartz, dark brown oxide of iron, and black iron oxide, a portion of which appears to be magnetite. This rock resembles very closely the fragmental rocks found just above the non-fragmental ones on Black River.

9166

Sl. 2928

Ferruginous Chloritic Greywacke Slate.

C. R. Van Hise, Feb. 15. 1886.

Macroscopic Description.

This rock differs from 9030 in that it is of a dark green instead of a brown color.

Microscopic Description.

The section differs from that of 9030 only as to the condition in which the iron oxide is found. The greater part of it being black and some of it magnetite.

The interstitial material consists of quartz, chlorite, kaolin, ferrite, with some biotite and muscovite.

9194

Sl. 2932

9515

Sl. 2985

Clay Slates.

C. R. Van Hise. Feb. 15. 1886

Macroscopic Description.

The rocks are aphanitic, of gray color, have slaty cleavage, which in the case of 9194 cuts across the bedding plane.

Microscopic Description.

The sections ^{is} are exceedingly fine grained. ^{it} They appear to consist of a confused mixture of chlorite, Kaolin, quartz, ferrite, mingled with which are here and there a few larger grains of quartz which appear to be ^{elastic}.

9518

Sl. 3090

Micaceous Greywacke Slate.

C. R. Van Hise. Feb. 16. 1886.

Macroscopic Description.

The rock is fine grained, of a dark gray color, and finely laminated. Upon its cleaved surface numerous minute glittering mica scales are seen.

In thin section Microscopic Description.

Rather small elastic particles of quartz and feldspar compose about one-half the bulk of the rock. The grains of quartz are generally enlarged and the feldspars are usually much decomposed. The interstitial material consists of quartz, chlorite, biotite, muscovite and ferrite. Folia of muscovite and biotite are arranged with their ^{longer} axes in a common direction as though the rock had been subjected to squeezing.

9517

Sl. 2986

Chloritic Greywacke.

C. R. Van Hise. Feb. 16. 1886

Macroscopic Description.

The rock is rather coarse grained, of a gray color, massive, and breaks with a sub-conchoidal fracture.

In thin section Microscopic Description

Rather large fragmental particles of quartz and feldspar, the two minerals being in about equal abundance, compose the greater part of the rock. The grains of quartz are usually quite widely enlarged. A portion of the feldspar is quite fresh but the greater part of it is badly chloritized and kaolinized. (p. 62)

Mica Schists West of Penokee Gap.

73 Wis.

78 Wis.

79 Wis.

Muscovitic Biotite Schists

C. R. Van Hise. Feb. 20. 1886.

Microscopic Description.

These sections are ^{is W} rather fine grained, ^{unlike} apparently ^{dark a} completely crystalline, typical mica schists. The ground mass consists chiefly of quartz mingled with which is feldspar, both orthoclase and plagioclase. Biotite in rather small, well defined folia of nearly uniform size, is very plentiful. Muscovite is much less abundant. That all the biotite is a secondary alteration product ^{of feldspar} cannot be proved but a portion of it is certainly of this nature. Many grains of feldspar are partly surrounded and cut by folia of biotite, while many of the larger particles of feldspar contain throughout their areas numerous folia of biotite which in magnitude and appearance are precisely like the great mass of the biotite in the sections. (Excellent instance, ^{No. 79} 54-19.) Quite numerous black grains and crystals of a mineral which is taken to be pyrite are seen, which are included alike in the quartz, feldspar, and mica.

2001 Wis.

2002 Wis.

Muscovitic Biotite Schists.

C. R. Van Hise. Feb. 20. 1886

Microscopic Description.

These sections resemble closely 73, 78, and 79 Wis. However, their clastic origin and subsequent alterations are much more clearly made out. Mingled with the fine grained secondary quartz in 2002 are large well-rounded plainly fragmental grains. In most cases the original outlines of the feldspar grains are seen. These particles are of large size and usually numerous detached minute areas of feldspar remain which in each particular grain act as units. The larger part of the space, however, once occupied by the feldspar is now taken up by biotite, muscovite, kaolin, and quartz, the biotite usually being more plentiful than the other minerals. These rocks then in their original condition were plainly composed of quite large fragmental grains of quartz and feldspar, mingled perhaps with smaller grains of the same minerals. In

2001 Wis. some cases the fragmental quartz grains have been enlarged.
2002 Wis. The feldspars have altered as above described. Slides 73, 78, and 79 Wis. doubtless represent rocks which were doubtless originally in much the same condition as 2001 and 2002 Wis.; but here the decomposition of the feldspars to mica and quartz has been in most cases complete, thus forming a rock which is apparently a completely crystalline, fine-grained schist. 2001 is an excellent case illustrating the alterations in these mica-schists.

2006 Wis.

Biotite Schist.

C. A. Van Hise Feb. 20. 1886

Microscopic Description.

This section is exceedingly thick and except to mention its constituents little can be made out of it. The important minerals are quartz, feldspar, and biotite. Quite a proportion of this biotite is plainly secondary to feldspar.

2017 Wis.

Biotite Schist.

C. A. Van Hise Feb. 20. 1886.

Microscopic Description.

This rock is very plainly fragmental its chief original constituents being quartz and feldspar. The feldspar is badly decomposed the resultant products being chiefly biotite, many individuals being of considerable size, and kaolin with some muscovite. The biotite and kaolin are mingled in the most intricate and confused way. The folia of biotite include many particles of kaolin. As the exteriors of the folia ^{of biotite} are approached the kaolin becomes more and more abundant and finally the biotite grades into the kaolin by imperceptible degrees. An explanation which gives the origin of one must give the origin of the other. That both are secondary to feldspar, as stated above, is very plain.

9657.

9656

Sl. 3386

Olivine Gabbro.

C. R. Van Hise, Feb. 26. 1886

Macroscopic Description.

The rock is coarse grained, of a gray color, massive, and appears to be perfectly fresh.

Microscopic Description.

Large individuals of olivine, plagioclase, magnetite and augite compose the rock. All these minerals are extraordinarily fresh the only one which has altered to any considerable degree being olivine. Many of the individuals of this mineral are almost completely unaltered while others have decomposed to some extent along lines of fracture. Numerous dark colored linear inclusions parallel to definite planes are found in the olivine diallage and plagioclase. The rock differs from 9631 only in being less altered. (The determination for feldspar will be found on p. 189 of this book.)

101 His.Altered Biotitic and Hornblende Diabase.

C. R. Van Hise. Mar. 2. 1886

Microscopic Description.

Original constituents: plagioclase, magnetite, augite. Secondary ones: hornblende and biotite. The plagioclase is little altered. The augite has to a great extent changed to hornblende and biotite. The alteration of each individual of augite has ordinarily resulted in the formation of an aggregate of hornblende.

Nuroman Greenstones.

9661

Sl. 3387

Gabbro

C. R. Van Hise Feb. 23 1886

Macroscopic Description.

The rock is coarse grained, massive, mottled dirty yellow and black. Magnetite in large grains is ^{very} plentiful.

Microscopic Description.

The rock is composed of coarse grained plagioclase (), magnetite and diallage. All these minerals are exceedingly fresh, biotite being the only secondary mineral present and this in small quantity. The plagioclase nicely shows black inclusions arranged in regular lines, as described by Judd, and explained by him under the term Schillerization. The diallage shows beautifully its three cleavages. The magnetite is in very large irregular areas often including augite. It appears to have been the last mineral to crystallize. A small quantity of biotite is found in contact with a portion of the grains of magnetite.

9631

Sl. 3346

Olivine Gabbro

C. R. Van Hise Feb. 23. 1886

Macroscopic Description.

The rock is coarse grained, massive, ^{and} mottled black and ^{white}.

Microscopic Description.

The section is chiefly composed of olivine, plagioclase (), and diallage, with a little magnetite and secondary products. The olivine is much decomposed each of the large areas being cut in every direction along the lines of fracture by alteration products. This secondary material is serpentine, chlorite, chromite (?), and a little biotite. The plagioclase is quite badly kaolinized and chloritized. The augite is mostly fresh but in some places has suffered a chloritic alteration. The magnetite is not great in quantity and frequently is partly surrounded by secondary biotite.

9672

Sl. 3393

Gabbro

C. R. Van Hise Feb. 23. 1886

Macroscopic Description.

The rock is coarse-grained, massive, and of a dark gray color.

Microscopic Description.

In all essential respects this rock is like 9661 the only difference of importance being that it contains relatively less magnetite.

9108

Sl. 2901

Olivine Diabase

C. R. Van Hise. Feb. 23. 1886

Macroscopic Description.

The specimen is a medium grained, dark gray colored, massive rock.

Microscopic Description.

The essential constituents are olivine, plagioclase, (), magnetite and augite. The olivine is quite fresh, abundant, and so far as altered, its decomposition has resulted in the formation of chlorite. The plagioclase and augite are also quite fresh although in places the former is somewhat kaolinized and chloritized. Magnetite is rather uniformly distributed through the rock in medium sized grains. Apatite is a very plentiful inclusion in the plagioclase, frequently being present in large crystals.

9668

Sl. 3391

Gabbro.

C. A. Van Hise, Feb 23. 1886.

Macroscopic Description.

The rock is medium grained, massive, mottled dirty yellow and black in color.

Microscopic Description.

The rock is finer grained than 9661 and 9672 but in most respects is very little different from them. The plagioclase () is fresh, the augite little chloritized. The only noticeable things about the section are the exceedingly large, greatly ramifying areas of magnetite. A single one of these areas includes or partly includes many grains of augite and plagioclase. The magnetite is then clearly the last of the three important minerals to crystallize.

9516

Sl. 7984

Olivine Diabase.C. A. Van Hise, Feb. 23rd. 1886Macroscopic Description.

This rock is almost precisely like 9108 the only difference being that it is finer grained.

Microscopic Description.

The rock is finer grained, somewhat more altered, and contains less olivine than 9108. The plagioclase () is very fresh throughout the greater part of the section. The augite and olivine are, however, chloritized to a considerable degree.

9597

Sl. 3333

Altered Diabase.

C. R. Van Hise Feb. 23. 1886

Macroscopic Description.

The rock is a fine-grained, massive, greenish gray one. It differs from 9516 only in being finer grained.

Microscopic Description.

Original constituents: plagioclase (), magnetite and augite. Secondary ones: ^{hornblende} chlorite and biotite. The plagioclase is quite fresh. The augite has decomposed to a large extent to ^{considerable} chlorite and ^{hornblende} biotite, the former being more plentiful than the latter. As is common in the greenstones, the biotite has frequently arranged itself around particles of magnetite, thus indicating that that mineral has furnished a portion of the iron necessary for the formation of the biotite.

9579

Sl. 3325

Biotitic Chloritic Hornblendic Diabase.

C. R. Van Hise Feb. 23. 1886.

Macroscopic Description.

The rock is medium grained massive, and of a dark green almost black color. Its broken surface shows here and there the yellow lustre of pyrite.

Microscopic Description.

Original constituents: plagioclase (), augite, magnetite. Secondary ones: chlorite, hornblende, and biotite. The plagioclase is tolerably fresh but has in places altered somewhat to chlorite and biotite. Little or none of the original augite remains. Its decomposition products are chlorite, biotite, and hornblende, all being plentiful. The hornblende frequently has a brown color and shows nicely its two cleavages at an angle of $124^{\circ} 30'$. The characteristic position of secondary biotite in greenstones about and included in the ramifying magnetite is here nicely shown.

9686
Sl. 3396

Biotitic and Chloritic Gabbro.

C. R. VanDise Feb. 23. 1886.

Macroscopic Description.

The rock is medium grained, massive, and of a dark grayish green color.

Microscopic Description

Original constituents: plagioclase (), magnetite, and augite. Secondary ones: chlorite and biotite. The plagioclase is considerable altered the decomposition product being mostly chlorite. Not more than one-tenth of the diallage remains it having decomposed to chlorite and biotite, chiefly the former. The characteristic association of magnetite and secondary biotite is here again seen.

9114
Sl. 2791

Altered Biotitic and Chloritic Diabases.

C. R. VanDise Feb. 23. 1886

9585
Sl. 3378

Macroscopic Description.

The rocks are fine grained, massive, and dark greenish gray in color.

9687
Sl. 3397

Microscopic Description.

Original constituents: plagioclase (), magnetite and augite. Secondary ones: chlorite and biotite. These rocks differ from the previously described chloritic biotitic diabases only in being finer grained. They differ among themselves in the varying degree of alteration. In 9114 probably not more than one-third of the augite is altered to chlorite and biotite while in 9585 fully one-half of it is thus changed and in 9687 but little original augite remains. The decomposition of the feldspars has kept pace with that of the augite it being very largely decomposed in 9687 and quite fresh in 9114.

9664

Sl. 3388

Altered Gabbros.

C. A. Van Hise Feb. 23. 1886

9667

Sl. 3389

Macroscopic Description.

9670

Sl. 3392

The rocks are exceedingly coarse grained, massive, and composed in about equal proportions of brownish gray and feldspar and dark green hornblende or diallage. Mingled with these minerals is a comparatively small quantity of magnetite and some pyrite. The coarsest grained one (9667) shows cleavage surfaces of the more important minerals more than half an inch long.

Microscopic Description.

The original minerals were plagioclase () and diallage, with a little magnetite. The secondary ones are hornblende and epidote. The plagioclase occurs in very large individuals. It is mostly quite fresh although it is everywhere somewhat kaolinized and in places has altered to chlorite and epidote. The plagioclase of 9670 has the most remarkable series of inclusions, parallel to certain planes, yet seen in any feldspar. These inclusions are in long lines which resemble needles of rutile in quartz. Their numbers are indefinitely great and they are arranged parallel to four definite planes in each individual of feldspar. Whatever their nature it is certain that the crystallographic properties of the feldspar have controlled their position. In a single twinned feldspar individual these inclusions are arranged parallel to different planes in the two sets of bands. Prof. Judd would consider these inclusions explained by "Schillerization". Inclusions like those in 9670 are equally abundant in 9667 but a higher power is required to discover them. The large areas of original diallage are always partly and often completely altered to hornblende. The resultant hornblende from a single individual of diallage is sometimes a unit and frequently a complex area.

9699

Sl. 3399

Biotitic Hornblende Diabase.

C. R. Van Hise. Feb. 24. 1886

Macroscopic Description.

The rock is a coarse grained, dark greenish gray, massive one.

Microscopic Description.

Original constituents: augite, plagioclase () and magnetite. Secondary ones: biotite and hornblende. The feldspars are small and considerably decomposed. The augite has very largely altered to hornblende and the hornblende partly to biotite. The areas of augite have been very large a single one frequently including scores of crystals of plagioclase. This illustration of ophitic structure is very fine and shows equally well whether the augite is unchanged or has altered to hornblende, a unit of the latter mineral resulting from the former. The partial farther alteration of hornblende to biotite has usually resulted in the formation of many detached, small folia of biotite from a single individual of hornblende; or, if the alteration has proceeded far enough, aggregates of biotite folia. The magnetite occurs in ramifying, grate-like areas and is little decomposed. The augite, as it includes both plagioclase and magnetite, was the last of the three important minerals to crystallize.

9683

Sl. 3395

Altered Hornblende Diabase.

C. R. Van Hise. Feb. 24. 1886.

Macroscopic Description.

This rock is in no respect different from 9699.

Microscopic Description.

Original constituents: apatite, plagioclase (), titanite iron and augite. Secondary ones: chlorite, hornblende and leucocene. This rock differs from 9699 chiefly in its greater alteration. The feldspars are cut by numerous small reticulating aggregates of needles of chlorite and hornblende. The titanite iron is found in grate-like forms as found in 9699. It has largely decomposed, gray leucocene being the resultant product. The augite has almost completely if not quite altered to green hornblende. These secondary areas of hornblende still retain the ophitic structure of the original augite. The apatite is an abundant inclusion in large crystals in all the other minerals.

9601

Sl. 3336

Dioritic Schist.

C. R. Van Hise Feb. 24. 1886.

Macroscopic Description

The rock is a fine grained, light gray, finely laminated, ^{schist.}

Microscopic Description.

Essential constituents: plagioclase (), magnetite, and hornblende. The plagioclase is in part coarse grained and in part fine grained. The coarse grains appear like porphyritic crystals while the fine grains act as a matrix in which the hornblende and magnetite are set. The particles of hornblende are ordinarily of quite small size while often they are in minute, needle-like forms. These hornblende particles are arranged without the slightest reference to the individuals of feldspar, the latter mineral being everywhere cut by them. The hornblende particles are arranged with some regularity with their longer axes in a common direction. The magnetite in small grains and crystals is scattered abundantly and uniformly through the section, being included alike in the hornblende and plagioclase. The rock is believed to be a squeezed eruptive, the metamorphosis to a schist having taken place much as described by Mr. Teall (2. J. G. S., No. 162, p. 133). If this hypothesis is a true one it is probable that the large, somewhat altered individuals of plagioclase are remnants that are left from the originally crystallized rock, while the smaller fresher plagioclases are due to a re-arrangement of the feldspathic material. At first sight this rock somewhat resembles a fragmental one, but the absence of quartz and the thoroughly crystalline character make the clastic origin of the rock very improbable.

9602

Sl. 3337

Dioritic Schist.

C. R. Van Hise, Feb. 24. 1886.

Macroscopic Description.

The rock is a medium grained, black, finely laminated, hornblende schist.

Microscopic Description.

Essential constituents: feldspar, hornblende, magnetite. The feldspar is not particularly abundant. It occurs in individuals of both large and small size and is much kaolinized. Brown basaltic hornblende is the most abundant mineral present, composing perhaps three-fourths of the mass of the rock. Magnetite in small grains is plentifully found between and included in the individuals of hornblende. The ^{chief} only essential difference between this rock and 96³² is that it is much coarser grained and contains no augite.

9632

Sl. 3383

Biotitic Dioritic Schist.

C. R. Van Hise, Feb. 24. 1886

Macroscopic Description.

This rock is not different from 9601.

Microscopic Description.

Essential constituents: plagioclase (), hornblende, biotite, and magnetite. This rock resembles very closely 9601. The re-arrangement of the plagioclase has not proceeded so far there being present more numerous, large, partly decomposed areas of this mineral. In places the hornblende has altered to biotite, in others to chlorite. With these slight differences the rocks are the same.

9402.

Separation by Sp. Gr. of the Feldspars Contained.

E. H. Park, Feb. 1886.

The feldspar was first separated from the ^{other} material in the rock by crushing and collecting the material which passes through a No. 60 sieve and is too large to pass through the No. 80 sieve. In this manner grains of approximately the same size are obtained. They are then placed in a glass-stoppered funnel containing in this case 35 c.c. of Mercury "iodide" solution, sp. gr. 3. At this sp. gr. all the feldspars, together with those having particles of other material clinging to them, float. Sufficient water, sp. gr. 1, is now added to reduce the solution to a sp. gr. 2.75, the maximum sp. gr. for the highest feldspar, anorthite. 5 c.c. of water are required to thus reduce the sp. gr. of the solution. Drawing off the residue at the bottom, the feldspars alone remain. 13 c.c. of the liquid were drawn off with the residue. The remainder, 27 c.c., was now diluted again with water to the maximum sp. gr. of the next lower feldspar, labradorite, (2.71) requiring .63 cu. c. of water, sp. gr. 1. After thoroughly mixing all the feldspars still floated. The solution was again diluted to the maximum sp. gr. of the next lower feldspar, andesite (2.69), requiring .32 c.c. of water sp. gr. 1. A portion of the feldspars now sink. The sp. gr. of the solution ranging between the maximum for labradorite and the maximum for ^{the next lower variety} andesite, the grains that sank must necessarily be labradorite. Drawing this off together with 3 c.c. of the liquid, the remaining solution is again diluted by .5 c.c. water sp. gr. 1 to the sp. gr. of the next lower variety, oligoclase, or 2.65. The remainder of the feldspars now sink thus indicating that they are andesite.

The separated feldspars were now collected on filters, washed thoroughly and then dried. They were then mounted in balsam on glass slides, a few grains being scattered in a place over the slide. They were then dissolved in hydrofluosilicic acid (H_2SiF_6) by placing a drop of acid upon each group. After ~~any~~ solution they recrystallized out as the acid evaporated forming crystals of the mineral. They are now in shape to be studied microscopically or microchemically.

Greenstone Area of the Little Presq Isle.

9407
Sl. 3173

Olivine Diabase.

C. R. Van Hise Feb. 24. 1886

Macroscopic Description.

The rock is a medium grained, gray, massive, fresh one.

Microscopic Description.

Essential constituents: olivine, plagioclase (), magnetite and augite. The plagioclase is very fresh throughout the greater part of the section and in a few places it is somewhat kaolinized. The larger part of the augite is also unaltered although in places quite badly chloritized. The individuals are large and they each include many small plagioclases. The olivine is not great in quantity. The order of crystallization was olivine, plagioclase and magnetite, augite.

9400
Sl. 3047

Biotitic and Chloritic Diabases.

C. R. Van Hise Feb. 24. 1886.

Macroscopic Description.

9401
Sl. 3048

The rocks are medium grained, massive, and of a greenish gray color.

Microscopic Description.

Original constituents: plagioclase (), magnetite, and augite. Secondary ones: chlorite and biotite. In both rocks the plagioclase is considerably altered. Fully one-half the augite has changed to chlorite and biotite and in the remaining half incipient decomposition has begun. These rocks differ from 9402 only in the absence of olivine and in their greater decomposition.

Rocks 7460, 7464, and 7479 described in another place resemble very closely 9400 and 9401.

9367

Sl. 3033

Biotitic Chloritic Diabase.

C. R. Van Hise Feb. 25. 1886.

Macroscopic Description.

The rock is a massive, medium grained, gray one closely resembling 9400 and 9401.

Microscopic Description.

Original constituents: plagioclase (), titanite, iron, augite. Secondary ones: chlorite, biotite, leucosene, and epidote. This rock is considerably more decomposed than 9400 and 9401 but originally must have resembled them closely. The plagioclase is badly altered, its areas everywhere including abundant chlorite and sometimes biotite and epidote. The epidote appears to be secondary to the chlorite while the small brown folia of biotite are direct alterations of the feldspar. The augite to a large extent has also altered to chlorite and biotite. The areas of titanite iron are always surrounded by leucosene and often the original large areas are cut by this material into many smaller ones.

9368

Sl. 3034

Chloritic and Biotitic Diabase.

C. R. Van Hise, Feb. 25. 1886.

Macroscopic Description.

The rock is medium grained, massive, and of a dark grayish green color.

Microscopic Description.

Original constituents: plagioclase (), titanite, iron, augite. Secondary ones: chlorite, kaolin, epidote, and leucosene. The feldspars are almost entirely altered to chlorite and, through this mineral, frequently to epidote. In some places the alteration has been partly a kaolinic one. Augite is the freshest mineral in the section. The greater number of areas of this mineral are chloritized only upon their exteriors. The titanite iron has almost wholly altered to leucosene. This material contains only narrow, grate-like bars of the original menaccanite.

9359

Sl. 2980

Diabase Porphyrite

C. R. Van Hise Feb. 25. 1886.

Macroscopic Description.

The rock is coarse grained, of a light gray color, and shows nicely the lustre mottling characteristic of melaphyrs.

Microscopic Description.

Original constituents: plagioclase () titanite iron, augite. Secondary ones: chlorite, epidote, and leucosene. The ground mass of the rock now consists of plagioclase and chlorite with some titanite iron. The plagioclase is considerably altered the resultant products being chlorite and epidote. The large areas of chlorite, however, are in forms and occupy places, with reference to feldspars, ordinarily taken by augite. It is probable that augite once occupied this position but it is also possible that the chlorite has resulted from the decomposition of a partly unindividualized ground mass, in which case the rock is a true melaphyr. The porphyritic crystals of augite are of great magnitude. They show beautifully an ophitic structure a single crystal contains scores or perhaps a hundred or more of small tabular feldspars. These areas of augite are generally little altered although often the interior plagioclase is largely changed to chlorite and epidote. The titanite iron is generally surrounded by fibres of leucosenes. This rock is closely allied to 9374 and 9375 which are found to the westward in the lower series.

9380

Sl. 3170

Much altered, Fine grained Diabase.

C. R. Van Hise, Feb. 26. 1886

Macroscopic Description.

The rock is fine grained, massive, of a greenish gray color, the fractured surface showing crystals of pyrite.

Microscopic Description.

The constituents are partly altered plagioclase (), titanite iron, leucosene, chlorite and epidote. The secondary minerals, chlorite and epidote, are more plentiful than any of the others. The minerals are all mingled together in a confused way and the original ones so far decomposed as to make it difficult to determine more accurately their relations.

9361

Sl. 3030

Altered, Fine-Grained Diabase.

C. A. Van Hise. Feb. 25. 1886

Macroscopic Description.

The rock is very fine grained, dark greenish gray in color, and the fracture gives indication of a faint schistose structure.

Microscopic Description.9363

Sl. 3031

Aphanitic Diabase.

C. A. Van Hise. Feb. 25. 1886

Macroscopic Description.

The rock is exceedingly fine grained, grayish green in color, and cleaves somewhat more readily in one direction than in the other. Here and there are seen crystals of pyrite.

Microscopic Description.

The rock is exceedingly fine grained and much altered. It consists of a confused, intimately mingled mass of much decomposed plagioclase, of chlorite, of epidote, of titanite iron, and of leucosene.

9257

Sl. 7957

Altered Epidotic Diabase

C. A. Van Hise Mar. 17. 1886.

Macroscopic Description.

The rock is a very fine grained, gray, massive one, in many places spotted with green epidote.

Microscopic Description.

The section now consists of plagioclase, augite, and titanite iron as original constituents and of chlorite, epidote, and leucocene as secondary ones. But little of the original augite remains in a perfectly fresh condition. The plagioclase has very badly decomposed. The alteration of both the plagioclase and orthoclase has resulted in the formation of plentiful chlorite and epidote. Of the plentiful original magnetite only black bars remain in the secondary leucocene. Rock 7421 is precisely like 9257.

9256

Sl. 2951

Altered Epidotic Diabases.

C. A. Van Hise. Mar. 17. 1886

9258

Macroscopic Description.

Sl. 3266

Sl. 3306

9260

Sl. 3106

The rocks are massive fine grained, dark green rocks with the exception of 9258 and 9260 which cleave more readily in one direction than in the others.

Microscopic Description.

9268

Sl. 2954

9269

Sl. 2955

Original minerals: plagioclase, augite, magnetite. Secondary ones: actinolite, chlorite, epidote, and leucocene. The rocks are so badly altered that the various minerals are very confusedly mingled. The augite has very largely, and in some sections completely, altered to actinolite, chlorite and epidote. The plagioclase has also very largely altered to chlorite and epidote so that these minerals are now perhaps the most plentiful ones in the rocks. Some of the areas of epidote are of large size. The magnetite has altered as in 9257. The specimens differ among themselves and from 9257 only in extent of alteration.

Kevernawan Series Greenstones.

Penokee Gap.

2038 Wis.

Chloritic and Biotitic Diabase.

C. R. Van Duse Feb 26. 1886.

Microscopic Description.

Original constituents: Plagioclase (), magnetite, augite. Secondary ones: hornblende, biotite, chlorite and quartz. Accessory: apatite. The plagioclase is much kaolinized and is replaced at times by saturating quartz. This secondary quartz is very considerable in quantity the individuals often being large. But little of the original augite remains it having altered to hornblende, chlorite and biotite. The small grains of magnetite are little changed.

13 Wis.

Altered Gabbro (?)

2028 Wis.

C. R. Van Duse.

Microscopic Description.

The sections are composed of large individuals of plagioclase () and irregularly roundish areas of pale green material which appears to be tremolite and chlorite. In a few places are seen remains of diallage. The areas with regularly curved outlines composed of aggregates of tremolite and chlorite appear to be alteration products of diallage the alteration often having been complete. Farther, if these areas are secondary to diallage the tremolite and chlorite must have eaten into the surrounding feldspar and thus formed the curiously curved outlines.

2037 Wis.

Altered Greenstone.

C. R. Van Duse Feb. 26. 1886

Microscopic Description.

The section consists of partly decomposed tabular crystals of feldspar, of very numerous minute particles of magnetite, and of green fibrous chlorite, the latter being more plentiful than the two preceding minerals combined. A little hornblende also is found.

2 Wis.Altered Gabbro

C. R. Van Hise Feb. 27. 1886.

Microscopic Description

Original constituents: plagioclase, magnetite, diallage; secondary ones, chlorite and biotite. The plagioclases are much kaolinized and often partly chloritized upon their exteriors and sometimes quite to their centers. Fully three-fourths of the diallage has altered to chlorite and biotite chiefly to the former. In the individuals in which this alteration has occurred it has completely chloritized the diallage. The large diallage areas remaining are little affected by chloritic alteration. Much of the pyroxene might more properly be called augite than diallage.

5 Wis.Diorite

C. R. Van Hise Feb. 27. 1886

Microscopic Description

The section is composed of plagioclase and hornblende with a little magnetite and some quartz. Many of the hornblende areas are aggregates of small individuals. If the rock was once a diabase no trace of its original augite remains.

West of Penokee Gap.9704

Sl. 3401

Altered Diabase.

C. R. Van Hise, Feb. 26. 1886.

Macroscopic Description

The rock is medium grained, dark grayish green in color, massive, and along cleavage planes shows the bright green of epidote.

Microscopic Description.

Original constituents: plagioclase, magnetite, augite. Secondary ones: chlorite and kaolin. The individuals of plagioclase are small and the greater portion of them are much altered, the resultant products being chlorite and kaolin. Fully one-half of the augite has chloritized. Many of the individuals are of large size one including frequently many crystals of plagioclase. There are seen a few large, roundish areas which are filled entirely with chlorite and almost completely amorphous silica. These areas appear to be pseud-amygdules.

9700

Sl. 3400

Amygdaloid.

C. R. Van Hise, Feb. 26. 1886.

Macroscopic Description.

The rock has a dark, brownish green, ground mass through which are abundantly found amygdules of white quartz or of quartz combined with chlorite or epidote.

Microscopic Description.

The ground mass of the rock is very fine grained, much altered, and consists apparently of tabular crystals of plagioclase, abundant magnetite, chlorite, and in places epidote. The amygdaloid cavities are filled with quartz, chlorite, epidote, and less frequently calcite or with two or more of these minerals combined.

9708

Sl. 3402

Altered Greenstone.

C. R. Van Hise, Feb. 26. 1886

Macroscopic Description.

The rock is a dark green, almost black, medium grained, massive one.

Microscopic Description.

The rock now consists of partly decomposed plagioclase, of chlorite, of magnetite, of augite, and of epidote. Secondary alterations have proceeded so far that it is difficult to get a definite idea of the original condition of the rock.

33 Ks

Olivine Diabase.

C. R. Van Hise Feb. 27. 1886

Microscopic Description.

The rock is medium grained and is composed chiefly in about equal quantities of plagioclase and augite. Mixed with these minerals is some olivine, quite numerous grains of magnetite, and a little biotite. All the minerals are very fresh the only alteration of any importance being that of augite to biotite.

64 Ks

Altered Gabbro (?)

C. R. Van Hise Feb. 27. 1886

Microscopic Description.

The original constituents are plagioclase, diallage (?), magnetite. Secondary ones: chlorite, quartz, epidote. The section is very coarse grained and much altered. The large individuals of plagioclase are often much kaolinized, at times partly altered to chlorite and epidote, and some areas are very largely replaced by saturating quartz. Where partly replaced by quartz the remaining feldspar is stained by brown ferrite. The areas, which from their shape and location are believed to have been originally diallage, are now composed of chlorite and hornblende. The magnetite is unaltered.

70 Wis.
84 Wis.

Olivine Gabbros.

C. R. Van Hise Feb. 27. 1886

Microscopic Description.

These rocks are very fresh and coarse grained. The mineral constituents are plagioclase, magnetite, augite, and olivine, with some secondary biotite, chlorite, and serpentine. The plagioclase is unaltered and has very numerous dark lines of inclusions parallel to definite planes described in others of the olivine diabases from this region. The diallage is mostly unaltered and so far as affected its alteration has resulted in the formation of hornblende, biotite, and chlorite. The areas of olivine are frequently altered along lines of fracture to serpentine and chromite (?). A narrow border of magnetite frequently surrounds the grains of magnetite. In almost every respect, except in relative proportion of minerals, these rocks are like 9656 previously described.

112 Wis.
113 Wis.

Altered Gabbros.

C. R. Van Hise Feb. 27. 1886

Microscopic Description.

These rocks are exceedingly coarse grained and much altered. The original constituents were plagioclase, diallage, and magnetite. The secondary ones are kaolin, epidote, chlorite, and hornblende. The most of the plagioclase is so largely kaolinized as to have lost twin lamellation and to some extent has altered to chlorite and epidote. The diallage is almost completely altered to hornblende and chlorite, cores only being found in a few of the areas. In this alteration a single diallage has generally formed an aggregate of chlorite and hornblende although in some cases a single large hornblende has resulted from the alteration of a diallage individual. The areas of magnetite are very large and fresh.

106 Wis

2022 Wis.

Biotitic and Hornblende Gabbro.

C. R. Van Duse, Feb. 27, 1886

Microscopic Description.

Original constituents: plagioclase, diallage, and magnetite. Secondary ones: hornblende, biotite, quartz and chlorite. A portion of the plagioclase is quite badly kaolinized and a part replaced by quartz. The alteration of diallage to hornblende and biotite has extensively taken place, more largely to biotite than hornblende. These sections give a very nice illustrations of these forms of alteration. The magnetite is mostly unchanged although it is quite often surrounded by borders of biotite. Large crystals of apatite are abundantly included in all the other minerals.

East of Inokee Gap.

9122

Sl. 2793

Diorite Porphyrite.

C. R. Van Duse. Feb. 27. 1886

Macroscopic Description.

The matrix of the rock is fine grained, of a greenish gray color. In this matrix are numerous, large, dirty white, roundish areas of feldspar.

Microscopic Description.

The matrix is composed very largely of small green needles of hornblende. These needles are in aggregates their longer axes running in all directions. Mingled with the hornblende are quite plentiful, small grains of magnetite and, here and there, crystals of plagioclase. Scattered through this ground mass are very numerous, large, roundish areas of plagioclase ~~and~~ ^{and complex quartz areas} orthoclase. These individuals vary in size from those an eighth of an inch in diameter to those so small as to be lost in the fine hornblendic matrix. The feldspar is quite badly kaolinized at times and often includes many needles of hornblende. In the larger individuals this hornblendic alteration or penetration has not affected their interiors but the smaller grains are pierced through and through by the hornblende needles. The quartzose areas are as large and numerous as those of the feldspar. They are, however, generally complex, whereas the porphyritic feldspar areas are generally simple. Whatever the magnitude of the quartz areas they are cut in every direction by the needles of hornblende. It is probable that the quartz is all secondary, having, perhaps, replaced porphyritic feldspars. It would then be easy to understand the abundant hornblende inclusions. Does the feldspar alter to hornblende where penetrated by needles of this mineral?

9307

Sl. 3110

Diabase Porphyrite

C. A. Van Hise, Feb. 27, 1886.

Macroscopic Description.

The rock is a massive, very fine grained, dark greenish gray one containing ⁱⁿ numerous, large, porphyritic crystals of feldspar some of them a half inch in diameter.

Microscopic Description.

The original constituents of the matrix are plagioclase (), augite and magnetite; secondary ones kaolin, quartz, and chlorite. The plagioclase is found in tabular crystals which are usually quite largely altered, the result and products being kaolin and chlorite. Probably a third of the augite has altered to chlorite. In places finely crystalline, complex quartz has replaced the feldspar. The magnetite is usually but little altered. The large porphyritic crystals of plagioclase are comparatively fresh although many of them are affected to quite an extent by kaolinic decomposition and a few of them have partly altered to chlorite and through that mineral to epidote and in part are replaced by quartz and calcite.

9164

Sl. 2926

Amygdaloid.

C. A. Van Hise Feb. 27, 1886.

Macroscopic Description.

The rock is a massive, exceedingly fine grained, black one containing amygdules of various minerals, calcite and quartz, being the more plentiful.

Microscopic Description.

The ground mass of the rock is exceedingly fine grained. It consists of much altered, minute, tabular feldspars, of small particles of magnetite, and of gray amorphous material. Scattered through this ground mass are very numerous porphyritic crystals of plagioclase. These porphyritic plagioclases are considerably kaolinized and in places altered to chlorite and epidote. The few amygdules in the section are filled with chlorite and finely crystalline quartz or chalcedonic silica. In some amygdules the chlorite is chiefly in the centers with chalcedony surrounding it; in others the reverse is the case; and in still others the two minerals are confusedly intermingled. Throughout the section except in the amygdules quite plentiful grains of epidote are found.

9165

Sl. 2927

Amygdaloid or Pseud-Amygdaloid.

C. R. Van Hise Feb. 27. 1886

Macroscopic Description.

The rock is a rather fine grained, massive, greenish brown one through which are scattered very plentiful roundish black areas which give it a mottled appearance.

Microscopic Description.

The original constituents of the matrix are plagioclase (), augite, magnetite; secondary ones kaolin, chlorite, and epidote. The feldspars are much altered the abundant alteration products being kaolin, chlorite, and epidote. But little if any of the original augite remains. Its decomposition has apparently resulted in the formation of chlorite and, through this mineral, very largely of epidote. The titanite iron is somewhat altered to leucosene. The amygdaloid cavities are filled with chlorite, and exceedingly finely crystallized quartz.

9317

Sl. 3017

Porphyritic Amygdaloid & Pseud-Amygdaloid.

C. R. Van Hise Feb. 27. 1886.

Macroscopic Description.

The matrix of the rock is massive, of a dark green color, fine grained, and contains numerous, small, dark-green amygdulæ. Scattered plentifully through this matrix are large, dirty pink porphyritic feldspar crystals.

Microscopic Description.

The matrix has for original constituents plagioclase, (), augite, magnetite; as secondary ones chlorite and epidote. The plagioclase is in rather small comparatively fresh crystals which are, however, often partly altered to chlorite and epidote. Much of the original augite still remains although much of it has altered to chlorite and epidote. The small amygdaloid cavities are filled with chlorite, finely crystallized quartz, calcite and epidote, one or more of these minerals being present in a single cavity. The section contains but a ^{few} single large porphyritic crystal of feldspar and this is considerably kaolinized.

9306

Sl. 2968

Porphyritic Amygdaloid.

C. A. Van Hise Feb. 27. 1886

Macroscopic Description.

The matrix of the rock is massive, fine grained and of a dirty greenish gray color. It contains numerous dark green amygdules and dirty white porphyritic feldspars.

Microscopic Description.

The rock has undergone an extreme degree of alteration. The matrix now consists of partly altered plagioclase, of chlorite, of epidote, and of the gray decomposition product of titanite iron, with here and there, a little of the unaltered menaccanite. The porphyritic plagioclase is very large replaced by quartz and altered to chlorite and epidote. The few amygdaloid cavities in the section are filled with chlorite and quartz.

9204

Sl. 2997

Amygdaloid

C. A. Van Hise Feb. 27. 1886.

Macroscopic Description.

The rock is a fine grained, greenish brown massive one containing numerous amygdules filled with white quartz and green chlorite and epidote.

Microscopic Description.

The rock is much altered. The matrix now consists of partly decomposed plagioclase, titanite iron and its gray decomposition product, chlorite, and epidote. The amygdaloid cavities are filled with chlorite, epidote, and quartz, with some hematite in one case.

3160 Wis.Amygdaloid.

C. R. Van Hise

Microscopic Description.

The matrix of the rock is composed of partly altered plagioclase, gray amorphous material, magnetite, chlorite and epidote. The amygdaloid cavities are filled with chlorite, epidote, and quartz.

3166 Wis.Olivine Diabase.

C. R. Van Hise. Feb. 24. 1886

Microscopic Description.

The rock is very fresh. It is composed of plagioclase (), magnetite, augite, and olivine. The olivine and magnetite are much less in quantity than the other two minerals. Included in the plagioclase are plentiful, quite large crystals of apatite. The augite has altered a little in some places the resultant minerals being chlorite and biotite.

3168 Wis.Diabase.

C. R. Van Hise. Feb. 24. 1886

Microscopic Description.

This rock is not so coarse grained as 3166 but is more altered than it. It also contains no olivine. The ^{augite} chlorite is altered to a considerable extent to chlorite and to a less degree to biotite.

9316

Sl. 3117

Altered Diabase

C. R. Van Hise. Feb. 27. 1886.

Macroscopic Description.

The rock is a rather fine grained, massive, dark gray one.

Microscopic Description.

Original constituents: plagioclase (), magnetite, augite; secondary ones: chlorite and hematite. The plagioclase is considerably chloritized and kaolinized. Comparatively little of the original augite remains it having almost completely altered to chlorite. The plentiful magnetite is in rod-like forms.

Lower Series Schists Gneisses^{and} Granites.

9674

Sl. 3394

Biotite Gneiss.

C. R. Van Hise. Mar. 10. 1886.

Macroscopic Description.

The rock is light gray in color, fine grained, and rather feebly banded. The bands are due to alternations of coarse and fine material.

Microscopic Description.

The section consists of coarse and fine grained parts. The coarser particles are very largely feldspar. This feldspar is mostly in grains which appear to be rounded. These grains are frequently altered to a considerable extent, the resultant product being small flakes of included biotite. The biotite is more plentiful near the exteriors of the feldspar grains than in the centers. The fine grained parts of the section are composed of finely crystalline quartz, of abundant brown folia of biotite and of feldspar. The general appearance of the section suggests the idea that the rock was originally a clastic, feldspathic one which has undergone the same sort of alteration that has occurred in the Penokee mica schists.

9530

Sl. 3313

Biotite Schist.

C. R. Van Hise, Mar. 10. 1886

Macroscopic Description.

The rock is a dark gray color, of a uniform medium grain and shows its schistose plane by ready cleavage although in appearance it is quite massive and breaks with a sub conchoidal fracture.

Microscopic Description.

The section is composed of quartz, feldspar, and biotite. The biotite is to a considerable degree secondary to feldspar and very possibly all of it is of this nature. The feldspars besides including biotite contain many brilliantly polarizing flakes of kaolin. The quartz is in medium-sized, angular grains, which show no trace of clastic origin. The feldspars, too, if originally rounded have lost their contours. It seems probable from the study of the Penokee mica-schists that this rock is an altered clastic one, however. If this supposition is true the quartz and biotite are doubtless secondary products, both resulting from the disintegration of the feldspars.

9528

Sl. 3331

Hornblende Biotite Schist.

C. R. Van Hise, Mar. 10. 1886

Macroscopic Description.

The rock is a dark gray, fine-grained, and finely schistose one, and cleaves quite readily along the plane of schistosity.

Microscopic Description.

The ground mass of the rock consists of feldspar, most of which is orthoclase, and quartz. Between the particles of feldspar and quartz and included in them are plentiful, quite small folia and blades of quite uniform size of biotite and hornblende; and also small grains of magnetite. In many places the feldspar is kaolinized and a portion of the biotite and hornblende appears to be secondary to it. Included in the quartz and feldspar are quite a number of crystals of apatite. The rock is a thoroughly crystalline one and gives little indication as to the method by which it reached its present condition.

9529

Sl. 3312

Biotitic Schist.

C. R. Van Hise. Mar. 10. 1886

Macroscopic Description.

The rock is of a light gray color, fine grained, finely schistose, and breaks very readily along its schistose plane. It appears from 9528 only in containing a smaller proportion of biotite and hornblende and being consequently of a lighter color.

Microscopic Description.

The ground mass consists of quartz and feldspar as in 9528 and 9530. Also as in those rocks the feldspar is much more plentiful than the quartz and is very largely orthoclase. The partial decomposition of the feldspars has resulted in the formation of kaolin and a little chlorite and biotite. Whether all the biotite is thus secondary to feldspar it is impossible to say. The biotite and magnetite in kind are like those found in 9528 but are much less in quantity.

9080 s

Sl. 2992?

Chloritic Biotite Schist.

C. R. Van Hise Mar. 10. 1886

Macroscopic Description.

The rock is grayish-green, fine grained and finely schistose.

Microscopic Description.

As in the preceding mica schists, the ground mass consists of orthoclase and quartz, the former being preponderant. The biotite and chlorite are very frequently intergrown and are ordinarily buried in the feldspar. This feldspar is so badly kaolinized that it is with difficulty that the outlines of the individuals are determined. In the biotite are included numerous small needles of some black substance. The parallel intergrowth of the chlorite and biotite, referred to above, is in many cases quite complex, there being in each flake several parallel layers of each of the two minerals.

9229

Sl. 2945

Chloritic Biotite Schist.

C. K. Van Duse Mar. 10. 1886

Macroscopic Description.

The rock is of a light gray color, fine grained and finely laminated. In appearance and cleavage it is a typical biotite schist.

Microscopic Description.

In essential points this rock differs little from 9080. Its groundmass is quartz and kaolinized orthoclase. The biotite and chlorite are intergrown in the same manner. The principal differences between this rock and 9080 are coarseness of grain and relative proportions of the different minerals.

9458

Sl. 3077

Hornblende Biotite Schist.

C. K. Van Duse, Mar. 10. 1886

Macroscopic Description.

The rock is of a dark green color, has a fine grained ground mass which contains numerous large grains of hornblende, and has a well developed schistose structure.

Microscopic Description.

The ground mass consists of rather small grains of quartz and partly altered ones of feldspar. The biotite is in small flakes which have their longest axes in a common direction. These folia cut through both quartz and feldspar without paying the slightest attention to them. The hornblende is in large bluish green blades, which often include many particles of quartz and feldspar. These blades of hornblende sometimes have partial crystal out lines. In a few cases they are cut ^{perpendicular to the} vertical axis, when they show both prismatic cleavages and the transmitted light is yellow. Here and there small grains of magnetite are seen.

9060

Hornblende Schists.

Sl. 2921

C. R. Van Hise, Mar. 10. 1886.

9351

Macroscopic Description.

Sl. 3117

Rocks 9060 and 9351 are dark green, fine grained, typical hornblende schists. 9351 is coarser grained and more massive.

Microscopic Description.

In all the specimens there is a fine grained, intricately interlocking ground mass consisting of quartz and feldspar. The feldspar is more altered in 9351 and 9352 than in 9060. The decomposition products are here kaolin, chlorite, and epidote. In this fine ground mass are very abundant large blades of hornblende and, in 9060, large individuals of feldspar. The areas of hornblende vary from those of large size ~~to~~ down to minute needles. The large areas generally have serrate ends which frequently cut through many grains of quartz and feldspar. In 9060 the larger feldspar grains contain very numerous small needles of hornblende and the feldspars are often farther cut by the long serrate terminations of the hornblende blades of greater magnitude. Whether this hornblende is secondary to the feldspar in this case or the feldspar has grown around the hornblende particles it is impossible to say. In all the sections quite plentiful, small grains of magnetite are uniformly distributed.

9353

Epidotic Hornblende Schist.

Sl. 3028

C. R. Van Hise, Mar. 10. 1886.

9200

Macroscopic Description.

Sl. 2934

The rocks are coarse grained, of a dark green color, and are quite massive although a little indication of schistose structure is seen.

Microscopic Description.

A rather sparse ground mass of quartz and badly altered feldspar contains very abundant hornblende with some biotite and chlorite. The decomposition of the feldspar has resulted in the formation of kaolin, chlorite, and epidote. A little magnetite is seen. The sharp serrate terminations of the hornblende blades and the numerous independent needles of the same mineral are found cutting the quartz and feldspar *

9050

Sl. 2776

Hornblende Schist.

C. R. Van Hise, Mar. 10. 1886.

Macroscopic Description.

The rock is a dark green, medium grained, typical hornblende schist.

Microscopic Description.

A fine ground mass consisting of quartz and badly altered feldspar is found as in the previous hornblende schists. Besides the small grains of feldspar there are plentiful, large, well rounded ones which have a decided clastic appearance. These larger feldspars, as well as the small ones, are almost completely altered to brilliantly polarizing kaolin or muscovite or both. Hornblende in blades of varying sizes is very abundant. While these blades frequently cut the smaller grains of quartz and feldspar they nowhere penetrate the large feldspar grains. Epidote and magnetite are accessories.

9196

Sl. 2933

9197

Hornblende Schist.

C. R. Van Hise, Mar. 10. 1886

Macroscopic Description.

The rock is a light greenish gray, coarse grained schist.

Microscopic Description.

Medium sized grains of feldspar and quartz make up the ground mass of the rock. The feldspar is much ^{more} abundant than the quartz, is in small part plagioclase, and is badly kaolinized. The hornblende is not particularly abundant and is scattered uniformly throughout the section. Apatite, magnetite, and epidote are accessories.

Hornblende Schists.

C. R. Van Hise Mar. 11. 1886

9057

Sl. 2887

9058

Sl. 2888

9080

Sl. 2893

9131

Sl. 2910

Macroscopic Description.

The rocks are very fine grained, of a dark grayish green color. They have a very finely laminated, schistose structure, but are so massive that breakage takes place quite easily across the schistose planes.

Microscopic Description.

The sections are much finer grained than any of those of the previously described hornblende schists. In all a finely crystalline, abundant ground mass composed of quartz and plagioclase is present. In this ground mass are plentiful small needles and blades of hornblende, which compose perhaps one third of the mass of the rocks. The individuals of this mineral cut through those of quartz and feldspar and are arranged with some uniformity with their longest axes in a common direction. The feldspars are kaolinized in different degrees in the rocks. In 9058, are found some large individuals of orthoclase and plagioclase which have a fragmental appearance. These areas are usually deeply cut by blades of hornblende and upon their exteriors also include fine grains of quartz. These areas look as if this quartz and hornblende are secondary, they have resulted from the decomposition of the feldspar. Is it possible that a coarse-grained, clastic, feldspar rock can by its alterations produce a fine grained, quartz, feldspar, hornblende one, * without involving anything more than ordinary metosomatic changes? Magnetite in small grains is quite an important accessory. Accompanying the hornblende in 9058 and 9080 is a considerable quantity of biotite. Epidote is also in small grains an accessory mineral.

9150

Sl. 2801

Hornblende Schist.

C. R. Van Hise, Mar. 11. 1886

Macroscopic Description.

This rock is not materially different from 9057, 9058, 9080, and 9131. The broken surface shows plentiful small crystals of pyrite.

Microscopic Description.

A sparse ground mass consisting of minute particles of quartz and feldspar, the latter ^{badly} decomposed, contains abundant green hornblende and less plentiful chlorite, the latter minerals composing fully two thirds of the mass of the rock. Epidote, magnetite, and sparing large crystals of pyrite are accessories. In one place in the section covering perhaps a third of its area is a complex oval outlined concretion composed almost wholly of quartz and feldspar with little hornblende.

9456

Sl. 3076

Hornblende Schist.

C. R. Van Hise, Mar. 11. 1886

Macroscopic Description.

The rock is an aphanitic, dark grayish green, finely schistose one.

Microscopic Description.

The section is so exceedingly fine grained that it is difficult to make out with certainty all of its constituents. It appears, however, to be almost wholly composed of very finely crystalline quartz and minute blades of hornblende, mingled with some epidote and ferrite and probably also with feldspar.

Chloritic Hornblende Schist

C. R. Van Hise, Mar. 11. 1886

Macroscopic Description.

The rock is grayish green in color, very fine grained, and, by cleavage rather than appearance, indicates its schistose structure.

Microscopic Description

The section consists of confusedly mingled quartz, feldspar, hornblende, chlorite, and epidote, the two latter minerals, however, being less abundant than the three former. The particles of quartz and feldspar are mostly of small size, but here and there much larger ones are found. These feldspars are badly altered and include many blades of hornblende and grains of epidote these minerals both appearing to result from the decomposition of the feldspar.

9093

Sl. 7786

Chloritic and Magnetitic Hornblende Schist.

C. R. Van Hise, Mar. 11. 1886.

Macroscopic Description.

The rock is a mottled grayish green, fine grained, and quite massive schist.

Microscopic Description.

The section has a ground mass consisting of quartz and feldspar, a portion of the latter being plagioclase, which includes very plentiful hornblende, magnetite, chlorite, and many small flakes of white mica. The chlorite is sometimes concentrated in large complex areas excluding all other minerals. The magnetite is very often crystal outlined. There are present a few large grains of partly kaolinized orthoclase and plagioclase. Calcite or dolomite is an accessory.

9281

Sl. 2958

Chlorite Schists.

C. R. Van Hise Mar. 12. 1886.

9283

Sl. 2960

Macroscopic Description.

9279

The rocks are of a light gray color, fine grained, and finely schistose. They cleave readily parallel to the schistose plane.

Microscopic Description.

The ground mass of the section consists of quartz and badly kaolinized feldspar. The chlorite is in pale green flakes which mostly have their cleavage and longest axes in a common direction. The flakes are often buried in or partly surrounded by the feldspar, but whether secondary or not to that mineral it is impossible to say. The feldspar is mostly so badly kaolinized as to make it uncertain what part of it is plagioclase. Here and there a grain of plagioclase is fresh enough to show twin lamellation.

9282

Sl. 2959

9278

Chlorite Schist

C. R. Van Hise, Mar. 12. 1886.

Macroscopic Description.

The rock is a greenish gray, coarse grained schist, containing numerous crystals of pyrite.

Microscopic Description.

This rock differs from 9281 and 9283 chiefly in being coarser grained than they are. Some of the feldspar grains, both orthoclase and plagioclase, are very large and all are badly kaolinized. The chlorite is also sometimes in large areas. Scattered here and there through the section are crystals of pyrite. Calcite is an accessory.

9102

Hornblende Chlorite Schists.

Sl. 2898

C. R. Van Hise Mar. 12. 1886

9103

Macroscopic Description.

Sl. 2899

The rocks are grayish green, fine grained schists, showing in many places cleavage surfaces of calcite.

Microscopic Description.

The larger parts of the sections are composed of confusedly mingled quartz, chlorite, and somewhat kaolinized feldspar, all in fine particles. Scattered through this ground mass are quite large grains of orthoclase and plagioclase. These larger feldspars generally have rounded outlines but whether clastic or porphyritic it is difficult to say. In large patches through the sections a portion of the chlorite is massed. Secondary calcite has replaced wholly or partially quite large areas.

9106

Chloritic Schist

Sl. 2900

C. R. Van Hise Mar. 12. 1886

Macroscopic Description.

The rock is a fine grained, almost massive, grayish green schist, mottled by patches of dark green chlorite.

Microscopic Description.

The greater portion of the section is exceedingly fine grained and is composed of most confusedly mingled quartz, partly decomposed feldspar, kaolin and perhaps epidote. In this ground mass are contained large oval grains of feldspar now almost completely kaolinized; and also quite numerous roundish areas composed of complex, coarse grained, interlocking grains of quartz. Calcite is an accessory.

9179

Sl. 3304

Chloritic Schist

C. R. Van Hise, Mar. 12. 1886.

This rock resembles closely 9106 but is more chloritic and schistose.

Microscopic Description.

The section differs but little in essential particulars from that of 9106. The ground mass is not quite so fine grained nor so confused. The minerals contained are the same. Large complex areas of quartz and large individuals of orthoclase and plagioclase are found precisely as in 9106. In some cases the alterations of the feldspars have proceeded so far as to make them almost like the matrix.

9277

Sl. 2956

Calcitic Chlorite Schists

C. R. Van Hise, Mar. 12. 1886.

9278

Sl. 2957

Macroscopic Description

The rocks are of a dirty green color and coarse grained.

Microscopic Description.

The sections are composed of quartz, kaolinized feldspar, chlorite, and calcite, with some iron oxide. These minerals are so confusedly mingled that little more can be said of them.

9416

Sl. 3057

Chlorite Schists

C. R. Van Hise, Mar. 12. 1886.

9417

Sl. 3058

Macroscopic Description

The rocks are of a grayish green color, are fine grained and finely schistose. While breaking most readily along the schistose plane, they are so massive that fracture takes place easily across the plane of schistosity. In all of them pyrite is seen. 9427 contains concretions of white complex quartz which at first sight resemble small pebbles.

Microscopic Description.

The sections are mostly composed of rather small, interlocking particles of quartz, feldspar, folia of chlorite, with calcite and epidote. Mingled with these minerals are larger individuals of somewhat kaolinized orthoclase and plagioclase. In 9427 is seen one of the roundish complex quartz concretions.

q428

Sl. 2981

Chlorite Schist

C. R. Van Hise, Mar. 12. 1886.

Macroscopic Description.

This rock is like q427.

Microscopic Description.

The ~~rock~~ appears to have been like q427 but the feldspar has almost completely altered to chlorite and epidote.

q459

Sl. 3309

Sericitic and Chloritic Schist

C. R. Van Hise, Mar. 12. 1886

Macroscopic Description.

The rock is of a light greenish gray color. Its broken surface shows the schistose structure but it is so massive that it breaks almost as readily perpendicular to the schistose plane as parallel to it. ^{Microscopic Description.} As in the previously described schists, the ground mass consists of quartz and feldspar, but the proportion of the quartz in this rock is very great. This ground mass contains many simple ^{and} complex large ^{in the} areas of feldspar which are often more or less deeply cut by the matrix, are considerably kaolinized and include quite large folia of secondary sericite or muscovite. Scattered thickly through the matrix are small ^{green} folia of chlorite and colorless ones of muscovite or sericite. The larger of the folia of sericite or muscovite often include many grains of quartz. They are in appearance precisely like those secondary to the feldspars. The section is cut by veins and reticulating areas of calcite. ^{It} The longer this section is examined the more closely it ^{is seen to} resemble the muscovitic greywackes from Tenokoe Gap, in which their present condition has been reached by metamorphic changes their original ^{one} being clastic feldspathic rocks.

9172
Sh. 929

Actinolitic Chlorite Schist or Rock.

C. R. Van Hise. Mar. 12. 1886

Macroscopic Description.

The rock is a dark green, fine grained, schistose one, breaking readily parallel to the plane of schistosity.

Microscopic Description.

A large part of the section is composed of an almost solid mass of chlorite. This chlorite is seen to include calcite and quartz and doubtless contains other minerals. The only remaining mineral of importance in the section is actinolite. This mineral occurs in sections with crystal outlines when cut perpendicular to the vertical axis in which case both prismatic cleavages are seen. But when cut parallel to the vertical axis the individuals terminate in many, long, needle-like points, which penetrate deeply into the chlorite. Sometimes the blades of actinolite are clustered in sheaf-like forms. The perfect freshness of the actinolite and its deep penetration of the chlorite indicate that it is secondary to the latter mineral. Magnetite is an accessory in small particles.

General.

A study of the lower green schists makes it appear probable that many if not all of them have developed from clastic rocks by metamorphic changes, and these changes are of the kind described in ^{the} Fenokee Gogebic Haronian mica schists. The reasons for this belief of their origin are briefly as follows: A few of the less altered ones are almost certainly of this origin, as is shown by their descriptions. (Examples 9459, 9530, 9674.) In nearly all of the schists large individuals of feldspar are found which have fragmental appearances. In almost every case these feldspars are more or less altered, producing by this alteration mica (both muscovite and biotite), chlorite, epidote, ^{and} kaolin. The chemical compositions of orthoclase and oligoclase ~~are~~ such that in the formation of these minerals free silica or quartz must also have been produced. In other words, a quartz, feldspar fragmental rock by simple metamorphic alteration may produce all the minerals which are ordinarily found in the lower green schists. These

changes certainly do take place in many if not all of these schists, for the large feldspar grains are cut more or less deeply by the matrix and include these secondary minerals. Often the feldspar grades by imperceptible degrees into the fine quartzose matrix. If we but conceive that the changes which here so evidently occur, ^{to} have occurred extensively in the past it is easy to conceive how the present condition of the lower green schists might have been reached by metamorphic changes in quartz feldspar rocks.

Limestones, Quartzites² & Cherts East of Little Presqu' Isle,

qr13

Sl. 3000

Quartzitic Dolomites.

C. R. Van Hise, Mar. 13. 1886

qr14

Sl. 2937

Macroscopic Description.

The rocks are of a gray color, of medium uniform grain, massive, and break with a conchoidal fracture.

Microscopic Description.

The sections are composed of well rounded, clastic particles of quartz and feldspar set in a matrix of dolomite. The grains of quartz are of medium, uniform size. Often they are slightly enlarged and, while so plentiful as to compose one-third the mass of the rock, they are rarely in contact with each other. The feldspar is of the species orthoclase and plagioclases, a portion of the latter being microcline. It is much less abundant than the quartz and, like the quartz, is scattered through the dolomite in detached particles. Also in the dolomite are quite numerous cherty areas. A portion of these are certainly complex clastic fragments but others appear to be of a secondary nature. Surrounding all the above minerals, cementing them, and composing about one-half of the rock is crystalline dolomite. Chlorite, ^{sericite,} and ferrite are sparse accessories.

Rocks 7368 and 7369 described in another place differ from these rocks only in being coarser grained.

qr15

Sl. 2938

Ferruginous Quartzitic Dolomite.

C. R. Van Hise, Mar. 11. 1886.

Macroscopic Description.

This rock differs from qr13 and qr14 in that it is of a bright brick red color.

Microscopic Description.

The section of qr15 differs from those of qr13 and qr14 in that the dolomite is everywhere heavily impregnated by minute particles of reddish-brown ferrite.

Flint.

q216

Sl. 2939

C. A. Van Hise, Mar. 13. 1886.

Macroscopic Description.

The rock is a gray aphanitic chert or flint.

Microscopic Description.

The section is composed mostly of exceedingly finely crystalline interlocking quartz, perhaps in places mingled with some amorphous silica. A vein cutting across the section is quite coarsely crystalline, interlocking quartz. As accessories quite a good many small particles of dolomite and of dark brown or black ferrite are found. The sections of 7370 and 7371 resemble closely this rock.

q217

Sl. 2940

Galena-bearing Flint.C. A. Van Hise, Mar. 13th. 1886.Macroscopic Description.

The rock is an aphanitic flint heavily charged with galena, and in places with chalco-pyrite.

Microscopic Description.

The major portion of the section is composed of very finely crystalline, minutely interlocking quartz, like that in q216. A vein of coarse interlocking quartz cuts through the section and a portion of these grains are large clastic^{one}, while it is possible that all are of this nature. Scattered plentifully through the section are crystals of gray, lustrous galenite and less plentiful ones of chalco-pyrite. Sericite is an accessory in parts of the section.

9218
Sl. 2941

Chloritic and Quarzitic Dolomite.

C. R. Van Hise, Mar. 13. 1886.

Macroscopic Description.

The rock is a dark greenish gray, fine grained, massive one, cut by veins of calcite and containing layers of dark green chlorite.

Microscopic Description

Finely granular dolomite composes nine-tenths of the area of the section. This dolomite includes fibres of chlorite and is cut by veins ^{consisting} of quartz and coarsely crystalline calcite or dolomite.

9276
Sl. 3006

Ferro-Dolomite and Flint

C. R. Van Hise, Mar. 13. 1886.

Macroscopic Description.

The rock is a very light gray, fine-grained, massive one, breaking with a conchoidal fracture. It weathers to a porous dark brown, plainly heavily ferruginous material.

Microscopic Description.

The section is composed of intermingled, brilliantly polarizing ferro-dolomite and finely crystallized, interlocking quartz, the two minerals ^{both} being plentiful but the ferro-dolomite preponderant.

9284
Sl. 2961

Sericitic Greywacke.

C. R. Van Hise, Mar. 13. 1886

Macroscopic Description.

The rock is of a dark gray color, fine grained, schistose, and cleaves readily parallel to the schistose plane.

Microscopic Description

Rather small clastic particles of quartz and feldspar, the former preponderant, compose three-fourths or more of the rock. The grains of quartz are usually somewhat enlarged. The feldspar is in part orthoclase and in part plagioclase. The interstices are filled with finely crystalline quartz, with kaolin or sericite, with chlorite, and with plentiful grains of a black lustrous mineral which the magnet shows not to be magnetite but which may be galenite.

9285

Sl. 2962

Magnetite Schist.

C. R. Van Hise Mar. 15. 1886.

Macroscopic Description.

The rock is a black, medium grained, heavily magnetic schist.

Microscopic Description.

A continuous ramifying sheet of magnetite composes more than one half the area of the section. Set in this magnetite as a matrix are numerous fragmental grains of quartz and feldspar. The quartz is the more plentiful of the two minerals. The larger number of grains are simple although quite a good many are finely complex jasper particles. The simple quartz grains are in most cases slightly enlarged. The feldspar includes both orthoclase and plagioclase much of the latter being microcline. Quite a number of grains are badly kaolinized. This rock resembles very closely 7436. Mingled with the magnetite in places is a considerable hematite.

9286

Sl. 2963

Magnetitic Greywacke or
Magnetitic³ Feldspathic Quartzite.

C. R. Van Hise. Mar. 15. 1886

Macroscopic Description.

The rock is a medium grained, compact, gray quartzite or greywacke which breaks with a conchoidal fracture.

Microscopic Description.

Clastic particles of quartz and feldspar in rather small grains of quite uniform size compose four fifths or more of the section. The grains of quartz are usually quite largely enlarged. Most of them are simple but a small portion are complex jaspery grains. The feldspar is in part orthoclase and in part plagioclase. The grains are often badly kaolinized, and usually chloritized upon their outer borders. Sometimes the feldspar has been altered to kaolin and chlorite. Magnetite, finely crystalline silica, and secondary chlorite are the important interstitial minerals, magnetite being the most abundant of the three. This rock differs from 9285 in containing much less magnetite and much more quartz and feldspar. It is precisely like 7437.

9287

Sl. 3008

Magnetitic Greywackes.

C. R. Van Hise Mar. 15. 1886

9295

Sl. 3012

Macroscopic Description.

9295 is little different from 9286. 9287 is of a somewhat lighter gray color and coarser grained.

Microscopic Description.

The minerals present and their relations are but little different from those in 9286. The enlargement of the quartz grains in 9287 has resulted in much more intricate interlocking than in 9286, while 9295 occupies an intermediate position. The interlocking of the quartz grains in 9287 is of the most intricate, sharply serrate kind.

9307

Sl. 3014

9307 A

Sl. 3015

Magnetitic Greywackes.

C. R. Van Hise, Mar. 15. 1886.

Macroscopic Description.

9307 is finer grained than 9286 as is 9307 a finer grained than 9285. In other respects the rocks are alike.

Microscopic Description.

Rather small fragmental grains of quartz and feldspar are the most important minerals present. The enlargements of the grains of quartz are relatively very wide. The feldspar is altered to a considerable extent to Kaolin and chlorite. A few blades of white mica are found. Magnetite is an abundant interstitial mineral being more abundant in 9307 A than in 9307. Mingled with the magnetite is some hematite. Calcite is found in 9302.

9318

Sl. 3018

Magnetite Schist or Very Hardly Magnetitic Gneiss

C. R. Van Hise, Mar. 15/86.

9320

Sl. 2973

Macroscopic Description.

These rocks are massive, rather fine grained, of a very dark brown, almost black color, and break with a sub-conchoidal fracture.

Microscopic Description.

There is present a magma consisting of a continuous, ramifying mixture of hematite and magnetite. Scattered through this matrix and composing half the rock are small, rather angular grains of quartz and feldspar. The ^{simple} parti-

9318

9370

cles of quartz are enlarged. Many of them are finely complex, flinty and chalcedonic silica. The feldspar, which is much less abundant than the quartz, is mostly fresh, although a few of the grains are considerably kaolinized.

9305

Sl. 3109

Quartzitic Hematite and Magnetite.

C. R. Van Hise Mar. 16. 1886

Macroscopic Description.

The rock is a rather coarse-grained magnetite and hematite schist containing fragments of quartz, flint, and jasper.

Microscopic Description.

The section is composed of an almost solid mass of intimately mingled hematite and magnetite. Included in the hematite and magnetite are elastic grains of quartz, both simple and finely complex, and a few of feldspar.

9309

Sl. 2969

Magnetitic Greywackes.

C. R. Van Hise Mar. 16. 1886

9310

Sl. 3016

Macroscopic Description.

These rocks are fine grained dark green schists. The bedding lines are almost perpendicular to the planes of easiest fracture. The rocks then have true slaty cleavage.

Microscopic Description.

The rock in its original condition was composed largely of rather small clastic particles of quartz and feldspar. The grains of quartz have received secondary enlargement. Those of feldspar have very largely altered to aggregates of green chlorite, this mineral now being one of the most plentiful in the section. Numerous crystals of magnetite are uniformly distributed.

9291

Sl. 3011

Heavily Ferruginous Actinolite Schists.

C. R. Van Hise Mar. 16. 1886

9292

Sl. 3107

Macroscopic Description.

Sl. 3108

The rocks are banded, aphanitic, heavily magnetitic, dark green schists.

Microscopic Descriptions.

The sections are composed of actinolite, chlorite, magnetite and brownish red oxide of iron, and in places finely crystalline silica. The chlorite is all secondary to actinolite and that mineral was evidently the predominant one in the sections. It occurs in aggregate which are arranged in sheaf-like forms and in spherulitic radial masses. It is everywhere heavily stained with brownish-red and brownish-yellow oxide of iron. Included in it are numerous crystals of magnetite of varying sizes, most of them, however, being small. In 9291 the chloritic alteration of the actinolite has taken place to a greater extent than in 9292 and hematite and magnetite are much more important, being together as plentiful as the actinolite. The finely crystalline quartz is only seen in the thinner parts of the sections, but it is probably everywhere present but obscured by the large quantities of actinolite and iron oxides.

9354

Sl. 3308

Ferruginous Actinolite Schists.

C. R. Van Hise, Mar. 16. 1886.

9355

Sl. 3119

Macroscopic Description.

9356

Sl. 3268

These rocks are coarser grained than 9291 and 9292 but in other respects are like them.

Microscopic Description.

Actinolite, chlorite, quartz, magnetite, hematite, and brown ferrite are the minerals present in the sections. They were mostly composed of actinolite and iron oxides. The actinolite is now to a large extent altered to chlorite. It is everywhere deeply stained with hematite and limonite. The larger blades of actinolite are but little affected by the chloritic alteration and but little stained by iron oxides. The magnetite is in very numerous minute grains.

9297

Sl. 2965

Hematitic and Magnetitic Flint.

C. R. Van Hise, Mar. 16. 1886

Macroscopic Description.

The rock is a very fine grained, massive one of a red or black color according as hematite or magnetite is the predominating accessory constituent.

Microscopic Description.

Finely crystalline, intercatly interlocking quartz is the ground-mass and composes fully four-fifths the mass of the rock. Scattered through this ground-mass are numerous detached particles of hematite and magnetite and large irregular, ramifying areas of the same minerals.

Slates and Conglomerates East of the Little Reservoir

9206

Sl. 2935

Clay Slate.

C. R. Van Hise Mar. 17. 1886

Macroscopic Description.

The rock is a light grayish green, aphanitic, finely schistose slate.

Microscopic Description.

The section is composed of intimately mingled minute particles of quartz, chlorite, kaolin, with some ferrite.

9207

Sl. 3305

Chloritic Clay Slate.

C. R. Van Hise Mar. 17. 1886.

Macroscopic Description.

The rock is a light grayish green, soft, finely laminated slate or shale.

Microscopic Description.

Confusedly mingled chlorite, quartz, kaolin, ferrite and calcite compose the section. The quartz is very fine grained. Chlorite is in minute pale green fibres, which are arranged in a common direction, and is the most abundant mineral of the section.

9220

Sl. 3001

Clay Slates.

C. R. Van Hise Mar. 17. 1886.

9235

Sl. 3003

Macroscopic Description.

The rocks are aphanitic, dark gray cleaved slates.

Microscopic Description.

The sections are composed of chlorite, quartz, kaolin, and ferrite, the first two minerals being the preponderant ones. They are excessively fine grained and in this point and in containing very numerous dark brown and black opaque particles of ferrite they differ from 9207.

9233

Sl. 2946

Quartzitic and Feldspathic Dolomite.

C. R. Van Hise Mar. 17. 1886.

Macroscopic Description.

The rock is a medium grained gray rock, having a well developed schistose structure. It weathers to a dark brown color.

Microscopic Description.

Ferro dolomite constitutes the ground mass in which the other minerals are buried and composes two thirds the mass of the rock. Included in the ferro dolomite are plentiful clastic grains of quartz and feldspar. The larger number of the quartz particles are simple. The remainder are finely complex. The grains of feldspar are somewhat kaolinized and upon their exteriors chloritized and some of them are replaced in part by calcite.

9234

Sl. 2947

Ferro-Dolomitic Greywacke.

C. R. Van Hise Mar. 17. 1886.

Macroscopic Description.

The rock is a dark gray, rather fine grained schistose one containing very numerous dark brown areas of mingled ferro dolomite and limonite, which give the rock a strongly mottled appearance.

Microscopic Description.

The section has a very fine grained matrix consisting of quartz chlorite and black opaque ferrite. Scattered plentifully through this matrix are grains of clastic quartz and feldspar. The areas which give the rock its mottled appearance are composed of ferro dolomite or

9734 limonite or both combined. All of these rounded areas have plainly originally been ferro-dolomite. The alteration of this mineral has produced the limonite. All stages of the change may be seen, from those areas which are pure ferro-dolomite through those in which the ferro-dolomite has altered to limonite along cleavage lines to those in which no ferro-dolomite remains. Slide 1860 resembles closely that of 9734 but ^{in it but} little of the ferro-dolomite is altered to limonite.

9759

Ferro-Dolomitic Chlorite Schists.

Sl. 2953

C. R. Van Hise Mar. 17. 1886

9761

Macroscopic Description.

Sl. 3005

The rocks are dark green, finely laminated chlorite, schists, mottled with small white or yellow areas of some included mineral.

Microscopic Description.

The sections are composed of small particles of quartz, feldspar, chlorite, and ferrite. Included in this fine ground mass, which appears to contain fragmental material, are quite plentiful large, fragmental feldspar grains. These feldspars are partly decomposed and partly replaced by ferro-dolomite.

9222

Sl. 2942

9298

Sl. 2966

9299

Sl. 2967

Altered Diabases.

C. R. Van Hise Mar. 25. 1886

Macroscopic Description.

The rocks are fine grained dark green rocks which have a well developed cleavage.

Microscopic Description.

The sections are composed chiefly of badly altered plagioclase, chlorite, gray amorphous material, ferrite, with some epidote and calcite. The tabular crystals of plagioclase, which appears to have been the mineral of greatest importance in the rock, are very largely altered to chlorite and through this mineral, in part, to epidote. If the rocks have once contained augite it has now entirely disappeared and green chlorite and aggregates of gray amorphous material occupy the positions, relative to feldspar, ordinarily taken by augite in diabases. No ^{unmistakable} magnetite is found in the sections, but in slide 2966 are present very plentiful dark brown and black opaque particles of ferrite. Calcite is present as the last stage of the changes which have taken place with the feldspar. The alteration products of that mineral have often been entirely removed and are replaced by calcite. 7449, 7449a and 7451 differ from the preceding rocks only in containing a very much smaller quantity of chlorite. They are composed almost entirely of partly decomposed plagioclase and gray, amorphous material.

9328

Sl. 2976

Chloritic Diabase.

C. A. Van Hise Mar. 25. 1886

Macroscopic Description.

The rock is a dark green, rather fine grained, schistose one mottled by white, small granules which are very numerous.

Microscopic Description.

Plagioclase and chlorite compose the greater part of the rock. Epidote, ferrite, and gray amorphous material are the remaining constituents of importance. The plagioclase is in well defined crystals which usually show polysynthetic twinning although the mineral is considerably decomposed. The augite supposed to have once been present is entirely altered to chlorite. Here and there small black grains of magnetite remain although the greater part of this mineral has altered to hematite and limonite. Epidote has quite extensively formed from the alteration of the secondary chlorite. In one or two places in the section are large oval areas which are filled with chlorite and epidote in one case and in the other with chlorite and quartz.

9322

Sl. 3307

Chloritic Diabases.

C. A. Van Hise Mar. 25. 1886

9323

Sl. 2974

Macroscopic Description.

The rocks are dark green, fine grained, schistose ones containing quite numerous, spherical amygdules which are filled ^{apparently} with chlorite, calcite, and chert. In many cases the chert is kernel surrounded by a layer of chlorite, in other cases the various minerals are intricately mingled.

Microscopic Description.

The matrices of these rocks are essentially like 9328. This is particularly the case with 9322. In 9323 the decomposition of the augite and plagioclase has resulted in the formation of much actinolite as well as chlorite. Calcite is a replacing product of the badly altered plagioclase. The oval and spherical amygdules are filled with chlorite, flinty quartz, and in a few cases with calcite. Both hematite and magnetite are plentiful in small particles. The decomposition of these rocks has proceeded considerably farther than in 9328.

9338

Sl. 3114

Greenstone Schists.

C. A. Van Hise, Mar. 25, 1886

9339

Sl. 3115

Macroscopic Description.9358

Sl. 3023

The rocks are dark green, fine grained schists, having a conglomeratic appearance. Upon the weathered surfaces they look like typical conglomerates. Here the harder portions which are pebble-like in shape protrude in oval outlines. Upon the broken surfaces also the conglomeratic appearance is retained. The hard, irregular, roundish pebbles are of a lighter grayish green color than the matrix which contains them.

Microscopic Description.

The sections are composed of very much altered, long tabular crystals of plagioclase, of gray amorphous material, of chlorite, and some quartz, and epidote. The decomposition of the plagioclase has resulted in the formation of chlorite and epidote. There are a few larger crystals of porphyritic plagioclase found. The apparent pebbles and matrix noted macroscopically, differ from each other but little in composition. The "pebbles" seem to be but nodules due to secondary alteration. These nodules are of all sizes, from those an inch or more across to those so small as to be lost in the fine matrix.

9334

Sl. 2978

Greenstone Schists.

C. A. Van Hise, Mar. 26, 1886

9335

Sl. 3113

Macroscopic Description.9369

Sl. 3035

9334 and 9335 are dark gray, compact, fine grained rocks, having but a feebly developed schistose structure. 9369 resembles closely 9338 and 9339.

Microscopic Description.

These rocks appear to have been originally like 9338, 9339, and 9359; but the alterations are of a somewhat different nature and have extended farther. 9334 consists of almost entirely decomposed tabular plagioclases, of very numerous small blades of actinolite, and, in smaller quantities, of chlorite, epidote, quartz, and ferrite. In 9335 finely crystalline quartz, chlorite and epidote are the prominent constituents, plagioclase and ferrite being less abundant than the preceding minerals. 9369 differs but little from 9338 and 9339 except that it contains calcite.

9241Greenstone Schists.

Sl. 2948

C. R. Van Hise, Mar. 26. 1886

9242Macroscopic Description.

Sl. 2949

These rocks are essentially like 9338 and 9339. 9242 and 9243 have a somewhat more strongly developed schistose structure.

Microscopic Description.

The sections are composed of a confusedly mingled mass of partly decomposed plagioclase, actinolite, chlorite, epidote, finely crystallized quartz, gray amorphous material, with some ferrite. As in the previously described much altered rocks the origin of these schists is difficult to make out but they appear to be greatly altered eruptions. In 9241 large porphyritic crystals of decomposing plagioclase are found. 9241 is supposed to be a pebble (from the slate conglomerate) but microscopically it does not differ from the matrix (so called) 9242 and 9243.

9349Greenstone Schists.

Sl. 3027

C. R. Van Hise Mar. 26. 1886

9366Macroscopic Description.

Sl. 3022

The rocks are grayish green, fine grained, rather massive rocks, yet showing a schistose structure. 9369 shows nicely the pseudo-conglomeratic appearance of these greenstone schists.

Microscopic Description.

The mineral constituents are plagioclase, chlorite, quartz, gray amorphous material, with epidote and calcite and some kaolin. The plagioclase is much altered and its decomposition has resulted in the formation of some brilliantly polarizing kaolin. In amygdaloid cavities in 9349 there are present some zeolites.

Greenstone Schists

C. R. Van Hise, Mar. 26/86

Macroscopic Description.9312

Sl. 2970

Sl. 2971

9371

Sl. 3019

9377

Sl. 2975

9331

Sl. 2977

9336

Sl. 3021

9337

Sl. 3022

The rocks are dark green, fine grained schists.

Many of them have upon the weathered surface the pseudo-conglomeratic character noticed in some of the previously described rock. Upon the broken surfaces however, they show, with few exceptions, little indication of conglomeratic character. 9344 and 9345 contain dark purple, pebble-like masses which resemble more closely true pebbles than any found in the other rocks.

Microscopic Description.9344

Sl. 3024

9345

Sl. 3025

9273

Sl. 3002

9275

Sl. 2943

The sections are composed of most irregularly intermingled plagioclase, chlorite, actinolite, epidote, finely crystallized quartz, ferrite, and in some cases calcite. Some of the sections are from pseudo-pebbles and some from matrices but there is little or no difference in minerals contained. All of the rocks are very much altered but there is difference among them as to degree of alteration. Some sections appear quite plainly to be altered eruptions while the most of them are so much changed as to make any surmise of their origin a mere guess, unless account is taken of their relations to the less altered ones. The feldspars are best preserved 9377, 9331, 9337, and 9273. In 9377 and 9331 the very numerous tabular feldspars are comparatively fresh showing distinctly twinning bands. In 9273 and 9337 there are found a few roundish, large, fragmental appearing plagioclases.

9377

Sl. 3037

Actinolitic Chlorite Schist

C. R. Van Hise Mar. 26. 1886

Macroscopic Description.

The rock is a very dark green, finely grained, and finely laminated schist.

Microscopic Description.

Amorphous chlorite, and limonite-stained actinolite are the most plentiful minerals of the section. In some parts of it are quite abundant finely crystallized quartz grains. The chlorite serves as a ground mass in which the radiating bundles of actinolite are located.

9378

Sl. 3038

Actinolitic Chlorite Schist

C. R. Van Hise, Mar. 26. 1886

Macroscopic Description.

This rock differs from 9377 in being harder and more massive.

Microscopic Description.

The mineral constituents are the same as in 9377. The ground mass, however, consists of more uniformly mingled chlorite and quartz and the smaller, very plentiful needles of actinolite are generally arranged with their longest axes in a common direction. The fibres of the chlorite are parallel to this axial direction of the actinolite. Scattered thickly through the section, as in that of 9377, are patches of gray amorphous material which may possibly be a secondary product to titanite iron.

9656

Feldspar Determination.

E. H. Park, February, 1886.

For description

After proceeding in the same manner as in the case of 9402 (p. 86) for the separation of the feldspars from the other rock material, they were placed as before in the funnel with 35 c.c. mercury iodide solution, sp. gr. 3. 5 c.c. of water sp. gr. 1 are now added to reduce the solution to a sp. gr. of 2.75 or the maximum sp. gr. of the heaviest feldspar, anorthite. With the residue which now sinks, 6.5 c.c. of the liquid are drawn off. To the remaining 33.5 c.c. of the liquid .78 c.c. of water sp. gr. 1 is now added, thereby reducing the sp. gr. of the solution to 2.71, or that of labradorite, the next lower feldspar. As none of the feldspars sink at this point, .41 c.c. water sp. gr. 1 are added thus reducing the sp. gr. of the solution to 2.69 or that of andesite, the next lower feldspar. A portion of the feldspars now come down with which 4 c.c. of the liquid are drawn off. The solution is now reduced by the addition of .73 c.c. of water, sp. gr. 1, to a sp. gr. of 2.65 that of the next lower feldspar, oligoclase. At this point all the remaining feldspars sink suddenly. A check was taken to determine accurately the sp. gr. of this portion of the feldspars. 20 c.c. of solution sp. gr. 2.748 (determined by weight) were taken, and in this solution the feldspars were placed. Water, sp. gr. 1, was now added from a burette in quantity sufficient to reduce the solution to a sp. gr. at which the grains either fall to the bottom or are suspended in the liquid. Knowing the amount of solution, its sp. gr., the amount of water and its sp. gr. the sp. gr. of the resultant liquid is determined, being, in this case 2.68, thus indicating andesite. The labradorite and andesite were brought on a filter, washed, dried and mounted, and then dissolved in the same manner as in No. 9402.

9835
Sl. 4292.

Magnetite schist

C. R. Van Nise, Winter of 1888.

Macroscopic Description.

Banded; fine-grained; alternate bands green and black; the bands much contorted; weathers red or brown, due to peroxidation of the magnetite.

Microscopic Description.

A finely crystalline intricately interlocking quartz ground-mass contains much magnetite in almost solid bands, or in detached crystals. The green colored bands appear to owe their tint to chlorite.

9836
Sl. 4293

Magnetite schist.

C. R. Van Nise, Winter of 1888.

Macroscopic Description.

The specimen is fine-grained, finely banded, and of a uniform lustrous greyish-black color.

Microscopic Description.

The section marked 9836 appears not to be from that rock. Slide 4293 is an actinolitic? magnetitic schist. The background is as in 9835. Magnetite is much less plentiful, but is however disseminated through the section in small crystals. There is quite a quantity of nearly colorless, non-pleochroic or faintly pleochroic, fibrous mineral, which is taken to be actinolite or tremolite. Accompanying this mineral, and apparently an alteration product of it, is chlorite.

9837

Sl. 4294

Actinolitic and Magnetitic Schist.

C.R. Van Kise, Winter of 1888

Macroscopic Description.

The fresh fracture of the specimen indicates that it consists largely of soft red peroxidized iron oxide and of dark gray or black material, which may be specular hematite or magnetite. The two oxides are mingled in the most irregular fashion.

Microscopic Description.

The background of 9837 does not differ from that of 9835 and 9836. The amount of this quartzose background is much greater than would be expected from the hand-specimen. It composes fully a third of the rock. The magnetite and hematite are in irregular areas and in crystals. The particles of quartz everywhere include the iron oxides, where they do not exclude the quartz. Tremolite or actinolite are found as in 9836.

9838

Sl 4295

Hematitic and Magnetitic Schist.

C.R. Van Kise, Winter of 1888.

Macroscopic Description.

Like 9837

Microscopic Description

In this section differs from 9837 only in that the quartz is finer grained and less abundant, the proportion of iron oxides thus being greater.

9839
sl. 4296

Magnetite Schist

C. R. VanDike, Winter of 1888.

Macroscopic Description.

(No specimen.)

Microscopic Description.

The thin section is such a one as to indicate that the rock is very like 9836, if not that specimen. Since slide 4292 does not belong to that specimen, it is very probable that slide 4296 belongs there.

The slide is a typical magnetite schist. Here is a background composed of rather small, most irregular, intricately interlocking grains of quartz of approximately equal size. In this quartz is the magnetite in a continuous ramifying linear arranged mass. Some small part of the magnetite is in independent crystals. The only other constituent of the rock is a little actinolite or tremolite. The magnetite is arranged in complete independence of the quartz, being cut by that mineral in every direction. The relations of the two minerals that the magnetite crystallized first, and the quartz had subsequently arranged itself to the remaining spaces. A little of the iron oxide is in the form of hematite.

9840
sl. 4297

Actinolitic Magnetite Schist.

C. R. VanDike, Winter of 1888.

Macroscopic Description.

Precisely like 9835, except that the layers are not curved

Microscopic Description.

In thin section is essentially like 9835. The material which, in the less magnetitic bands, gives them a green color is quite plainly in large measure actinolite, although chlorite is also present.

9841

Sl. 4298

Magnetite Schist.

C. R. Van Hise, Winter of 1888.

Macroscopic Description.

Resembles closely 9836. The only difference is that in the heavily magnetitic material are layers of nearly pure quartz, and quartzose layers colored by some green material.

Microscopic Description.

This slide (4298) is almost precisely like 4296. It contains more actinolite or tremolite and its alteration product chlorite. The section is across one of the nearly colorless layers, and this is composed of nearly pure quartz, which differ from the background only in being finer grained than it. This belt contains a little magnetite in crystals and some actinolite

13829

Sl. 5642

Nematitic Magnetitic Schist.

C. R. Van Hise, Winter of 1888.

Macroscopic Description.

Consists of alternate layers of black and white material. The white layers appear to be almost pure quartz, and the black ones chiefly magnetite.

Microscopic Description.

In essential constituents and their arrangement, this specimen does not materially differ from 9839 and 9841. The chief difference between them is that 13829 is much coarser-grained - the white belts being as coarse-grained as an ordinary fragmental quartzite. The interlocking and irregularity of shape of the quartz-grains is quite as great as in any of the preceding magnetite schists, and there is absolutely no indication of a fragmental nature. In fact, in all particulars this quartz is like that ordinarily classed as a chemical sediment. Magnetite is contained in all parts of the quartz individuals just as in the preceding rocks. The only other inclusions in the quartz are minute brilliantly polarizing leaflets of a mineral which is taken for sericite. In this respect this rock is like the quartzite in connection with the ore at Republic, Mich.

13850
 Sl. 5648

Actinolite Magnetite Schist.

C. R. Van Hise, Winter of 1888.

Macroscopic Description.

The specimen consists of alternate bands of white, green and black material. The white ones appear to be nearly pure quartz, the green ones have a fibrous texture, and the black ones are heavily ferruginous.

Microscopic Description.

The rock is a typical actinolite magnetite schist. A quartz background as in the previous schists contains the other minerals. The magnetite is precisely like the magnetite of previous specimens. Actinolite occurs in almost solid belts and scattered through other parts of the section. It is mostly perfectly fresh, feebly pleochroic, and shows all the remaining characteristics of actinolite. The actinolite in places contains areas consisting of granules of epidote. This is the first time that the occurrence of this mineral has been noted in this class of rocks. The order of crystallization of the minerals, as shown by their present relations, is magnetite, actinolite, quartz; for magnetite is included in both actinolite and quartz, and actinolite cuts the quartz in every direction. In some places the actinolite is arranged about the magnetite in such fashion as to suggest that that mineral is a reactionary one. The quartz particles have the longer axes with great uniformity in a common direction, as though subject to great pressure. Contained in the quartz are a few small areas which appear to be some carbonate.

13820
 Sl. 5640

Actinolite Magnetite Rock

C. R. Van Hise, Winter of 1888.

Macroscopic Description.

The rock is massive, fine grained, mottled green and black; green where fibrous actinolite is predominant, and black where magnetite is abundant.

Microscopic Description.

This rock differs from those previously described, in that actinolite is more abundant than in any of them and quartz less so. The rock is then composed almost wholly of actinolite and magnetite, with a little quartz. The relations of the three minerals are precisely the same as in the actinolite magnetite schists noted on the previous pages.

13847

Al. 5647

Actinolite Magnetite Rock.

C. R. Van Nise, Winter of 1888.

Macroscopic Description.

Drill core; fine-grained; alternate belts of green, white, and black materials, according as to the actinolite, quartz or magnetite predominate.

Microscopic Description.

This rock resembles 12820. It, however, differs from it, in that the actinolite is altered to some extent into chlorite and epidote. A vein of almost pure quartz cuts across the section, and mingled with the actinolite and magnetite is some quantity of a grey carbonate.

13846

Al. 5646

Calcite Actinolite Rock.

C. R. Van Nise, Winter of 1888.

Macroscopic Description.

Drill core. The rock is dark green, fibrous, and contains numerous crystals of pyrite.

Microscopic Description.

The rock is mostly composed of actinolite. With this is much of some carbonate in nearly equal quantity. The intersecting and interlocking of the two minerals is of the most intricate sort. In the calcite areas are included often many fibres or blades of actinolite, and the large actinolite blades include calcite in most irregular areas. The only other minerals of importance are pyrite and magnetite, both of which are present in crystals and large irregular areas, the former much more plentiful than the latter.

13839
Sl. 5645

Chloritic Muscovite Schist.

C. R. Van Hise, Winter of 1888

Macroscopic Description.

The rock is finely laminated and foliated, and of a dark-green color.

Microscopic Description.

A finely crystalline quartz background contains much chlorite and muscovite. Aside from these minerals, the only ones of importance are iron oxides. A vein cutting across the section contains large areas of what appear to be iron oxide, and of calcite or other carbonate. The chlorite and muscovite are in small folia, the lengths of which are usually several times their breadths. The particles of chlorite and muscovite are quite unusually arranged. They are concentrated largely in belts, which correspond to the schistose direction in the hand-specimen and presumably the bedding plane. However, the average direction of their longer axis of the individual folia is almost at right angles to this direction of foliation. While this average direction is at right angles, the individual folia vary quite widely in direction, being in many curved lines. The lamellae of them of the chlorite and muscovite would indicate that the rock was a very finely and strongly and irregularly foliated one in the direction of these particles, while the hand-specimen shows the rock also to be a regularly laminated one in a direction about at right angles to the above. The question as to whether this rock belongs with and is interstratified with the actinolite magnetite schists is difficult to answer certainly. The presence of a considerable quantity of iron oxides distributed through the chlorite and muscovite, and its almost entire absence from the quartz, would seem strongly to point toward the idea that the rock belongs to a different series; for one of the most characteristic features of the actinolite magnetite schists, is that the magnetite and other iron oxides are included in almost every individual of quartz, in such a manner as to prove beyond question that the magnetite was formed prior to the quartz, or else that it was deposited under such conditions as to be able in connection with other reactions to penetrate the quartz in every direction. The foliation of the rock transverse to the microscopic direction of lamination has not been observed in any of the actinolite magnetite schists. The longer axes of the blades of actinolite in them always correspond with the macroscopic lamination. As a result of the above facts, it seems probable that this chlorite muscovite schist does not belong with the iron rocks before described, but to a different layer in the same series of rocks, or to a different series altogether.

13828
Pl. 5641

Muscovite or Sericite Schist.

C. R. Van Hise, Winter of 1888

Macroscopic Description.

Fine-grained, strongly foliated, of a silvery white color, except where stained brown by iron oxide.

Microscopic Description.

Quartz and muscovite, or sericite, are the two important constituents. The quartz is free from inclusions, except muscovite in rather small grains of varying sizes, and intricately interlocking both within itself and with the muscovite. The muscovite, or sericite, is found almost everywhere in the section, but is chiefly concentrated into belts which correspond to the lamination seen macroscopically. While many of the lamellae correspond also to this direction, most of them are at a greater or less angle to it, or are curved from this direction at one end, while many are transverse to this direction. In fact, a secondary foliation at right angled to that of lamination is as plain as in 13839, only the effect have not been so great. Much of the muscovite or sericite is stained with yellow oxide of iron. Here and there are small areas of some iron oxide. Quite numerous very perfect small crystals of blue and black tourmaline are contained in the section. They are cut in both transverse and longitudinal directions and show nicely their characteristic crystallographic forms and optical properties.

13830.

Sl. 5643.

Chlorite Biotite Gneiss.

C. R. Van Hise, Winter of 1888.

Macroscopic Description.

Coarse-grained; strongly laminated and foliated; white and yellow feldspar, quartz and broad flakes of mica are all in large easily distinguished individuals.

Microscopic Description.

Constituents orthoclase, quartz, biotite, chlorite, iron oxide. The relations of the constituents are much the same as in an ordinary gneiss. The feldspars are much altered, and quite a portion of the chlorite, biotite and quartz have resulted from this decomposition, as is shown by the fact of their inclusions in and around the remaining feldspars, and it is of course possible that much or all of the chlorite and biotite, and much of the quartz, are from this source. This decomposition of the feldspar with the above results are finely shown. In large single reticulating remaining areas of the feldspar, its reticulating and interlocking with the resultant constituents and with themselves are of the most intricate sort. Magnetite in small areas and crystals is quite an abundant accessory. While the primary foliation as seen in the hand-specimen is much the most worked and controls the longer axes of the larger individuals, many of the smaller folia of chlorite and biotite are arranged with their longer axes more or less nearly in a transverse direction, which indicates as clearly as in 13825, 13838, the action of forces at different times in different directions.

13834

Sl. 5644.

Muscovitic Biotite Schist.

C. R. Van Klee, Winter of 1888.

Macroscopic Description.

Coarse-grained; highly foliated. Large lustrous brownish flakes of mica and a green material are the only substances macroscopically visible.

Microscopic Description.

Chief constituents quartz, biotite, muscovite, and some undetermined mineral. Accessories Brookite or Rutile, probably the latter, and iron oxides. The biotite is very abundant; is of a very dark brown color. That which is fresh is strongly pleochroic, but much of it has altered to such an extent as to lose many of the characteristics of biotite. This alteration has resulted in the formation of much hematite. The undetermined mineral is fibrous, at times radial fibrous, is colorless, but gives in polarized light a blue absorption. There are also present many small well-formed crystals of a dark brown, weakly pleochroic mineral with high refraction power, which are taken to be rutile or brookite.

(Investigate farther and describe more closely.)

8894

Sl. 3598

Siderite and Flint.

C. R. Van Klee, Spring of 1888.

Microscopic Description.

A flint background contains siderite in about equal quantity, the siderite being in irregular more or less disconnected areas more commonly than in rhombohedra. A little fragmental quartz is included.

7003
Sl. 2076

Hematitic and Magnetitic Quartz-Schist

C.R. Van Hise, Spring of 1888

Microscopic Description.

Quartzose background completely and relatively coarsely crystallized. Hematite and magnetite intimately intermingled, the two together forming in the quartz reticulating areas, with little tendency to concretionary arrangement. The interiors of the hematite-magnetite areas are commonly of the two minerals; the exteriors of the areas are almost always hematite. Occasionally the magnetite is in a solid piece instead of numerous spots as is ordinarily the case in the iron oxide areas, and here the magnetite is a core in the hematite. The relations of the two minerals suggest that the iron oxide was first all magnetite, and that subsequently it was in part peroxidized to hematite.

7013
Sl. 2082

Magnetitic Actinolite Quartz-Rock.

C.R. Van Hise, Spring of 1888.

Microscopic Description.

A quartzose background contains a reticulating mass of iron-stained actinolite which composes a third or more of the section. In this actinolite is found nearly all of the magnetite, occurring in small well formed crystals. A little siderite is found contained as cores in some of the actinolite areas, the remaining carbonate, however, being penetrated in every direction by needles of actinolite. The relations of the two minerals strongly suggests that the siderite has furnished the iron necessary for the formation of the actinolite. From the complex areas of actinolite very numerous long needles of the mineral radiate which penetrates deeply into the quartz, so deeply that most of the quartz is cut in every direction by these minute needles. The farther the quartz is from an actinolite area, the fewer needles are contained. Here it would seem that the greater part of the actinolite had formed before the deposition of the silica but that the needles of actinolite continued to grow during the time of the deposition of the silica.

8898Silicified Gabbro.

Sl. 3599

C. R. Van Hise, Spring of 1888

Now contains biotite in large areas.

8899Crystalline Schist.

Sl. 3600.

C. R. Van Hise, Spring of 1888.

Silicified Gabbro & compare 8898.

8896Gabbro.

Sl. 3856

C. R. Van Hise, Spring of 1888.

10157

Sl. 3700

C. R. Van Hise, Spring of 1888

A continuous sheet of iron oxide contains many fragmental particles of quartz and feldspar, the latter being orthoclase, microcline and plagioclase, and also some iron carbonate.

10158

Sl. 3701

C. R. Van Hise, Spring of 1888.

As in 10157, a continuous sheet of iron oxide contains fragmental material and siderite. It, however, differs from 10157 in that the amount of fragmental material is greater although the individual particles are smaller. Siderite also, instead of being sparse, is plentiful in numerous small roundish or rhombohedral areas. Frequently the siderite areas have cores of iron oxide, and as they occur in iron oxide the appearance is that of a ring of siderite buried in iron oxide.

10165

Sl. 3702

C. R. Van Hise, Spring of 1888.

Belong to Iron Series &

10166

Sl. 3703

C. R. Van Hise, Spring of 1888.

Belong to Iron Series &

8893

Sl. 4065

Flinty Slate.

C. R. Van Hise, Spring of 1888.

Belong to Iron Series &

8895

Sl. 4066

Flinty Siderite.

C. R. Van Hise, Spring of 1888.

The siderite background contains a considerable quantity of quartz, which is, however, mostly concentrated in roundish areas & veins.

10548

Sl. 4991

Feruginous Greywacke

C. R. Van Hise, Spring of 1888.

A background of iron oxides, with perhaps carbon material, contains very numerous minute angular fragments of quartz and feldspar, the fragments and their alteration products composing two thirds or more of the rock.

